

Awareness and Knowledge of Congenital Cytomegalovirus (cCMV) Among Audiologists and Speech-Language Pathologists in Saudi Arabia: A Cross Sectional Survey

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Abstract: Congenital cytomegalovirus (cCMV) is the most prevalent congenital infection in the world. It can result in various neurodevelopmental disorders, one of which is environmental hearing loss among children. This study aimed to assess the awareness and knowledge of cCMV among audiologists and speech-language pathologists (SLPs) in Saudi Arabia and to seek their perception of it. An online survey was conducted from May to June 2023, targeting participants through social media, and a descriptive and inferential analysis was performed. A total of 107 participants (31 audiologists and 76 SLPs) were enrolled in this study. Awareness about cCMV was significantly higher among audiologists (84%) compared to SLPs (49%) (p -value < 0.001). However, both groups exhibited poor cCMV knowledge, which was revealed by their low mean knowledge scores (6.8/14 for audiologists and 5.7/14 for SLPs). The difference between their mean scores was non-significant (p -value > 0.05). The majority of SLPs and audiologists agreed that it is crucial for them to learn more about cCMV to enrich their professional backgrounds. This study emphasized the necessity for cCMV education for audiologists and SLPs. Increased awareness and knowledge may allow them to be more mindful of cCMV symptoms and therefore provide enhanced service to their pediatric patients.

Keywords: congenital cytomegalovirus, audiologist, speech-language pathologist, hearing loss, neurodevelopmental disorder

Introduction

Congenital cytomegalovirus (cCMV) is the most common congenital infection worldwide and a major cause of neurodevelopmental impairment in children.^{1,2} CMV, a member of the human herpes virus family, is typically asymptomatic in immunocompetent individuals. However, nearly 10% of primary infections result in mononucleosis- symptoms such as malaise, persistent fever, myalgia and cervical lymphadenopathy with less common symptoms such as pneumonia and hepatitis.^{3,4} It is crucial to note that the vast majority of CMV infections in pregnant women are asymptomatic.⁵

Most cCMV cases present no signs or symptoms at birth. However, asymptomatic infants may develop neurodevelopmental impairments later in life. Research indicates that up to 13.5% of asymptomatic infants may experience late-onset neurodevelopmental impairments or sensorineural hearing loss (SNHL).^{6,7} In contrast, symptomatic cCMV infections at birth are associated with a higher risk of severe neurodevelopmental sequelae, including intellectual disability, cerebral palsy, and profound SNHL.^{8,9} Studies suggest that approximately 15%–35% of infants develop SNHL due to cCMV,¹⁰ with bilateral hearing loss more common in symptomatic cases and unilateral hearing loss more frequently observed in asymptomatic cases.^{11–13}

Globally, it is estimated that cCMV affects 0.5% to 2% of newborns annually. However, the exact prevalence of cCMV in Saudi Arabia is not publicly documented. Seroprevalence studies indicate CMV seropositivity ranging from 91.2%–100% across all age groups of females tested.^{14–16} cCMV infection happen due to reactivation or reinfections during pregnancy. With approximately 500,000 births annually in Saudi Arabia,¹⁷ assuming a 1% congenital infection

rate, an estimated 5,000 infants could be born with cCMV each year. This prevalence suggests a significant public health impact, potentially leading to up to 1750 cases of hearing loss annually attributable to cCMV.

The importance of CMV screening for all newborns, particularly asymptomatic infants, has been underscored in research and clinical practice guidelines.^{18,19} Screening facilitates early identification of infants at risk for hearing loss and other sequelae, allowing for timely intervention and management. While antiviral therapies such as ganciclovir and valganciclovir may mitigate symptoms and potentially improve outcomes in symptomatic cases, their impact remains under investigation.²⁰

Audiologists and speech-language pathologists (SLPs) play integral roles in multidisciplinary teams caring for children with cCMV.^{21,22} Audiologists specialize in evaluating and treating individuals with hearing and balance disorders, while SLPs focus on assessment and treatment of speech, language, communication, swallowing, and voice disorders.²³ This multidisciplinary approach is crucial given the wide-ranging impact of cCMV on developmental outcomes.^{21,22}

Insufficient awareness and knowledge of cCMV among healthcare professionals, including audiologists and SLPs, can significantly impact patient care quality. Missed diagnoses or delays in intervention for hearing and speech impairments may occur due to an inadequate understanding of cCMV.²⁴ This issue is compounded by variations in educational preparation and clinical training across countries, including in Saudi Arabia, where audiologists and SLPs typically require a bachelor's degree, emphasizing university-level education.^{25,26}

In Saudi Arabia, audiology and speech-language pathology are relatively new professions, with the first university program launched in 1985. Currently, there are 879 certified SLPs and 252 audiologists.²⁷ Due to the early development of the field and a shortage of professionals, it is expected that knowledge of cCMV may be lacking. This study aims to assess the awareness and knowledge of cCMV among licensed audiologists and SLPs in Saudi Arabia. Identifying their knowledge gaps and perceptions can help improve care strategies and educational initiatives for children affected by cCMV.

