Phonological Development in Hearing-Impaired Malay-Speaking Children

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ABSTRACT

This study explores the phonological development of hearing-impaired Malay-speaking children, shedding light on the unique challenges and patterns that characterise their phonological process. The subjects of the research include 40 hearing aids Malay-speaking children with a chronological age of 5 to 9 years old and hearing age of a minimum of 2 years. Utilising a mixed-method research method, we examined the effect of hearing-impairment on the acquisition of Malay phonological features and the association between socio-demographic factors and phonological process in hearing-impaired Malay-speaking children. Through the analysis of speech samples and sociodemographic information that were collected through a standardised picture naming task, it was concluded that the phonological process in hearing-impaired Malay-speaking children is fronting, assimilation, stopping, voicing, initial consonant deletion, epenthesis, deaffrication, depalatalisation, denasalization, devoicing, prevocalic voicing, final consonant deletion, reduplication, and gliding. Furthermore, there is a relationship between socio-demographic factors and the phonological process in hearing-impaired Malay-speaking children. Lastly, hearing age is an important variable that is statistically significant in predicting the relationship between sociodemographic factors and phonological process in hearing-impaired Malay-speaking children. The results of this research contribute to a deeper comprehension of the phonological development of hearing-impaired children in a Malay-speaking context, with its relationship to sociodemographic factors.

Keywords: phonological processes; Malay phonemes; sociodemographic factors

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INTRODUCTION

Hearing impairment, also known as hearing loss or deafness, is a condition that affects an individual's ability to perceive sounds to varying degrees. It can be congenital, meaning present at birth, or acquired later in life due to numerous factors such as illness, injury, exposure to loud noise, or simply ageing. Hearing impairment in children is a particularly critical issue as it can significantly impact their language development, academic performance, social skills, and overall quality of life. Unlike adults who may have acquired hearing loss due to various factors, children with hearing impairment may face unique challenges, especially if the impairment occurs early in life. Phonological acquisition is a crucial component of language development since it influences or determines linguistic theories (Baddeley et al. 1998). Supporting and determining the linguistic opinions of the specialists can be accomplished through phonological research, which looks at the general complexity, order, and limitations of the sound system. The fact that these sounds only arise depending on an individual's abilities is another reason why phonology is a crucial area of study. (Kilpatrick 2015). In other terms, since human biology does not develop in the same way as other animals, one could argue that the acquisition of sound cannot be measured in years or months. Each child's phonological acquisition is unique as a result. This draws attention to the research that linked children's phonological development to hearing aids. According to Tomblin et al. (2014), it was revealed that hearing aids have an impact on the spoken language development of hearing-impaired children positively. It was asserted that hearing aids has improved speech production and phonological development (Ambrose et al. 2014; Persson et al. 2021; D'Ortenzio & Volpato 2019). However, little research has shown that hearing-impaired children have difficulty acquiring phonological skills when using hearing aids (Shojaei et al. 2016; Brosseau-Lapre & Roepke 2019; John et al. 2016; Baek 2008). This provides evidence that hearing-impairment may affect Malay-speaking children's phonological development. The current research is therefore conducted to investigate this situation further. Thus, the objectives of the current study would be to identify and analyse the specific phonological processes undergone by hearing-impaired Malay-speaking children with hearing aids. Other than that, the association between socio-demographic factors and the phonological processes observed in hearing-impaired Malay-speaking children with hearing aids would also be explored.

PROBLEM STATEMENT

In a cross-sectional study conducted by Saari (2012) examined the variables influencing the learning of the Holy Quran in children with cochlear implants who were profoundly and severely hearing impaired. Moreover, Soleymani et al. (2016) discovered that children with cochlear implants may have difficulties learning both language and phonological knowledge in their investigation of the impact of cochlear implants on language and phonological acquisition. The basis of these studies included subjects with CI users which were compared with typical hearing children. This could be due to the unique pattern CI users have in acquiring phonological skills. It was discovered that kids with CIs had receptive vocabulary skills that were suitable for their age. These studies show that children with cochlear implants frequently experience phonological acquisition difficulties and hearing deficits; hence the phonological process in children wearing hearing aids was further studied with the help of the current study and the pattern of their phonological skills was studied in comparison to typical hearing children.

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The various research that is based on phonological process and children with hearing loss is often conducted outside of the Malaysian context. For example, a study done by Rosen and Skoruppa (2018) investigated phonological processing in hearing-impaired children from London. The study found that children with hearing-impairment demonstrated low sensitivity to word-final place changes; but this phenomenon was not discussed in association with the influence of the geographical region of the study. Moreover, Asad et al. (2018) researched the phonological processes of Australian children with hearing aids and found that there was a high substitution of final consonant deletion, weak syllable deletion and glottalisation in the hearing aid users. Like the previous study, the phonological processes that the hearing aid users underwent were not discussed in relation to its geographical region. However, Penney et al. (2019) revealed that the Australian accent does have an impact on the phonological acquisition especially with the occurrence of glottalisation.

To further validate the data, the study also examined these circumstances in two separate datasets of Australian English. This not only provides insight for the current study to highlight the effects of a language or accent to phonological process but also brings awareness on the type of studies that are done outside of the Malaysian region. It is undeniable that there are multiple phonology studies in Malaysia, but researchers in Malaysia often focus on other languages such as English or Tamil language compared to the Malay language which is the national language of Malaysia. Joseph (2007) examined the sound acquisition of Malaysian English in children of Indian descent. The researcher was able to provide the effects of the Tamil language on the acquisition of English phonemes in children, but due to the small number of subjects in the study, it is quite difficult to generalise the outcome to the Malaysian population. Furthermore, the study solely focused on typically developing children's phonological process; hence it would also be difficult to associate the findings of the study with hearing-impaired children. This could indicate that little research has been done on phonological processes and children with hearing aids in the Malaysian geographical magnitude and targeting the Malay language. Thus, this study will contribute to addressing this gap, since the participants of this research are Malay-speaking hearing-impaired children for whom Malay is their dominant language and are also analysing the Malay language phonemes.

LITERATURE REVIEW

SPEECH SOUND DEVELOPMENT

Early developing sounds begin to emerge between the ages of one and three, and they become constant at that age, according to Shriberg, L (2018). Around age 5.5, middle-developing sounds become consistent, having developed between the ages of 3 and 6.5. Around age 7.5, late-emerging sounds become constant after forming between the ages of 5 and 7.5.

