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The Association between Marriage Consanguinity and Hearing Loss in Jordan: A Retrospective Analysis

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Abstract **Purpose:** This study aimed to explore the association between marriage consanguinity and hearing loss in a Jordanian demographic. **Methods:** A retrospective analysis was conducted on medical records from Al-Ahliyya Amman University Hearing and Speech Center between 2020-2023. The study included 416 patient records, all under the age of 18. Diagnostic methods included Pure-tone audiometry, Distortion product Otoacoustic emissions, Auditory brainstem response, and Immittance metering. Statistical analysis involved chi-square tests and logistic regression, considering marriage consanguinity, sex, and family history. **Results:** A total of 416 children were included in the study (58.18% males). The average age of the sample was 59 months (±45). A positive family history of hearing loss was observed in 77.88% of the children. Marriage consanguinity was reported in 38.46% of the sample population. Logistic regression indicated an increased risk of hearing loss in consanguineous marriages (log odds=0.895, p=.029), with a significant interaction between consanguinity and family history (log odds=0.362, p=.007). A marginally lower risk of hearing loss in females than in males was also observed (log odds= -0.498, p=.050). **Conclusion:** The study identified a significant association between consanguineous marriages and the incidence of sensorineural and mixed hearing loss, underscoring the genetic risks associated with consanguineous marriages and the importance of genetic counselling and audiological screenings in such populations.

Keywords Consanguineous Marriage, Middle East, Hearing Loss, Genetic Risks

1. Introduction

Consanguineous marriages, or unions between close relatives, are deeply woven into the cultural and historical tapestry of numerous societies globally [1]. An estimated 20% of the global population resides in areas where such marriages are preferred [2]. Consanguineous marriages are particularly prevalent in the Middle East and North Africa (MENA), where 20% to 50% of marriages are between relatives [3,4]. Within this regional context, Jordan stands out with its notably high rates [5], ranging from 28.5% to 63.7%, a range that is among the highest in the MENA region [3,5,6]. The underpinnings of this prevalence are multifaceted, including cultural norms that emphasize maintaining familial bonds and lineage, social motivations like preserving family honor and social status, and economic benefits linked to property and wealth consolidation [7,8]. Despite these deeply ingrained cultural and social imperatives, consanguineous marriages are associated with increased genetic risks, including congenital hearing loss, underscoring a critical public health issue linked to this longstanding tradition [9–11].

Congenital hearing loss, a hearing loss present at birth, occurs when the ability of the ear to convert the vibratory mechanical energy of sound into the electrical energy of nerve impulses is impaired [12]. Congenital hearing loss

arises from a complex interplay of genetic and environmental factors, with genetic causes accounting for approximately 70% of congenital hearing loss cases [12,13]. The estimated prevalence of hearing loss in developed countries in Europe and North America is approximately 1.33 per 1,000 live births [14]. According to a cross-sectional study in Jordan, congenital hearing loss was much higher, at 15.32 per 1,000 [15].

Previous studies have identified consanguineous marriages as a risk factor for hearing loss in countries such as Oman, Qatar, and Saudi Arabia [16–19]. However, this research did not specify which types of hearing loss (e.g., Conductive hearing loss versus sensorineural hearing loss) are associated with marriage consanguinity. Moreover, data from Levantine countries, such as Jordan, are notably absent. Given the differences in hearing loss prevalence in the Arab region, additional research in other countries is necessary to extend the validity of these findings. Therefore, this study aims to investigate the relationship between marriage consanguinity and hearing loss in a Jordanian sample, focusing on different types of hearing loss.

2. Materials and Methods

2.1. Study Design and Population

This study is a retrospective analysis of medical records from Al-Ahliyya Amman University Hearing and Speech Center in Jordan, spanning three years (2020-2023). The following inclusion criteria were established: records of patients below 18 years, ensuring the focus on a pediatric demographic. Children included must have undergone a comprehensive hearing assessment. Information regarding the presence or absence of consanguineous marriage within the family was also required. Participants needed to be residents of Jordan to ensure their relevance to the regional context under investigation. Finally, the inclusion of any child's record was conditional upon receiving explicit consent from their parents or legal guardians, upholding ethical standards and ensuring informed participation. As a result, a total of 416 records were included in the analysis. Any records with incomplete information (5% of the records) were excluded.