Material and Methods

Study Design and Setting

We conducted a cross-sectional survey-based study. Audiologists and SLPs who work in Saudi Arabia were invited to participate in an online survey. The survey link, created using Google Forms, was distributed through social media and snowball sampling among SLP and audiologists in Saudi Arabia. Potential participants received invitations to participate in the survey from a friend or encountered it through social media platforms, mainly LinkedIn, Twitter, and WhatsApp. The inclusion criteria were as follows: (1) both SLPs and audiologists needed to be licensed by SCFHS, and (2) their workplace must be located in Saudi Arabia. Those who were not licensed by SCFHS or not working in Saudi Arabia were excluded. The sample size for this study was calculated using Raosoft, Inc. (Seattle, WA, USA) (<http://www.raosoft.com/samplesize.html>) (accessed on 21 May 2022), with 90% confidence and an error rate of 10%. The suggested minimum recommended size of the survey was 89; however, we included more responses until we reached 107 participants.

Data Collection

The data were collected from May to June, 2023, using a self-administered 26-item questionnaire. The questionnaire was developed based on previous work examining healthcare professionals' awareness and knowledge about cCMV.^{28,29}

The questionnaire was divided into seven sections; section one was the participants' information sheet, and section two was the participant consent. In section three, the following demographic information was addressed; Saudi Commission for Health Specialties (SCFHS) registration and rank, highest degree, job, years of experience, working with children, workplace, frequency of working with patients with HL, hearing screening in the institution they work in, and whether or not they had children. In section four, participants were asked about their familiarity with various pediatric health conditions, and whether or not they had heard of CMV. If their answer was yes, they were transferred to the next section. Section five included six items that measure their knowledge about cCMV. The first item contains check boxes to assess the long-term sequelae of cCMV, followed by two-point Likert scale questions and three multiple choice questions that assess their general knowledge about cCMV, presentation of HL, and audiological management. In section six, participants were asked about their sources of cCMV information. In the last section, participants were asked about

their perspectives on how to raise cCMV awareness. A pilot study with five participants was conducted to test the questions' clarity and the time needed to answer them. However, based on their feedback, no modifications were needed.

Ethical Consideration

Participants were aware of the study's purpose and were asked voluntarily to fill out the survey after informed consent. Responses were completely anonymous and confidential. The study was ethically approved by the Institutional Review Board, KSU (Ref. No. 23/0344/IRB). All data were kept confidential and were available only to the research team.

Statistical Analysis

Based on the Central Limit Theorem, the sample size of 1007 participants is sufficiently large to assume normality of the sampling distribution. However, to rigorously confirm the normality of our data, we performed several normality tests including the Anderson-Darling test, D'Agostino & Pearson test, Shapiro-Wilk test, and Kolmogorov-Smirnov test. These tests were conducted to validate our assumption of normality for the continuous variables (knowledge scores).

For categorical variables, frequencies and percentages were calculated, and the Chi-square test was used to compare familiarity with pediatric health conditions and cCMV awareness between audiologists and SLPs. Means and standard deviations were computed for continuous variables.

The knowledge score for each participant was calculated by assigning a score of 1 for every correct answer and a score of 0 for every incorrect or "I don't know" response, with a total possible score of 14. We compared the knowledge scores of audiologists and SLPs using the Student's *t*-test, given the confirmation of normality. All data analyses were conducted using GraphPad Prism 9.

Results

Demographics and Work Experience of the Respondents

The survey was distributed through social media platforms, and 107 responded with a completion rate of 100%, of whom 29% were audiologists and 71% were SLPs. As shown in Table 1, the SLPs had slightly more years of experience than the audiologists (p -value= 0.35). Most of the respondents, in both groups, were ranked as specialists holding a bachelor's degree. More than half of the audiologists (58%) and 34% of SLPs work in hospitals. The most common workplace for the SLPs in this study was centers/clinics (49%). Regarding hearing screenings, 68% of the audiologists responded that their institutions offer hearing screening while 50% of the SLPs responded that their institution does not offer it. When participants were asked about the frequency they see patients with HL, the highest proportion of audiologists (65%) responded that they "always" see patients with HL. However, the highest proportion of SLPs (43%) responded that they "sometimes" see patients with HL. The majority of the respondents, from both groups, stated that they always work with children but most of them do not have children of their own.