TABLE 1. Age and type sounds developed

Age	Sounds developed
2-3 years	p, b, m, d, n, h, t, k, g, w, ng, f, y
4 years	l, j, ch, s, v, sh, z
5 years	r, zh, th (voiced)
6 years	th (voiceless)

Children who wear hearing aids or who have hearing loss do not pick up words or phonemes as quickly as children with normal hearing (D'amico et al. 2012). Moreover, their poor hearing may also cause them to have difficulty communicating coherently. Due to their quiet nature and difficulty being picked up by hearing aids, sounds like s, sh, f, t, or k may also be omitted by children wearing them. Additionally, they might speak in a high pitch by nature (Baek 2008).

However, numerous studies also refute these claims. In a 2014 study, Ambrose et al. examined the speech sounds produced by two-year-old hearing-impaired children. It was discovered that while hearing-impaired children had worse consonant production skills, their vowel production abilities were comparable to those of typical children. Moreover, female gender, stronger vocabulary scores, less than 45 dB HL hearing loss, and hearing aid fits by the age of six months were all linked to better speech outcomes in children with hearing loss. Additionally, the necessity of early speech evaluation considering linguistic, audiological, and demographic factors was raised. This makes it easier to identify kids who have speech impairment.

In connection with this, Shojaei et al. (2016) discovered that phonological abilities in the two groups of early and late-fitted hearing aids differed significantly. In late-identified children wearing hearing aids, inappropriate phoneme usage, common phonological irregularities that affect speech production clarity include word onset/offset consonant deletion and known vowel addition between two surrounding vowels, especially in complex conversation contexts.

Additionally, according to Shojaei et al. (2016), stress disorders—which are brought on by inappropriate use of phonetic duration, breathing control weakness, repetitive pauses in the speech continuum, breathing-speech producing imbalance, speech tonality disorder, and abnormal speech rhythm—are the most common speech abnormalities in children who use hearing aids. In terms of lexical stage development, children with hearing impairments also comprehend and utter shorter, simpler phrases than children with good hearing. Complex sentences with relative pronouns ("The teacher whom I have for math's was sick today") or passive voice ("The ball was thrown by Mary") may be particularly challenging for them to comprehend and write. Children who have hearing loss have trouble hearing word ends like -s or -ed. This results in pluralization, misinterpretations and violations of verb tenses, disagreements between the subject and the verb, and possessive usage (Markides 1984).

PHONOLOGICAL ACQUSITION IN HEARING-IMPAIRED CHILDREN

Stoel-Gammon and Otoma (1986) compared the babbling development of children with hearing impairments versus children with normal hearing. Eleven typically hearing participants between the ages of 4 and 18 months and eleven hearing-impaired children between the ages of 4 and 28 months had their phonetic transcriptions compared by the researcher. Compared to hearing-impaired participants in the same age group, who had smaller repertoires that similarly shrank with time, it was evident from the observation that typically hearing youngsters had larger consonantal repertoires as they grew older. Additionally, it was discovered that children with hearing impairments tended to generate a substantial proportion of vocalisation with glides or glottal stops when comparing their multisyllabic utterances.

Additionally, Moeller et al. (2007) conducted comparison research that examined the vocalisation of newborns with normal hearing versus hearing loss. The phonetic development that took place throughout that time was the focus of the investigation. The study discovered that some infants with severe hearing loss seem to have difficulty developing their fricative or affricate

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sounds. This may also have to do with how sensorineural hearing loss affects high-frequency information, how amplification restricts bandwidth, and how audibility is affected in noisy and reverberant environments. The usage of fricatives later in life may potentially affect morphological development. Thus, a kid may be at risk for delayed speech development if their syllable development is developing slowly.

In the Malaysian context, Saari (2012) investigated three elements—self-factors, parental and instructional factors, and other factors—that could influence a group of Malay children with hearing impairments' ability to acquire the Arabic sounds found in the holy Quran. This study included children from Mali who were implanted with cochlear devices. Based on the study's findings, self-factors accounted for 55.1% of the variance observed in the reading scores, making them the only meaningful predictive factor. This indicated that among children with cochlear implants who are hearing challenged, self-factors were most important for making learning the sounds of the holy Quran easier.

SOCIODEMOGRAPHIC FACTORS AND PHONOLOGICAL ACQUSITION

In the Brazilian capital, Nogueira et al. (2020) carried out a cross-sectional study to examine the association between sociodemographic characteristics and speech ability in young and old persons. 60 participants from the Brazilian capital were included in the study sample; they were divided into two age groups based on age: older individuals (aged 60 and above) and younger persons (19–39 years old). Within each group, 15 participants had between 2 and 7 years of schooling, while the remaining 15 had at least 8 years.

Additionally, information on socioeconomic position, age, and educational attainment was gathered. The BDAE's Verbal Agility Subtest was used to conduct the phonetic-phonological evaluation. In terms of statistical analysis, phonological performance was analysed by using Spearman's correlation coefficient, while sociodemographic characteristics were compared between the groups using Fisher's exact and Mann-Whitney tests. The study's conclusions demonstrated the relationships between phonological performance and age, education level, economic situation, and cognitive characteristics.

Furthermore, Zaretsky et al. (2022) also did a study analysing one of the socio-demographic factors which are bilingualism. Four-year-old monolingual and bilingual children learning German (N = 1,441) were the study's subjects. They took tests using quasi-universal non-words (QUNW) and German-based non-words (GBNW). Bilinguals produced noticeably worse results in GBNW but not in QUNW, it was discovered. Presumably, multilingualism increases the pressures placed on PSTM over monolingualism, which speeds up the development of phonology.

In terms of analysing the phonological variation and relationship with the social health determinant, Lee and Al Otaiba (2015) conducted a study on 74 children between the age of 4 to 10 years old. The researchers utilised the Phonology Test of Children's Language Test–PTCLT to collect data. The analysis of the data was done through frequency distribution and central tendency and dispersion measurements, and Pearson and Mann-Whitney, Chi-square tests were used for the associations. The study also utilised Regression analysis in determining the relationship. The study showed that there is a relationship between the result of the phonological evaluation and the parental education of children referred for evaluation in the four to ten-year-old age group. This result evidenced the importance of phonological performance in public education and health networks.

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Moreover, in a sample consisting of 925 people aged 18-89 with 1-28 years of schooling, Campanholo et al. (2017) evaluated the predictive influence of education, occupation, and family income on the decline in executive functions such as phonological and grammatical functions. The assessment instruments for this study were the Card Sorting Test (CST), Phonemic Verbal Fluency (FAS) Task, and Semantic Verbal Fluency (SVF) Task. In addition to Pearson's and Spearman's correlations, Linear Regression was used to analyse the data. The findings indicate that whereas education, wealth, and occupation were positively associated ($p<0.001$) with the tasks used, age had a substantial negative connection ($p<0.001$) with performance on the CST, FAS, and SVF.