2.2. Ethical Consideration

The study has been approved by the Al-Ahliyya Amman University institutional review board (approval: PS-F36-01-003). All parents and legal guardians of participants under the age of 18 signed a consent form to allow the data collected to be used for research purposes. Consenting participants were not personally identified, and participation was voluntary. The work described has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) [20].

2.3. Protocol

For the purpose of this study, patient records were assessed for evidence of hearing loss – This was identified based on Pure-tone thresholds, which were obtained using calibrated diagnostic audiometers (Interacoustics AC-40) to diagnose adult hearing loss. Distortion product otoacoustic emissions were recorded using Madsen Capella Otometrics to diagnose pediatric cases with hearing loss. Auditory brainstem response (ABR was recorded using a two-channel Auditory evoked potential (Biologic, Navigator-Pro) system to determine hearing loss type and degree. A calibrated Immittance meter (Madsen Zodiac, Otometrics) was used to assess the status of the middle ear. Data regarding marriage consanguinity, age, sex, hearing loss type, family history, and other risk factors were also retrieved.

2.4. Statistical Analysis

Descriptive statistics were used to calculate the prevalence of hearing loss and the frequency of marriage consanguinity in the sample. The association between marriage consanguinity and hearing loss was evaluated using a chi-square test. A logistic regression model was also developed to control for potential confounders, with hearing loss as the dependent variable and marriage consanguinity as the independent variable, adjusting for sex and family history. An interaction term was introduced to the model to evaluate the effect of family history on marriage consanguinity and hearing loss relationship. A forest plot was used to visualize the estimates and their respective confidence intervals from the logistic regression analysis. A p-value of less than 0.05 was considered statistically significant. All analyses were conducted using R Statistical Software (version 2.14.0; R Foundation for Statistical Computing, Vienna, Austria).

3. Results

Our sample consisted of 416 participants, predominantly male (242 males, 58.18%). Females accounted for 41.82% of the sample (174 females). Table 1 details the demographic characteristics of the sample population. The participants' average age at study recruitment was 59 months, with a standard deviation of 45 months. The mean age at onset of hearing loss was five months, with a standard deviation of 4 months. A significant portion of the participants, 77.88% (n=324), reported having hearing loss, while 22.12% (n=92) did not. Regarding marriage consanguinity, 38.46% (n=160) of the participants reported having consanguineous marriages, whereas 61.53% (n=256) did not. Regarding family history, 28.84% (n=118) had a family history of hearing loss, while the majority, 71.63% (n=298), did not. Other risk factors noted were birth complications and neonatal factors by 10.54% (n=45),

infectious diseases by 3.51% (n=15), jaundice by 1.17% (n=5), medical conditions by 1.17% (n=5), neurological disorders by 1.17% (n=5), and physical damage by 1.64% (n=7) of participants. A large percentage, 325 (78.69%), reported having no risk factors.

Table 1. Baseline Characteristics of the sample population (n=416)

Sample Demographic	
Age (m, SD) months	59 (45)
Age of Hearing Loss Onset (m, SD) months	5 (4)
Sex (M) (n, %)	242 (58.18%)
Sex (F) (n, %)	174 (41.82%)
Hearing Loss (Yes) (n, %)	324 (77.88%)
Hearing Loss (No) (n, %)	92 (22.12%)
Sensorineural hearing loss (n, %)	271 (65%)
Conductive hearing loss (n, %)	139 (33%)
Mixed hearing loss, (n, %)	6 (1%)
Marriage Consanguinity (Yes) (n, %)	160 (38.46%)
Marriage Consanguinity (No) (n, %)	256 (61.53%)
Family History (Yes) (n, %)	118 (28.84%)
Family History (No) (n, %)	298 (71.63%)
Other Risk factors	
Birth Complications and Neonatal Factors (n, %)	45 (10.54%)
Infectious Diseases (n, %)	15 (3.51%)
Syndromes (n, %)	9 (2.11%)
Traumatic or Physical Damage (n, %)	7 (1.64%)
Jaundice (n, %)	5 (1.17%)
Medical Interventions or Conditions (n, %)	5 (1.17%)
Neurological Disorders (n, %)	5 (1.17%)
None (n, %)	325 (78.69%)

The Association between Marriage Consanguinity and Hearing Loss

A total of 416 participants were analyzed. Among those with a history of marriage consanguinity, 156 individuals had hearing loss, while four did not, totaling 160 participants in this group. Conversely, among participants without a history of marriage consanguinity, 176 had hearing loss, and 80 did not, resulting in 256 individuals in this category (Figure 1).