Familiarity of cCMV Compared to Other Conditions

Participants were asked to rate their familiarity with several pediatric conditions. When asked about their familiarity with cCMV, 39% of audiologists reported that they are "very familiar" with cCMV. In contrast, 1% of SLPs reported that they are "very familiar" with cCMV (p -value 0.0001). Most of the SLPs in this study were not familiar with most pediatric disorders, except for fetal alcohol syndrome, with which 37% of them were somewhat familiar, greater than the audiologists (p -value 0.437) (Table 2). On the other hand, audiologists were at least "slightly familiar" with all the listed pediatric disorders except for connexin 26 mutation, fetal alcohol syndrome, and toxoplasmosis.

Awareness and Knowledge of cCMV

Awareness about cCMV was significantly lower among SLPs compared to the audiologists (Figure 1). Only 5 of the 31 audiologists (16%) said they had never heard of cCMV, which was significantly lower compared to 39 out of 76 (51%) SLPs ($X^2=17.57$; $df=2$; p -value 0.0002).

Table 1 Descriptive Characteristics of Participants in the Survey (N=107)

Characteristic	Audiologists (N = 31)		Speech pathologists (N = 76)	
	Mean	5.3	Mean	6.3
	SD	4.0	SD	5.6
Years in Practice	Respondents (N)	%	Respondents (N)	%
Rank in SCHS				
Specialist	25	81	58	76
Senior Specialist	5	16	16	21
Consultant	1	3	2	3
Degree				
Bachelor	21	68	46	61
Master	8	26	26	34
AuD	2	7	0	0.0
PhD	0	0.0	4	5
Place of work				
Hospital	18	58	26	34
College/University	2	7	6	8
Center/ Clinic	1	3	37	49
School	0	0.0	4	5
Hearing aid company	8	26	0	0.0
Private practice	0	0.0	1	1
Other	2	7	2	3
Does your institution offer hearing screening?				
Yes	21	68	36	47
No	7	23	38	50.0
I do not know	3	10	2	3
How often do you see patients/clients with hearing loss?				
Never	0	0.0	6	8
Rarely	2	7	25	33
Sometimes	3	10	33	43
Often	6	19	10	13
Always	20	65	2	3
How often do you work with children?				
Never	1	3	2	3
Rarely	4	13	5	7
Sometimes	6	19	7	9
Often	5	16	4	5
Always	15	48	58	76
Parent				
Yes	7	23	33	43
No	24	77	43	57

To measure their knowledge, participants whose answer was a yes or maybe to the question regarding hearing about cCMV were asked a series of factual questions on cCMV infection to evaluate the level of their knowledge about it. Detailed responses are presented in [Supplementary Tables S1](#) and [S2](#). The first question was about the sequelae of cCMV infection. All of the audiologists (100%) and 86% of the SLPs correctly chose HL as one of the sequelae of cCMV infection while 12% of audiologists and 8% of the SLPs incorrectly chose Asthma. Only 12% of audiologists and 14% of SLPs correctly knew that cCMV can lead to vocal cord paralysis. Most audiologist and SLPs agreed that cCMV is a significant contributor to neurodevelopmental delay and childhood hearing loss. When asked about the frequency of hearing evaluation, almost half (49%) of SLPs indicated that they do not know and audiologists gave inconsistent answers. However, more than half of the audiologists (58%) correctly replied that the follow up required for children

Table 2 Self-Reported Familiarity with Pediatric Health Conditions

Disease	Audiologists								Speech pathologists								P value
	Not Familiar		Slightly Familiar		Somewhat Familiar		Very Familiar		Not Familiar		Slightly Familiar		Somewhat Familiar		Very Familiar		
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	
Connexin 26 mutation	19	61	3	10	5	16	4	13	65	86	6	8	5	7	0	0	0.003
Fetal alcohol syndrome	10	32	8	26	8	26	5	16	14	18	21	28	28	37	13	17	0.437
Kernicterus Usher syndrome	5	16	4	13	12	39	10	32	42	55	17	22	11	14	6	8	<0.0001
Congenital Cytomegalovirus	5	16	8	26	6	19	12	39	44	58	18	24	13	17	1	1	<0.0001
Congenital rubella	5	16	8	26	6	19	12	39	44	58	18	24	12	16	2	3	<0.0001
Toxoplasmosis	12	39	10	32	4	13	5	16	49	64	22	29	4	5	1	1	0.004
Pneumococcal meningitis	7	23	7	23	8	26	9	29	30	39	26	34	13	17	7	9	0.024
Syphilis	4	13	11	35	9	29	7	23	25	33	24	32	19	25	8	1	0.123

born with cCMV is a serial audiological evaluation through the early school years and beyond as needed, while only 27% SLPs answered it correctly. Half of the audiologist and 35% of SLPs believed that infants born with asymptomatic congenital cytomegalovirus are at increased risk of HL at birth.