CONCEPTUAL FRAMEWORK

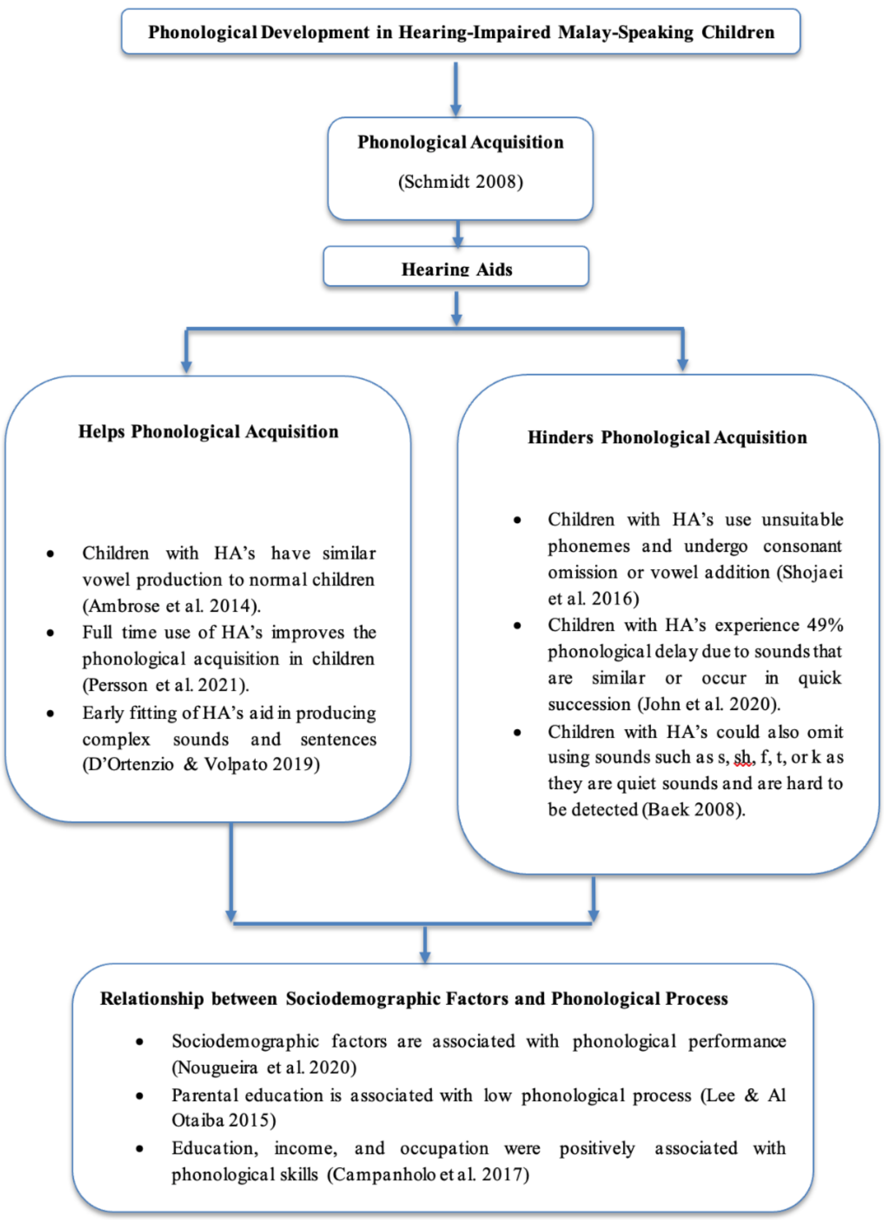

FIGURE 1. Conceptual framework of the study

METHODS

The design of this research was non-experimental analytical quantitative research. Thus, this study is a cross-sectional study where data was collected from many individuals at a single point in time (Jaiswal et al. 2022). The rationale behind collecting data through this method was to make inferences about a particular population of interest which is hearing-impaired Malay-speaking children at that point in time (Berg 1991). Furthermore, this study has also opted to utilise the quantitative method to allow the data to be organised analytically. The data received was arranged in tables, graphs, or even chart forms. This allows the process of data presentation and analysis much easier (Creswell & Creswell 2018). Similarly, if it is conducted properly, a quantitative study will also have consistent data, where the data collected will be precise, consistent, and reliable and can be analysed quickly using statistical software such as SPSS (Provan & Lester 1993).

SUBJECTS

The subjects of the study include 20 children with normal hearing between the ages of 2 to 6 years old for sampling purposes. Meanwhile, 40 children with hearing aids who have a hearing age of a minimum of 2 years were recruited for analysis purposes. They were required to be in between a chronological age range of 5 to 9 years old. The researcher has also chosen 20 male and 20 female subjects within the hearing-impaired children and 10 males and 10 females within normal children. Since Malaysia is a multicultural country and most of the population is either bilingual or multilingual, the subjects of the current study are required to be Malay-speaking children where Malay is their dominant language. Mueller & Thomas (2009) define language dominance, also known as a dominant language, as the "more proficient" or "further developed one," and it refers to the relative strength of bilingual proficiency in each language. The subjects of this current study were selected through a purposive sampling method where the participants possess characters that the researcher prefers (3.5.2 Inclusion Criteria). It is to be noted that the subjects of this study were recruited from various private speech therapy clinics and audiology centres in Klang Valley. For normal children, subjects were also recruited in Klang Valley. The following table outlines the inclusion and exclusion criteria of the subjects.

TABLE 2. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Children with hearing aids who have attended speech therapy sessions optimally at least for a year after their day of fixation.	Children with other kinds of amplification devices such as cochlear implants.
Children with hearing aids should use their hearing aids for at least 12 hours per day.	Children who have lower than average proficiency in the Malay language.
Children with hearing aids should be fitted before the chronological age of 4 years old.	Children who suffer from any other physical impairment such as visual, mobility, chronic fatigue, and pain.
They should also have a moderate level of hearing impairment with sensorineural hearing loss.	
Both normal and hearing-impaired children should be Malaysian.	
Malay should be their dominant language if they are bilingual or multilingual.	
Children with typical development.	

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MATERIALS

Two questionnaires have been incorporated in this research which acts as a medium to collect data. The form utilised is an adapted version of a co-existing reliable questionnaire by Gosnell et al. (2023). The first questionnaire for the parents encompasses two sections, where the first section will have a consent form and the second section collects the subjects' demographic information. For the speech therapists, the first section will be a consent form, the second will collect basic information about the subjects.