The Chi-square test revealed a noticeable difference in the proportion of hearing loss cases between individuals from consanguineous marriages (labelled as "yes") and those from non-consanguineous marriages (labelled as "no"). The association between marriage consanguinity (Mcons) and hearing loss (hl) was found to be significant with an X-squared value of 33.88, degrees of freedom (df) of 1, and a highly significant p-value of <0.001. This suggests a strong correlation between marriage consanguinity and the occurrence of hearing loss in the examined population.

Figure 2 sheds light on the association between marriage consanguinity and different types of hearing loss. Notably, among patients with positive marriage consanguinity, there is a pronounced prevalence of Sensorineural Hearing Loss (SNHL) and Mixed Hearing Loss (MHL). These types of hearing loss account for a substantial portion of the total compared to Conductive Hearing Loss (CHL). This data underscores the genetic implications and risks associated with consanguineous marriages and their linkage to hearing loss.

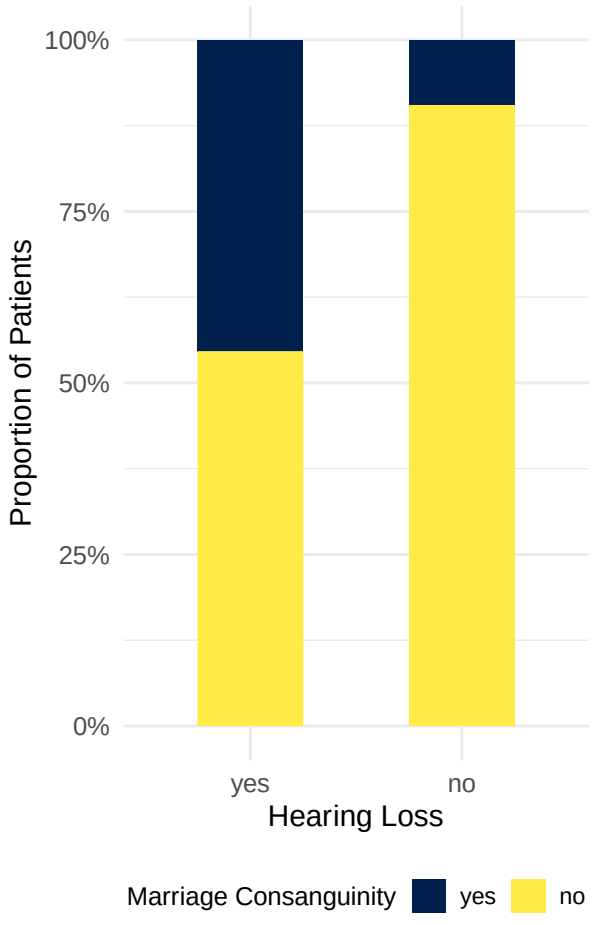
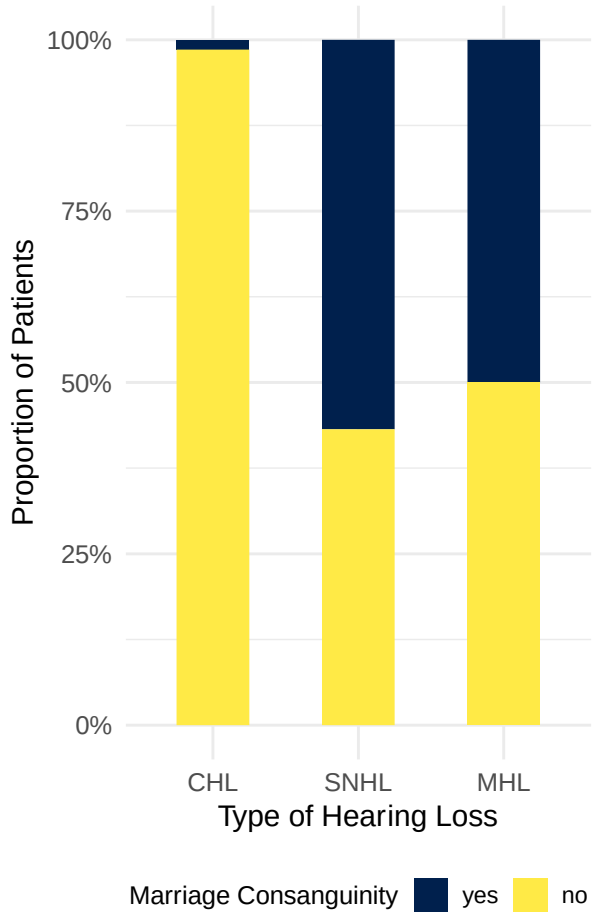
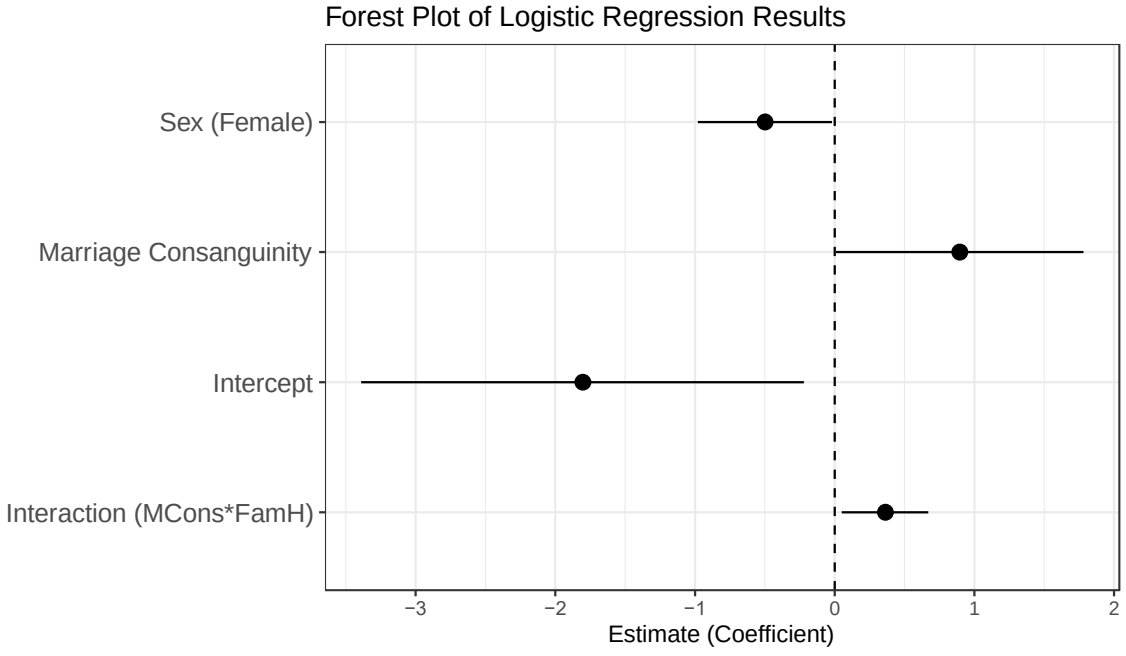


Figure 1. Prevalence of Hearing Loss in Consanguineous and Non-Consanguineous Marriages



CHL: conductive hearing loss, SNHL: sensorineural hearing loss, MHL: mixed hearing loss

Figure 2. Prevalence of Hearing Loss Types in Consanguineous and Non-Consanguineous Marriages