The knowledge score for each item was calculated and audiologists were compared to the SLPs (Table 3). The scores of the knowledge items between audiologists and SLPs were insignificant except for the question “cCMV is a significant contributor to childhood hearing loss”, in which audiologists scored significantly greater than SLPs (p -value=0.033) and the question “What follow-up is required for all children born with congenital cytomegalovirus?”, in which also the audiologists scored significantly greater than SLPs (p -value=0.0138). There was no significant difference between the mean knowledge scores for audiologists (6.8 out of 14, SD=2) and SLPs (5.7 out of 14, SD=2.5) (p -value=0.069).

Source of the Information

When the participants were asked where they received their education regarding cCMV, 53% of the audiologists and 45% of SLPs answered during their undergraduate study (Supplementary, Figure S1). Additionally, the majority of audiologists and SLPs stated that their institutions offer neither hearing tests that target early cCMV screening nor universal cCMV screening, or that they were unaware of their availability. There was no significant difference between the responses of the audiologists and SLPs (p -value >0.05) (Figure 2A and B).

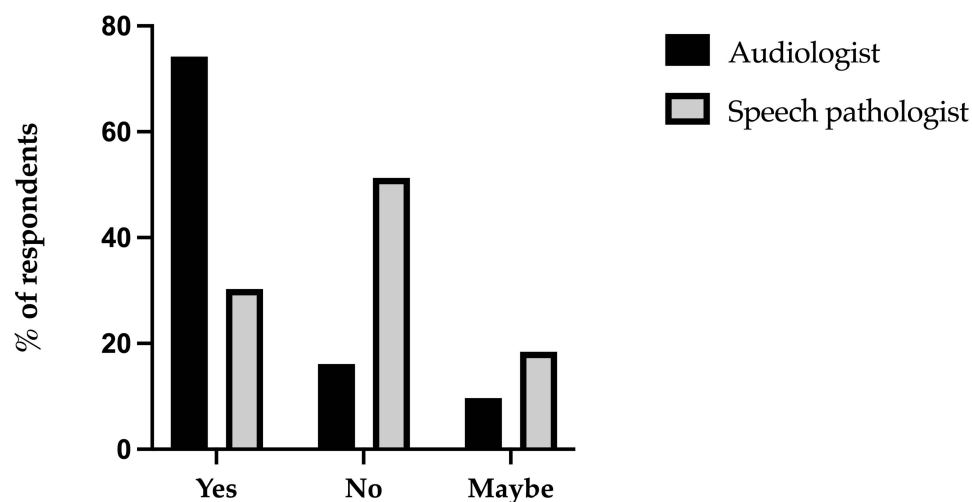


Figure 1 Awareness of cCMV among audiologists and speech pathologists. Chi-square descriptive comparative test was used. Participants were asked whether they had previously heard of cCMV. Percentages (%) are used to show how many respondents chose “Yes” or “No” or “Maybe” as their answer.

Table 3 Assessment Scores of cCMV Knowledge Among Audiologists and Speech Pathologists Who Have Heard of cCMV

Knowledge item	Mean score of Audiologist (N=26)	Mean score of Speech pathologist (N=37)	Difference	SE of difference	t ratio	df	P value
What are the possible long-term sequelae of congenital CMV infection (cCMV)?	3.769	3.459	0.310	0.488	0.635	61	0.528
cCMV is a significant contributor to neurodevelopmental delays?	0.731	0.730	0.001	0.115	0.009	61	0.993
cCMV is a significant contributor to childhood hearing loss?	0.923	0.703	0.220	0.101	2.173	61	0.033
How often should children with cCMV have hearing evaluation?	0.269	0.189	0.080	0.108	0.744	61	0.460
What follow up is required for all children born with congenital cytomegalovirus?	0.577	0.270	0.307	0.121	2.534	61	0.0138
Which is true of infants born with asymptomatic congenital cytomegalovirus?	0.539	0.351	0.187	0.127	1.480	61	0.144

Their Opinion and Perspective

Participants were asked about their opinions and perspectives regarding the importance of cCMV knowledge. The majority of both the audiologists (85%) and SLPs (84%) thought it was important for them to know more about cCMV, mainly because this knowledge is essential to their professional background. Additionally, they thought that cCMV knowledge should be part of their undergraduate studies.