PROCEDURES

The researcher shared the questionnaire with the parents of the subjects to input the subjects' sociodemographic background and another with the speech therapists to input the subjects' basic information of the subject. The output audio was recorded by the researcher. The audio output that was recorded was when the subjects were undergoing the picture naming task. A picture naming task is a task that was developed by Wilson (1980) to estimate the word recognition performance of non-verbal children (Wilson & Antablin 1980). In the current study, this task is used to elicit speech production and extract samples to examine the types of phonological processes these children undergo, where the children were shown a picture and asked to identify and name them in the Malay language. Furthermore, the sociodemographic items collected and analysed for this study would be the gender, ethnicity, hearing age, living area, income, parental education, screen time and other languages used at home. The collected data was then analysed through regression analysis. The transcription then undergoes coding, where the utterances of the participants are transcribed based on the International Phonetic Alphabet (IPA). The units of the data were organised with a pseudo-name of the participant and the line in which the utterances were found (Maxwell 2013). It was from these the coded data underwent comparison, where the researcher compared the manner of articulation with the initial, middle, and final sound of the utterance in the normal children sample. The manner of articulation chosen are plosive, fricative, affricate, nasal and approximant. Once the data was compared, the frequency of errors in the respective manner and position was recorded. For further analysis, the phonological processes such as "Substitution", "Fronting", "Deletion" and more will also be identified and analysed. These categories allowed the researcher to draft out the outline of the current research.

RESULTS

The phonological process that involves consonants will be presented based on the manner of articulation which is plosive, fricative, affricate, nasal and approximant. The consonants have also been analysed based on the sound positions such as initial, medial, and final. Furthermore, the data was also analysed in comparison to the normal children sample collected.

CONSONANT ANALYSIS

PLOSIVE

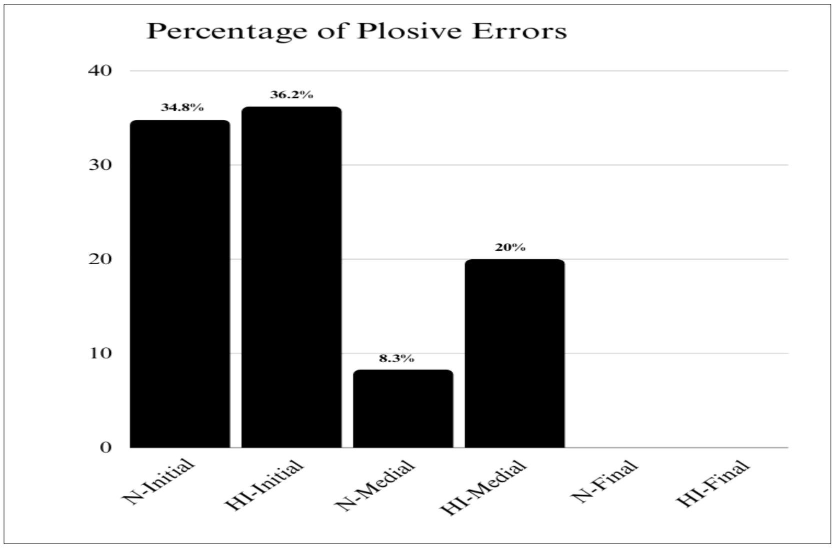

FIGURE 2. Plosive Errors

Plosive is a consonant sound which is produced by hindering air flowing out of the mouth and then releasing it in a sudden manner (Cambridge Dictionary 2024). Examples of plosive sounds are /p/, /b/, /t/, /d/, /g/ and /k/. From the above graph, 34.8% of normal-hearing children had errors with plosive consonant sounds in the initial position. The common error that was made was where the plosive sound in the initial position was deleted. This process is known as initial consonant deletion. For instance, the word [tisu] is pronounced as [isu]. This is like the hearing-impaired children, whereby 36.2% of them had errors in their plosive sounds in the initial position. Nonetheless, most of the kids with hearing impairments went through a procedure called fronting, in which a sound made at the back of the mouth was replaced with a sound made at the front. The word [kaki] was formed as [taki] in the current study, with the initial /k/ sound fronted to a /t/. It can also be seen that 8.3% of the normal children and 20% of the hearing-impaired children had plosive errors in the medial position. The common phonological process for both the subjects that has led to this phenomenon is velar assimilation. Assimilation is a process where a sound turns into a similar sound to its neighbouring vowel or consonant (Martínez & Itza 2012). In this case, both normal and hearing-impaired children had subjects that pronounced [katil] as [kakil] where the middle consonant /t/ was substituted with a /k/ which is like the initial sound of the word. Lastly, it could be noted that none of the subjects experienced an error in the final positioned plosive sound. Overall, for the plosive sound, it can be concluded that both normal and hearing-impaired children had the majority of errors in the initial position of the plosive and none of them had any errors in the final position of the plosive sound. Lastly, assimilation and initial consonant deletion were the phonological processes that normal hearing children underwent, whereas fronting, assimilation and initial consonant deletion were some of the phonological processes that hearing-impaired children underwent.