MCons: Marriage consanguinity, FamH: Family history

Figure 3. Logistic regression results

Figure 3 shows a forest plot to visualize the estimates (coefficients) and their respective confidence intervals from the logistic regression analysis. The plot is organized vertically, with each term from the logistic model displayed on the y-axis. The x-axis represents the value of the log-odds estimates, with a dashed line at 0 indicating no effect. The "Sex (Female)" term has a negative estimate, suggesting females may have a lower likelihood (in terms of log odds) of hearing loss compared to males when marriage consanguinity is present. The point estimate for "Marriage Consanguinity" is positive, suggesting that those with marriage consanguinity have higher log odds of hearing loss than those without it. The "Intercept" provides a baseline log-odds of the outcome when all predictors are set to their reference levels. Lastly, the "Interaction (MCons*FamH)" term represents the interaction effect of marriage consanguinity and family history on hearing loss, with its estimate being positive. The black dot indicates the point estimate for each term, and the horizontal line showcases its confidence interval. If the confidence interval of a term does not cross the 0 line, it can be considered statistically significant at p=0.05.

Several key findings emerged from the logistic regression results. Firstly, individuals with marriage consanguinity appeared to have increased log odds of hearing loss when compared to those without such unions. Specifically, the positive log-odds estimate of 0.895 highlights that the risk might be elevated for this group, and this observation is statistically significant with a p-value of .029. The sex-based analysis showed that Female participants exhibited a negative log-odds estimate of -0.498, suggesting they have reduced log odds of experiencing hearing loss relative to the males. This difference is right on the threshold of traditional significance levels, with a p-value of .05. Furthermore, there is a noteworthy interaction when examining the relationship between marriage consanguinity and family history. The log-odds estimate of 0.362 implies that family history may moderate the effect of marriage consanguinity on hearing loss risk. This interaction term was statistically significant with a p-value of 0.007, emphasizing the need to consider both factors concurrently when assessing hearing loss risk factors.

4. Discussion

This study revealed a significant relationship between consanguineous marriages and hearing loss, particularly in sensorineural and mixed hearing loss cases. These findings support existing research on the genetic risks of consanguineous unions, a deeply entrenched socio-cultural norm in the Middle East and North Africa (MENA) region [21]. Furthermore, this study contributes to diversity and inclusion in scientific inquiry by focusing on a unique phenomenon prevalent in underrepresented populations, underscoring the importance of understanding and addressing their specific healthcare needs.

Consanguineous marriages, culturally and socially favoured in many MENA countries, including Jordan, have been recognized as potential contributors to various genetic disorders due to the heightened risk of homozygosity for recessive traits [9]. These unions often arise from traditions rooted in ancient customs, religious beliefs, or socio-economic advantages, underscoring their significance beyond mere matrimonial bonds [3]. The Middle East, particularly Jordan, exemplifies this phenomenon, with such marriages being a hallmark of society rather than occasional occurrences [3,5].

Our results contribute to understanding the adverse implications of consanguineous marriages on hearing ability, as highlighted in previous studies [16–19]. Our data confirms the link between marriage consanguinity and hearing loss within the Jordanian demographic. To the best of our knowledge, this study is the first to examine the types of hearing loss associated with consanguineous marriages. The higher incidence of Sensorineural Hearing Loss (SNHL) and Mixed Hearing Loss (MHL) underscores the influence of genetic factors [22]. SNHL often stems from issues in the inner ear or auditory nerve, while MHL combines features of both conductive and sensorineural loss [23]. These forms of hearing loss are frequently rooted in genetics, particularly in autosomal recessive traits [13]. Given our current understanding, consanguineous marriages are known to increase the probability of passing identical recessive genes to offspring [24], unlike in the broader population, where unrelated couples are less likely to carry the same recessive gene [3,22]. Therefore, the higher occurrence of SNHL and MHL in children of consanguineous couples observed in our study likely results from inheriting autosomal recessive traits, which are more prevalent among closely related individuals.

Future genetic research is required to substantiate this link. The interplay between marriage consanguinity and family history further complicates the risk assessment for hearing loss [25]. Bergstrom et al. elucidate that while the marriage of two individuals with hearing loss only slightly increases the risk of hearing loss in offspring due to the low probability of both parents sharing the exact genetic cause of hearing loss, the scenario changes significantly with consanguineous marriages [26]. Our findings confirm this by demonstrating the additive effect of genetic predisposition from a positive family history and the enhanced risks associated with consanguinity. This combined effect suggests a synergistic interaction where both factors exacerbate the likelihood of hearing loss, reinforcing the necessity for comprehensive family history assessments in clinical evaluations. Therefore, clinicians should be vigilant in considering marriage consanguinity as a significant component of a patient's case history, especially when accompanied by a known family history of hearing loss.