Discussion

Raising awareness levels and knowledge of cCMV among SLPs and audiologists in Saudi Arabia has the potential to improve the care plans and the service quality for their patients. This study represents the first step toward this goal by assessing the awareness, knowledge, and attitude of these professionals towards cCMV. A total of 107 participants (31 audiologists and 76 SLPs) participated in an online survey. The findings highlight that there is a lack of adequate cCMV knowledge among both groups. While audiologists reported a high level of awareness of CMV, 51% of SLPs were not aware of the condition. However, many expressed a willingness to learn more.

In this study, 84% of audiologists and 49% of SLPs reported awareness of cCMV. It is expected that audiologists would have a higher awareness of cCMV compared to SLPs. This aligns with a previous study in the US, where 86% of audiologists were aware of cCMV compared to only 26% of SLPs.²⁹ The gap between audiologists and SLPs in the US study is greater than the current study. One possible reason for this difference could be the variations in qualifications and certifications between Saudi Arabia and the US. In this study, nearly half of the participants reported learning about cCMV during their undergraduate studies. In Saudi Arabia, two out of three academic programs follow the same

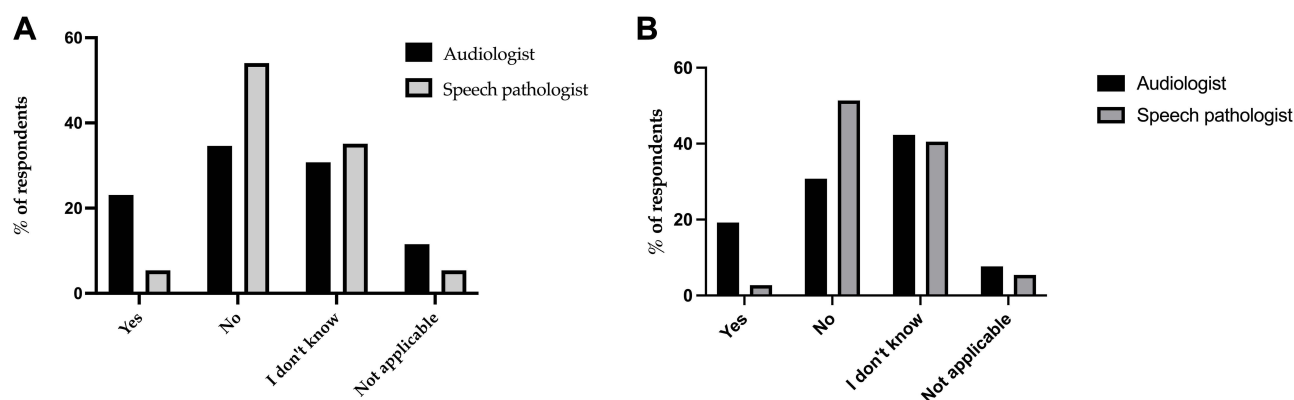


Figure 2 Congenital cytomegalovirus (cCMV) screening availability. Chi-square descriptive comparative test was used. (A) Does your institution or hospital offer hearing test targeting early cCMV screening? (B) Does your institution or hospital offer universal cCMV screening?.

curriculum to earn a bachelor's degree in speech and hearing science, followed by a one-year internship during which students choose to qualify as a SLP or an audiologist.²⁷ In contrast, students in the US qualify as audiologists or SLPs only after completing a graduate program.

This higher awareness among audiologists is also reflected in their greater familiarity with other pediatric health conditions than SLPs. The only exception, although non-significant, was fetal alcohol syndrome, where SLPs reported being "somewhat familiar", with their knowledge significantly greater than that of the audiologists. In this study, 58% of the audiologists work in hospital settings, compared to only 34% of SLPs, although it does not apply to fetal alcohol syndrome. This difference could be because fetal alcohol syndrome affects several functions within SLP's scope of practice, such as attention, memory and cognition.³⁰

Our study revealed that cCMV knowledge among both groups was limited, with scores of 6.8/14 for audiologists and 5.7/14 for SLPs. This finding aligns with previous research, which has also reported limited knowledge among health professionals across different countries.^{31–34} Some notable differences were observed in individual item scores between audiologists and SLPs. For instance, audiologists scored significantly greater than SLPs in identifying cCMV as "a significant contributor to childhood hearing loss" and in recognizing that "serial audiological evaluation" is required for children born with cCMV. However, the results also highlight knowledge gaps among audiologists who participated in this study. Specifically, 19% of audiologists responded with "I don't know" regarding the frequency of hearing evaluation, and 42% failed to recognize that "serial audiological evaluation" is required for children born with cCMV, despite this being essential core knowledge for their practice when treating children infected with cCMV.