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FRICATIVE

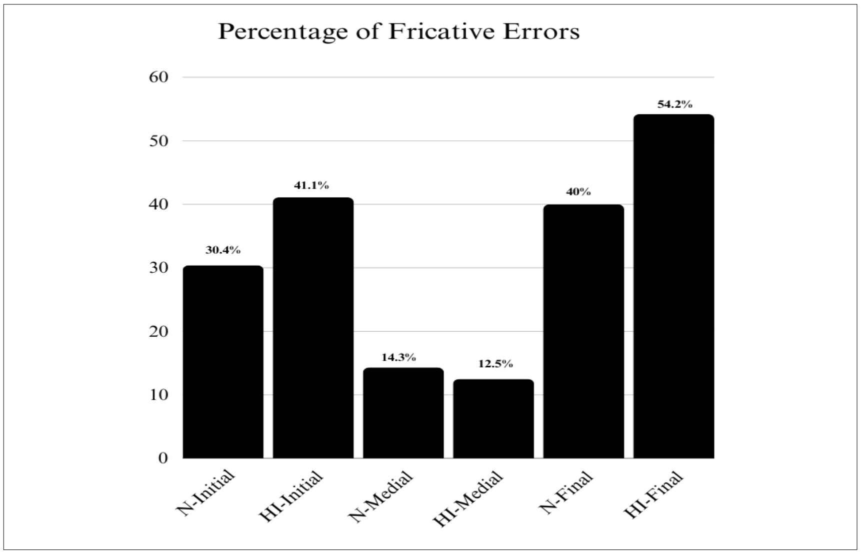

FIGURE 3. Fricative Errors

Fricative is a manner of articulation where the air passes through a constricted space that causes the air to flow turbulently and create a noisy sound (Tsao et al. 2006). Fricative sounds consist of /f/, /θ/, /s/, /ʃ/, /x/, /h/, /v/, /ð/ and /z/. Figure 4.2 depicts the percentage of subjects with fricative errors. From the above graph, 30.4% of the normal children had fricative errors in the initial position. The common phonological process that has led to this error is stopping. Stopping is a phonological process where the stop sound is substituted for a fricative or an affricate sound (Barlow & Gierut 1999). The children produced the word [fəri] as [pəri] where the /f/ sound is substituted with a /p/ sound. In terms of hearing-impaired children, 41.1% of the children had fricative errors in the initial position. Like normal children, hearing-impaired children also underwent the stopping phonological process. For instance, the word [zu] was produced as [ku] where the /z/ sound became the /k/ sound. Furthermore, most hearing-impaired children underwent the initial consonant deletion where the initial fricative sound is deleted; hence words such as /hidʒau/were pronounced as /idʒau/. For the medial fricative sound, 14.3% of the normal children had an error whereas only 12.5% of the hearing-impaired children had fricative medial errors. The common error that both subjects underwent is epenthesis where there is an insertion of the sound /r/ within the word /leher/. This has caused the word to be pronounced as /lerher/ which is incorrect. Moreover, 40% of the normal children and 52.4% of the hearing-impaired children also underwent the fricative error in the final position. For normal children, most children had an error with the word /zirafah/ where they produced it as /zirafa/. This process is called final consonant deletion. Similarly, for hearing-impaired children, the common phonological process that they underwent was devoicing, where their final voiceless fricative was replaced with a voiced consonant. For instance, the word /nənas/ was pronounced as /nənaz/. Lastly, some children also underwent the final consonant deletion process where the [bas] word is pronounced as [ba]. In conclusion, both subjects had errors at all three positions, however, both normal-hearing children and hearing-impaired children had the highest number of errors at the final position of fricative. Furthermore, hearing-impaired children had a higher number of errors in the initial and final position compared to normal-hearing children, but normal-hearing children had higher errors in the medial position in comparison to hearing-impaired children. The phonological processes that normal hearing

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children undergo are stopping and final consonant deletion. For hearing-impaired children, stopping, voicing, reduplication, final consonant deletion, initial consonant deletion, and epenthesis.

AFFRICATE

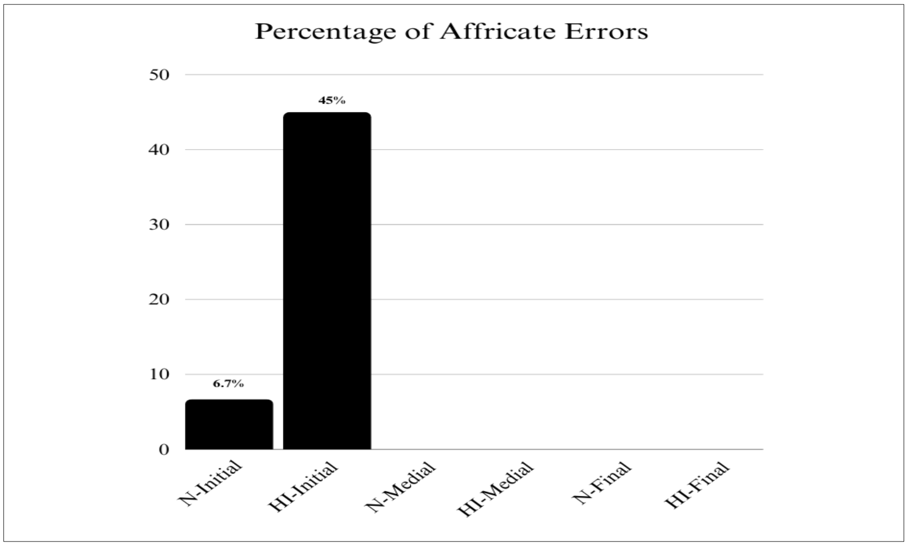

FIGURE 4. Affricate Errors

An affricate is a phoneme that blends a plosive with a subsequent fricative or spirant, both of which share the same place of articulation (Tsao et al. 2006). The consonants under this manner of articulation are /dʒ/ and /tʃ/. From the above graph, only 4.7% of the normal children which is the minority had affricate errors at the initial position where they underwent the stopping phonological process. Thus, targeted words such as [dʒam] became [dam] where the /dʒ/ sound was replaced with a /d/ sound. In contrast, most of the hearing-impaired individuals (45%) had errors at the initial affricate sounds. Unlike normal children, hearing-impaired individuals underwent several phonological processes. The prime phonological process was deaffrication, where the word [dʒari] was produced as [ʃari]. The /dʒ/ sound which is an affricate was replaced with the fricative sound /ʃ/. Furthermore, the hearing-impaired subjects also experienced depalatalisation with the word [tʃiʔgu]. The word that was commonly mispronounced as [tiʔgu] where the /tʃ/ palatal sound is replaced with an alveolar consonant /t/. Lastly, similar to normal children, several hearing-impaired individuals underwent the stopping process where words such as [dʒam] and [dʒari] were pronounced as [tam] and [dari]. From the graph, it could also be concluded that none of the participants had any affricate errors in both the medial and final positions. Nevertheless, hearing-impaired children had higher levels of affricate errors in the initial position with phonological processes such as deaffrication, depalatalisation and stopping. For normal-hearing children, the only phonological process that the children underwent was stopping.