In Saudi Arabia, the universal newborn hearing screening (UNHS) program, mandated by the Ministry of Health (MOH) since 2016, involves trained nurses conducting hearing tests in all public hospitals. Newborns who fail the screening after three attempts are referred for a full audiological assessment.³⁵ The cost of screening is covered by the government, ensuring wide access. However, CMV testing is not routinely integrated into these hearing screenings, revealing a gap in linking CMV testing with UNHS.³⁶ Addressing this gap could improve audiologists' understanding of cCMV.

On the other hand, almost half of the SLPs indicated that they "don't know" the frequency of the hearing evaluations needed for children diagnosed with cCMV. This can be attributed to the fact that conducting hearing evaluations is not within the scope of practice for SLPs, whereas it is a primary role for audiologists.³⁷ However, this question also revealed inconsistent responses among audiologists in this study. Such inconsistencies have been reported in previous research, which has linked them to the lack of consensus in the literature about cCMV hearing evaluation follow-ups.²⁹ Nevertheless, given the relatively low mean knowledge score among audiologists, we cannot establish a strong association. One possible reason for audiologists' low scores is that the majority of participants hold only a bachelor's degree in audiology, which may not provide as deep or specialized knowledge as one might be expected from audiologists with postgraduate studies.

Despite these gaps, both audiologists and SLPs emphasized the importance of gaining more knowledge about cCMV. The majority justified this need for their professional background rather than their current caseload. Moreover, they indicated that educational resources and activities about cCMV should be integrated into undergraduate studies and in their workplaces. The findings of this study can help establish targeted educational programs and training workshops to enhance understanding of cCMV and its implications among audiologists and SLPs in Saudi Arabia. This may prompt healthcare policymakers to establish or revise guidelines for screening and managing cCMV, incorporating it into standard newborn hearing screening protocols. Additionally, the study findings could encourage interdisciplinary collaboration among healthcare professionals to improve the management of cCMV cases. Highlighting the knowledge gap could also drive improvements in screening practices, leading to better detection and management of cCMV-related hearing loss in children, ultimately advancing pediatric audiology and SLP practices in Saudi Arabia.

This study has some limitations. Firstly, it relies on self-selection and self-reporting of participants' familiarity with pediatric conditions, including cCMV. Secondly, the sample size, especially for the audiologists' group, was relatively low. Lastly, the study did not include gender or age in the data collection process and did not examine the association of sociodemographic characteristics with cCMV awareness and knowledge. A study among women in the general population in Saudi Arabia reported that general knowledge of cCMV was limited. However, working in the healthcare field and having higher education levels were significantly associated with better knowledge of CMV.³⁸ Therefore, to better understand the gap between the audiologists and the SLPs regarding cCMV awareness, future research with a larger

sample size that assesses the association of sociodemographic characteristics, particularly gender, with cCMV awareness using multivariable analysis is required. Despite these limitations, this study is the first in Saudi Arabia to highlight the need to increase awareness of cCMV among SLPs and audiologists. The clinical implications of these findings are significant. Enhancing awareness and knowledge of cCMV among SLPs and audiologists could lead to better-informed clinical practices, improved screening protocols, and more effective management of cCMV-related conditions. This could translate into earlier and more accurate diagnoses, tailored interventions, and better overall patient outcomes. Improved awareness among these professionals may also lead to more consistent and effective communication with families regarding the implications of cCMV, ultimately supporting better long-term outcomes for affected children. Our findings highlight the need for increased awareness not only about cCMV but also for broader medical education among audiologists and SLPs. While the study focused on cCMV, it indicates a general need for improved knowledge across various pediatric conditions. Enhancing education on a range of medical issues, with a focus on cCMV, can lead to better clinical practices and overall patient care. This broader approach will ensure that healthcare professionals are better prepared for diverse medical scenarios, ultimately improving patient outcomes.

Conclusion

In conclusion, cCMV-infected children are anticipated to be commonly encountered by audiologists and SLPs as cCMV is a primary environmental cause of pediatric hearing loss. Our study has demonstrated that audiologists and SLPs require further education about cCMV, which can be integrated into their ongoing continuing education programs. Additionally, we recommend that university programs incorporate more material about cCMV in their curricula, as it is crucial for future healthcare professionals who will work closely with children to be knowledgeable about cCMV. Understanding cCMV's impact on pediatric hearing loss is vital for early diagnosis and intervention. Proper education and awareness among audiologists and SLPs can lead to better management and support for affected children, ultimately improving their communication outcomes and quality of life.

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Disclosure

The authors report no conflicts of interest in this work.