NASAL

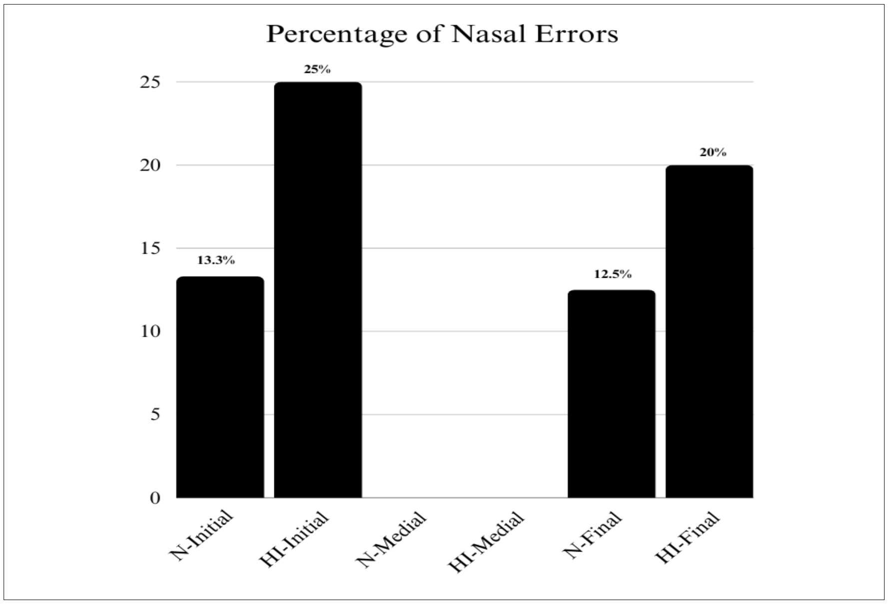

FIGURE 5. Nasal Errors

Nasal is a manner of articulation where speech sounds are produced through the air passage through the nasal cavity (Berent et al. 2009). Examples of sounds under nasal are /m/, /n/ and /ŋ/. From Figure 4.4, 13.3% of the normal-hearing children had nasal errors in the initial position. The common mispronunciations that could be seen are [botor] instead of [motor]. This phonological process is called denasalization where the nasal sound /m/ is replaced with a plosive sound /b/. In terms of hearing-impaired children, 25% of them had initial nasal errors. The common mispronunciations are like the normal children where the word [motor] was pronounced as [botor] or [dotor] which is also denasalized. Furthermore, prevocalic voicing could also be seen in hearing-impaired children where the word [pajuŋ] was pronounced as [bajuŋ]. The initial sound /p/ which is a voiceless sound was substituted with a /b/ which is a voiced consonant. Furthermore, 12.5% of the normal hearing children and 20% of hearing-impaired children had nasal errors in the final position. Both the subjects underwent the phonological process of final consonant deletion, where words such as [pajuŋ] were pronounced as [paju]. In addition to this, devoicing was also a phonological process mainly suffered by hearing-impaired children. The word [pajuŋ] was mispronounced as [pajuk], where the nasal-voiced/ŋ/ sound was replaced with /k/ which is a plosive voiceless sound. In conclusion, normal-hearing children underwent nasal errors under both initial and final positions, with phonological processes such as denasalization and final consonant deletion. In terms of hearing-impaired children, they had higher nasal errors in both the initial and final positions, with phonological processes such as denasalization, devoicing, prevocalic voicing, and final consonant deletion. It is also to be noted that none of the subjects had any errors in the medial position of the nasal sounds.

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APPROXIMANTS

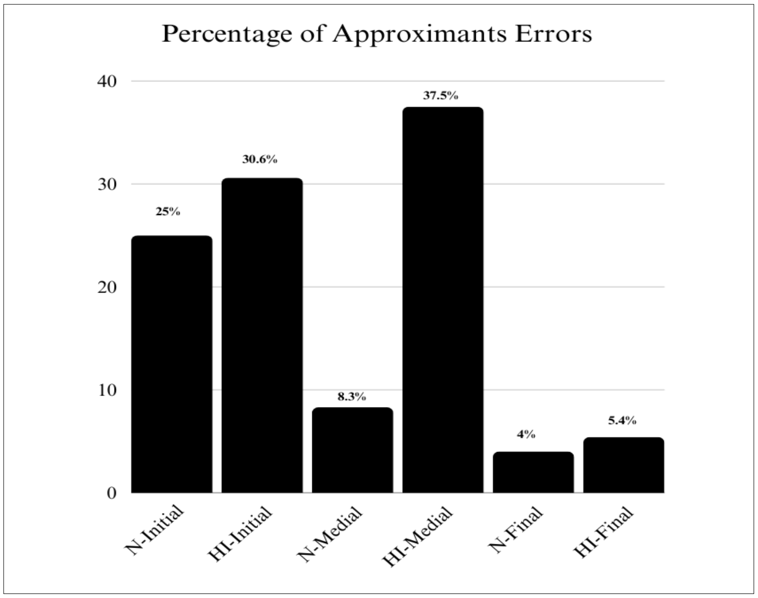

FIGURE 6. Approximants Error

Approximants are sounds that are generated by bringing one part of the vocal tract close to another, causing audible friction (Best & Strange 1992). The approximant sounds are /w/, /j/, /l/, and /r/. From Figure 4.5, 25% of normal-hearing children and 30.6% of hearing-impaired children had initial approximant errors. Most normal-hearing children had errors in the word [leher] where it was mispronounced as [reher]. This phonological process is called liquid assimilation where the /l/ sound is replaced with the liquid sound /r/. However, the majority of the hearing-impaired children underwent the gliding phonological process where the word [rumah] is pronounced as [wumah] and [lampu] as [yampu]. In terms of medial approximant error, normal hearing children had 8.3% whereas hearing-impaired children were 37.5%. A similar scenario happened for both normal and hearing-impaired children where they underwent the gliding process. The word [kərtas] was mispronounced as [kəwtas] and [dʒari] was produced as [dʒawi]. In both cases, the /r/ sound which is a liquid is replaced with the /w/ sound which is a glide. Lastly, 4% of normal-hearing children and 5.4% of hearing-impaired children had final approximant error. The only phonological process that both subjects underwent was final consonant deletion where words such as [katil] were pronounced as [kati]. In conclusion, normal-hearing children had approximant errors in all three positions through the phonological process such as liquid assimilation, gliding and final consonant deletion. Similarly, hearing-impaired children also had errors at all three positions with phonological processes such as gliding and final consonant deletion.

VOWEL ANALYSIS

The following analysis will be in relation to the vowel errors. It is to be noted that all the vowels are targeted through the picture-naming task. The data will also be analysed based on the tongue position and mouth shape.

TABLE 2. Percentage of vowel errors

Vowel	Errors in Normal Children (%)	Errors in Hearing-Impaired Children (%)
i	5 (kaki →kaka/ kaku)	12 (kaki → kaka/ kaku)
e	0	0
ə	0	0
a	0	4.2 (nenas → nenes)
u	1.3 (tisu → tis)	3.7 (rumah → ramah)
o	0	0
au	2 (pisau → pis)	5.3 (pisau → pis)