References

1. Baer HR, McBride HE, Caviness AC, Demmler-Harrison GJ. Survey of congenital cytomegalovirus (cCMV) knowledge among medical students. *J Clin Virol*. 2014;60(3):222–242. doi:10.1016/J.JCV.2014.03.023
2. Foulon I, Naessens A, Faron G, Foulon W, Jansen AC, Gordts F. Hearing thresholds in children with a congenital CMV infection: a prospective study. *Int J Pediatr Otorhinolaryngol*. 2012;76(5):712–717. doi:10.1016/J.IJPORL.2012.02.026
3. Gaytant MA, Steegers EAP, Semmekrot BA, HMMW M, Galama JMD. Congenital cytomegalovirus infection. *J Infect Diseases*. 2020;221(4):S9–S14. doi:10.1093/infdis/jiz446
4. Cannon MJ, Schmid DS, Hyde TB. Review of cytomegalovirus seroprevalence and demographic characteristics associated with infection. *Rev Med Virol*. 2010;20(4):202–213. doi:10.1002/rmv.655
5. Manicklal S, Emery VC, Lazzarotto T, Boppana SB, Gupta RK. The “Silent” global burden of congenital cytomegalovirus. *Clin Microbiol Rev*. 2013;26(1):86–102. doi:10.1128/CMR.00062-12
6. Nicloux M, Peterman L, Parodi M, Magny JF. Outcome and management of newborns with congenital cytomegalovirus infection. *Archives de Pédiatrie*. 2020;27(3):160–165. doi:10.1016/J.ARCPED.2020.01.006
7. Lanzieri TM, Dollard SC, Bialek SR, Grosse SD. Systematic review of the birth prevalence of congenital cytomegalovirus infection in developing countries. *International Journal of Infectious Diseases*. 2014;22:44–48. doi:10.1016/j.ijid.2013.12.010
8. Luck SE, Wieringa JW, Blázquez-Gamero D, et al. Congenital cytomegalovirus a European expert consensus statement on diagnosis and management. *Pediatric Infectious Disease Journal*. 2017;36(12):1205–1213. doi:10.1097/INF.0000000000001763
9. Oliver SE, Cloud GA, Sánchez PJ, et al. Neurodevelopmental outcomes following ganciclovir therapy in symptomatic congenital cytomegalovirus infections involving the central nervous system. *Journal of Clinical Virology*. 2009;46(4):22–26. doi:10.1016/j.jcv.2009.08.012
10. Grosse SD, Ross DS, Dollard SC. Congenital cytomegalovirus (CMV) infection as a cause of permanent bilateral hearing loss: a quantitative assessment. *Journal of Clinical Virology*. 2008;41(2):57–62. doi:10.1016/J.JCV.2007.09.004