From the above table, most errors were made for the vowel /i/. It could be seen that 5% of normal children and 12% of hearing-impaired children underwent this error. For both subjects, the /i/ vowel which is a front close vowel was reduced to /a/ sound which is a central, open vowel or a /u/ which is a closed back rounded (Munson & Solomon 2004). For instance, words such as [kaki] was mispronounce as [kaka] or [kaku]. This phonological process is known as vowel reduction. Furthermore, 1.3% of normal children had errors in the /u/ sound where the /u/ sound was eliminated. For example, the word [tisu] was pronounced as [tis]. Similarly, for hearing-impaired children, it was found that 3.7% of them had errors with the vowel. The errors were also like the normal hearing children where the [sudu] was pronounced as [sud]; hence the phonological process here is called final vowel deletion (Threatte 1980). Other than that, the hearing-impaired children had errors with the word [rumah] where it was mispronounced as [ramah], the /u/ sound was substituted for /a/. Moreover, 4.2% of hearing-impaired children had errors with the vowel /a/. Words such as [nenas] and [kaki] were mispronounced as [nenes] and [kiki], where the /a/ was replaced with a /e/ in [lampu] and /a/ with /i/ for [kaki]. This process is called assimilation, where the /a/ sounds are assimilated to similar sounds that exist in the words. In the current study, one of the words had the diphthong vowel /au/. A diphthong is a complex vowel sound that begins with one vowel sound and glides into another within the same syllable (Steinlen 2005). In other words, it's a combination of two vowel sounds pronounced in one syllable. In the current study, 2% of normal-hearing children and 5.3% of hearing-impaired children had errors with the diphthong /au/ in the word [pisau]. Both subjects eliminated the vowel from the word pronouncing it as [pis]. This process is called final vowel deletion, where the vowel in the final position is deleted. In conclusion, both subjects had errors for the vowel /i/ and /u/, whereas only the hearing-impaired children had errors in vowel /a/. It could also be seen that none of the participants had any errors with the vowels /e/, /o/ and /ə/.

REGRESSION MODEL

TABLE 3. Regression model

	Model	F	Sig
1	Regression	6.148	0.001

Multiple linear regression was used to determine how sociodemographic factors could affect the phonological process of hearing-impaired children. Based on Table 4.4, it can be seen that the p-value of 0.0001 is less than 0.05; $F (8, 31) = 6.148$, $p < 0.05$ $R^2 = 0.613$. Therefore, the regression model is significant in showing a relationship between the sociodemographic factors and the phonological process in hearing-impaired children. Therefore, the null hypothesis is rejected, and it could be concluded that there is a relationship between sociodemographic factors and the phonological process in hearing-impaired Malay-speaking children. Furthermore, F= 6.148 is more than 1 which indicates that the model is efficient.

COEFFICIENT TABLE

TABLE 4. Regression coefficient

Model	Unstandardized		Std. Coefficients	t	Sig	95.0% Confidence	
	B	Std Error				Lower	Upper
Constant	8.131	3.331		2.441	.021	1.337	14.925
Gender	-1.257	.720	-.221	-1.745	.091	-2.727	.212
Ethnic	-.228	.401	-.086	-.570	.573	-1.046	.589
Hearing Age	-1.113	.197	-.699	-5.645	<.001	-1.516	-.711
Living Area	2.179	1.683	.167	1.295	.205	-1.253	5.611
Income	-.0303	.439	-.106	-.690	.495	-1.198	.592
Parent education	.579	.572	.167	1.012	.319	-.588	1.746
Screen time	-.250	.546	-.054	-.459	.650	-1.364	.863
Other language	.090	.373	.036	.241	.811	-.671	.850

From the above table, only hearing age is statistically significant where the P-value of 0.001 is less than 0.05 (P-value> 0.05). Thus, it could be concluded that hearing age has uniquely explained its significant amount of variance in phonological processes. Furthermore, it could be seen that the unstandardised coefficient, B for hearing age is equal to -1.113. This means that for each one-year increase in hearing age, there is a decrease in the phonological process of 1.113.

DISCUSSION

Based on the findings explained above, most of the hearing-impaired subjects had the highest errors with the fricative and affricate consonants with phonological processes such as stopping, voicing, initial consonant deletion, epenthesis, depalatalization and more. This agrees with a study by Moeller et al. (2007) that stated that children with hearing impairment had difficulties in fricative sound development. This also aligns with research done by Wiggin et al. (2013) whereby it was found that affricates were found to be the toughest sounds to be produced by hearing-impaired children. It was suggested that this phenomenon might be connected to how sensorineural hearing loss affects high-frequency information, how amplification restricts bandwidth, and how audibility is affected in noisy and reverberant environments. Moreover, it could also be noticed that most of the fricative errors were in the final position. Sounds such as /h/ and /s/ were either deleted or substituted with other sounds.

This could be since these sounds are voiceless consonants with high frequency which may make it difficult for hearing-impaired children to hear and process these sounds (Phatak et al. 2009). Furthermore, all the hearing-impaired subjects in the current study are hearing aid users which may be the reason why they were not able to process the high-frequency sounds. This is because hearing aids are not suitable for processing high-frequency sounds unlike cochlear implants (Cox et al. 2016). Therefore, this could also be a factor that may have contributed to the high errors in the fricative and affricate sounds.

In relation to this, it could also be inferred that normal-hearing children had higher fricative errors in the medial position compared to hearing-impaired children. This could be related to speech therapy and intervention. Hearing-impaired children often receive early intervention services, including speech therapy, which focuses on improving their speech production abilities. Through targeted interventions, these children may have received explicit instruction and practice in producing fricative sounds correctly, including in medial positions (Nicholas & Geers 2006). As a result, hearing-impaired children may have demonstrated lower error rates for fricative sounds compared to normal-hearing children. A study by Yang and Xu (2023), revealed that children with hearing impairments had fewer errors in fricative and affricate positions compared to normal-hearing children. It was asserted that compared to normal hearing children, hearing-impaired children showcased a normal hearing-like pattern. Moreover, it could also be seen that most of the errors that were made by the normal-hearing children were aged 2 to 3 years old, which is a common age for children to undergo these errors and develop their phonological skills (Nicholson et al. 2015).

Furthermore, hearing-impaired individuals made the least number of errors for nasal consonants whereby only 25% and 20% of the hearing-impaired individuals had errors in the initial and final position respectively. This is like a study by Colton & Cooker (1968) that asserted that hearing-impaired speakers naturally speak in a nasalised manner in comparison to normal hearing speakers. This phenomenon could be attributed to nasal resonance where the sound waves created by the vocal cord are resonated within the nasal cavity (Liapi et al. 2015). A study by Sebastian et al. (2015) also revealed that hearing aid users had a higher percentage of nasalance in their speech production compared to cochlear implant users. This may explain the reason why most hearing-impaired subjects in the current study did not have many nasal errors as they are hearing aid users. To further support this claim, it was also found that a high number of hearing aid users substituted plosives and fricatives with nasal (Han et al. 2017).

In addition to this, the final consonant deletion process was found to be faced by most of the hearing loss children, especially with the hearing age of 2 and 3 years with approximants, fricative and nasal consonants at the final positions. It is a common fact that in 1- and 2-year-old children, a final consonant deletion is expected, and it happens due to them being the age at which a child is developing its speech system (James et al. 2008). This shows that the hearing-impaired children in the current study were in the early stages of hearing and developing stage of their speech system. Contrarily, none of the hearing-impaired children or normal children underwent the coalescence phonological process, which may be since coalescence is a less frequent process seen in most languages (Gnanadesikan 2004). Thus, maybe the low variation of words tested in the current study could have contributed to this result.

Moreover, it could be noticed from the findings that a high number of both normal hearing and hearing-impaired children underwent the stopping phonological process. Flipsen and Colvard (2006) asserted that stopping is a common phonological process that can be seen in all children, and it will disappear at the age of 3 to 4 years old. Since the current study selected subjects from 2 to 6 years old for normal children, and 2 to 7 years of hearing age in hearing-impaired children, it could be vividly seen that the stopping phonological process was undergone by normal children within the age of 2 to 3 years old and for hearing-impaired children, 2 to 4 years old.

In terms of vowel errors, both normal-hearing children and hearing-impaired children did not have many errors. The highest error that hearing-impaired children had was in the vowel /i/. It was observed that most of the /i/ sound was substituted with the /u/ sound. Such an issue could be attributed to the second formant frequency F2 of the vowels. The higher frequency for a front vowel such as /i/ could be the reason why it was substituted with a lower frequency for a back vowel such as /u/ (Fowler et al. 2015). However, in relation to the majority of the results, it can be seen that all the subjects had low errors in the vowel category. For normal-hearing children, it could be because they can effectively distinguish between various vowel sounds due to their clear auditory perception. Their auditory system possesses the capability to detect even the subtlest disparities in sound frequency, duration, and intensity, enabling them to recognise and differentiate the unique features of each vowel sound (Roepke & Lapré 2021). For hearing-impaired children, the low number of errors in the vowel category could be due to the lip-reading interventions that the hearing-impaired children undergo during their speech therapy sessions. According to Puviarasan and Palanivel (2011) lip reading intervention can be useful for understanding vowels, as the movements of the lips, jaw, and tongue play a significant role in the production of vowel sounds.

For the second research question, it is evident hearing age is statistically significant with the phonological process, where the P-value of 0.001 is less than 0.05. The hearing age of the hearing-impaired children in the current study is from 2 to 7 years old, whereby they are at the age of developing their phonological skills (Gilliver et al. 2016). It was found that the higher the hearing age of the subjects, the lower the number of phonological processes (Figure 4.6). This result is consistent with a study by Lee (2021) which found that children wearing cochlear implants and hearing aids have phonological processing skills significantly predicted by their hearing age. Dodd et al. (2003) found that older children produced speech with more accuracy and fewer error patterns, which lends further credence to this. Thus, it is possible to draw the conclusion that hearing age has a major impact on how hearing-impaired children acquire phonological skills.

Regarding the correlation between gender and the phonological process, it was discovered that no statistically significant association exists between these two variables. This finding is similar to a study by Dodd et al. (2003) that asserted that there is no gender difference in the production of phonology in hearing-impaired children especially in the younger age group. However, Auerbach and Delport (2018) did reveal that there is a relationship between gender and phonology whereby females develop cognitive-linguistic skills faster compared to males. Mingming (2020) also stated that there is a gender difference in the association between hearing impairment and cognitive function. Therefore, the difference in findings in the current study and past study could be due to sample size as low sample size could affect the coefficient p-value in a regression analysis (Morrissey & Ruxton 2018).

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Moreover, the current study revealed that there was no statistically significant difference between parental education level, living area and household income with the phonological process. This result is inconsistent with Lee and Al Otaiba (2015) who reported that there is a relationship between the result of the phonological evaluation and parental education. Campanholo et al. (2017) also asserted that education, income, and occupation were positively associated ($p<0.001$) with phonological development. In terms of living area, Wieling et al. (2011) revealed that geographical areas do play an essential role in linguistic development, especially in children. The contradictions in findings could be due to the fact that most of the subjects from the current study are from an urban living area; hence the low variation in data could be the reason why there is no clear difference between these two variables.

Since Malaysia is a multicultural country and most of the citizens are multilingual, the current study also decided to look into multilingualism and its effect on the phonological process. From the findings, it was found that bilingualism or multilingualism does not affect the phonological process of hearing-impaired children. This finding is similar to research by Deda (2020) that revealed that there is no distinctive difference in the phonological sensitivity in both monolingual and multilingual children. However, a study by Neumann et al. (2008) suggested that bilingualism is one of the factors that may influence the speech-sound development of an individual. Since the current study investigated the Malay language speakers where their dominant language is Malay; hence it could be believed that the secondary languages used at home did not primarily influence the language skills in those children.

In the technologically advanced world, screen time has also been an important factor in influencing speech production. Muppalla et al. (2023) asserted that there is a positive correlation between an infant's screen time and phonological abilities. In the current study, it was found that most of the subjects had a screen time of 2 hours per day; however, it was revealed that screen time is not statistically associated with the phonological process that the subjects produced. Silverman and Keane (2021) asserted that children may only be able to acquire language skills through viewing shows that have high language usage. Therefore, maybe it could be related to the type of content that is viewed by the subjects whereby it could be non-academic or not language-related content which may not have affected the subject's phonological skills in a positive nor a negative way.

CONCLUSION

The two specific objectives of the study have been achieved through the data collected from the picture naming task and the utilisation of multiple linear regression. Thus, it can be concluded that this research shows some indication that the phonological processes in hearing-impaired Malay-speaking children are fronting, assimilation, stopping, voicing, initial consonant deletion, epenthesis, deaffrication, depalatalization, denasalization, devoicing, prevocalic voicing, final consonant deletion, reduplication, and gliding. Moreover, from the above results, it could be concluded that hearing-aids may hinder the phonological acquisition of hearing-impaired Malay-speaking children. Lastly, there is a relationship between socio-demographic factors and the phonological process in hearing-impaired Malay-speaking children and hearing age is a statistically significant variable in the phonological process. The practical implication of this study is that speech pathologists would also be aware of the phonological errors made by hearing-impaired children and this early identification can help them provide appropriate intervention to tackle these issues. Furthermore, it could serve as a basis for many teachers who are interested in

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understanding the phonological process in hearing-impaired children, especially Malay speakers. Educators will be able to understand the common phonological errors and the factors that could contribute to them. With this knowledge, proper educational strategies can be implemented by educators to enhance the phonological skills of hearing-impaired children. Moreover, this study could provide the society with the information of socio-demographic factors that could influence the phonological processes in children, especially in hearing-impaired children. Lastly, many researchers often presume that both typically developing and hearing-impaired children undergo similar phonological processes. Through this, researchers will be able further explore the distinctness between typically developing children and hearing-impaired children's phonological process.

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