11. Aldè M, Binda S, Primache V, et al. Congenital Cytomegalovirus and Hearing Loss: the State of the Art. *J Clin Med*. 2023;12(13):4465. doi:10.3390/jcm12134465
12. Foulon I, Naessens A, Foulon W, GF CA, Gordts F. A 10-year prospective study of sensorineural hearing loss in children with congenital cytomegalovirus infection. *J Pediatr*. 2008;153(1):84–88. doi:10.1016/j.jpeds.2007.12.049
13. Fowler KB, Dable AJ, Boppana SB, Pass RF. Newborn hearing screening: will children with hearing loss caused by congenital cytomegalovirus infection be missed? *Journal of Pediatrics*. 1999;135(1):60–64. doi:10.1016/S0022-3476(99)70328-8
14. Ghazi HO, Telmesani AM, Mahomed MF. TORCH agents in pregnant Saudi women. *Med Princ Pract*. 2002;11(4):180–182. doi:10.1159/000065813
15. Almaghrabi MK, Alwadei AD, Alyahya NM, et al. Seroprevalence of human cytomegalovirus in pregnant women in the asir region, kingdom of Saudi Arabia. *Intervirology*. 2020;62(5–6):205–209. doi:10.1159/000506051
16. Ahmed MA-HEP, Faten Al-Abed MBBS, Ayed AAA, et al. Prevalence of toxoplasmosis, rubella, cytomegalovirus, and herpes (TORCH) infections among women attending the antenatal care clinic, maternity hospital in Abha. *Southwestern Saudi Arabia*. 2020;41(7):757–762. doi:10.15537/smj.2020.7.25121
17. KNOEMA. Saudi Arabia - Number of births. Available from: <https://knoema.com/atlas/Saudi-Arabia/topics/Demographics/Fertility/Number-of-births>. Accessed July 17, 2024.
18. Alifiraki S, Payne H, Hathaway C, Tan RWY, Lyall H. Delays in diagnosis and treatment initiation for congenital cytomegalovirus infection - Why we need universal screening. *Front Pediatr*. 2022;10. doi:10.3389/fped.2022.988039
19. Rawlinson WD, Boppana SB, Fowler KB, et al. Congenital cytomegalovirus infection in pregnancy and the neonate: consensus recommendations for prevention, diagnosis, and therapy. *Lancet Infect Dis*. 2017;17(6):e177–e188. doi:10.1016/S1473-3099(17)30143-3
20. Kimberlin DW, Lin CY, Sánchez PJ, et al. Effect of ganciclovir therapy on hearing in symptomatic congenital cytomegalovirus disease involving the central nervous system: a randomized, controlled trial. *Journal of Pediatrics*. 2003;143(1):16–25. doi:10.1016/S0022-3476(03)00192-6
21. Lin CH, Chou IC, Lee IC, Hong SY. Cytomegalovirus infection in infancy may increase the risk of subsequent epilepsy and autism spectrum disorder in childhood. *Children*. 2021;8(11):4–11. doi:10.3390/children8111040
22. Keymeulen A, De Leenheer E, Casaer A, et al. Neurodevelopmental outcome in children with congenital cytomegalovirus infection: a prospective multicenter cohort study. *Early Hum Dev*. 2023;182:105777. doi:10.1016/J.EARLHUMDEV.2023.105777
23. Association ASLH Roles and responsibilities of speech-language pathologists in early intervention: guidelines.
24. Dollard SC, Grosse SD, Ross DS. New estimates of the prevalence of neurological and sensory sequelae and mortality associated with congenital cytomegalovirus infection. *Rev Med Virol*. 2007;17(5):355–363. doi:10.1002/rmv.544
25. Al-dajani NM, Alghamdi TM, Mulla AF, et al. Awareness of cytomegalovirus infection among medical students at King Abdulaziz University. *Jeddah, Saudi Arabia*. 2020;4(June):1226–1232.
26. Specialties. SC for H. Regulation and requirements for professional qualification. Available from: <https://www.scfhs.org.sa/en/registration/Regulations-Requirements/Pages/default.aspx>. Accessed July 15, 2024.
27. Alakeel A. The Practice of Speech-Language Pathology in Saudi Arabia. *Arab Journal of Applied Linguistics*. 2022;07(01):87–99.
28. Muldoon KM, Armstrong-Heimsoth A, Thomas J, Nevels M. Knowledge of congenital cytomegalovirus (cCMV) among physical and occupational therapists in the United States. *PLoS One*. 2017;12(10):1–23. doi:10.1371/journal.pone.0185635
29. Dedhia K, Fifer RC, Muldoon KM, Park A. A cross-sectional survey evaluating awareness of congenital cytomegalovirus among audiologists and speech-language pathologists. *Am J Audiol*. 2021;30(1):145–159. doi:10.1044/2020_AJA-20-00167
30. Kodituwakku P, Kodituwakku E. Cognitive and Behavioral Profiles of Children with Fetal Alcohol Spectrum Disorders. *Curr Dev Disord Rep*. 2014;1(3):149–160. doi:10.1007/s40474-014-0022-6
31. Pesch MH, Muldoon KM. Congenital Cytomegalovirus Knowledge, Practices, and Beliefs Among Primary Care Physicians and Newborn Hospitalists. *J Prim Care Community Health*. 2022;13. doi:10.1177/21501319221106880
32. Pesch MH, Anderson C, Mowers E, Perez-Lopez FR. Improving Obstetric Provider Congenital Cytomegalovirus Knowledge and Practices. *Infect Dis Obstet Gynecol*. 2020. doi:10.1155/2020/8875494
33. Dedhia K, Tomlinson J, Murray N, Park A. Congenital Cytomegalovirus and Hearing Loss: a Pilot Cross-Sectional Survey of Otolologists' and Pediatric Otolaryngologists. *Knowledge. OTO Open*. 2019;3(2). doi:10.1177/2473974X19849874
34. Korver AMH, de Vries JJC, de Jong JW, Dekker FW, Vossen ACTM, Oudesluys-Murphy AM. Awareness of congenital cytomegalovirus among doctors in the Netherlands. *Journal of Clinical Virology*. 2009;46(4):S11–S15. doi:10.1016/J.JCV.2009.09.006
35. Alothman N, Elbeltagy R, Mulla R. Universal newborn hearing screening program in Saudi Arabia: current insight. *J Otol*. 2024;19(1):35–39. doi:10.1016/j.joto.2024.01.002
36. Zakzouk SM. Universal Newborn Hearing Screening. *Saudi Med J*. 2003;24(3):245–247. doi:10.1002/9780470987384.ch19
37. Stach BA, Ramachandran V. Clinical Audiology: an Introduction, Third Edition. *Plural Publishing*. 2022;623.
38. Almishaal AA Knowledge of cytomegalovirus infection among women in Saudi Arabia: a cross-sectional study. 2022:1–15. doi:10.1371/journal.pone.0274863.