The sex-based differences observed our study provide new and compelling insights into the epidemiology of

hearing loss. This finding contrasts with previous research, such as the study by Bener et al., which did not identify a significant association between sex and the impact of consanguineous marriage on hearing loss [19]. The current study found that females have a slightly lower risk of hearing loss compared to males, suggesting the need for further investigation into the genetic or physiological factors that might make males more vulnerable to hearing loss. Additionally, it is essential to consider the different modes of inheritance, such as autosomal recessive and multifactorial inheritance, which are further complicated in consanguineous marriages due to the introduction of homozygotic traits [9,19].

Given the link between consanguineous marriages and the increased risk of hearing loss identified in our study, it is crucial to promote proactive healthcare in areas where such marriages are common [2]. Genetic counselling is critical in this context, providing couples with essential information about the genetic risks to their children [27]. This counselling supports informed decision-making, helping couples understand and prepare for potential genetic issues. Regular audiological screenings are also vital for early hearing loss detection. Early identification allows for timely interventions and effective management strategies [28]. It is important to note that in the current study, delayed audiological testing could have influenced the average age of onset at five months. Timely testing is, therefore, critical to ensure early and more effective treatment. By implementing these healthcare strategies, we can significantly reduce the impact of hearing loss, especially in communities where consanguineous marriages are prevalent. This approach promises a healthier future for upcoming generations in Jordan and the MENA region.

In addition, congenital hearing loss is significantly influenced by genetics, with various genes playing roles in auditory function [12]. For instance, mutations in genes such as GJB2, associated with connexin 26, lead to autosomal recessive non-syndromic hearing loss - the most common genetic form [13]. This form requires the individual to inherit the defective gene from both parents [29]. Advances in genetic testing have made it possible to identify such mutations, which are crucial for diagnosis, guiding treatment, and providing genetic counselling [30]. While these genetic tests are available, they are not yet required from couples planning to marry a relative. This testing becomes particularly vital in areas with high rates of consanguineous marriages due to a higher likelihood of both parents carrying identical genetic mutations.

5. Limitations

Despite the novel insights our research offers, it is essential to acknowledge certain limitations. The retrospective nature of the study constrains our capacity to establish causality. Future research adopting a longitudinal and prospective design would more effectively confirm the observed relationships. Furthermore, while this study effectively elucidates the role of consanguineous marriages as a significant risk factor in the incidence of hearing loss, it does not extend its inquiry to the quantification of hearing loss severity, or the detailed genetic mechanisms involved. A comprehensive investigation into the degrees of hearing impairment and the identification of specific genetic mutations would enrich our understanding of the intricate relationship between the genetic determinants of hearing loss and the prevalence of consanguinity in marital unions.

6. Conclusions

This study revealed a significant association between marriage consanguinity and the incidence of hearing loss within a Jordanian cohort, specifically sensorineural and mixed hearing loss. The outcomes of this study showcase the necessity for genetic counselling and systematic audiological screenings in areas where consanguineous marriages are common. These findings also suggest that adopting such healthcare measures can substantially reduce the prevalence and severity of hearing loss. Early detection and prompt intervention are crucial in improving management and quality of life for individuals with hearing loss. This study promotes diversity and inclusion in research by focusing on phenomena predominantly found in underrepresented communities. It highlights their distinct healthcare requirements and genetic factors, especially in areas with a high prevalence of consanguineous marriages.

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Declaration of Interest Statement

The authors report there are no competing interests to declare.

REFERENCES

[1] Bittles, A.H., Black, M.L., "Consanguinity, human evolution, and complex diseases," Proceedings of the National Academy of Sciences, vol. 107, pp. 1779–1786, 2010. DOI: 10.1073/pnas.0906079106

[2] Modell B., Darr A., “Genetic counselling and customary

consanguineous marriage," Nature Reviews Genetics, vol. 3, no. 1, pp. 225–229, 2002. DOI: 10.1038/nrg754

[3] Tadmouri, G. O., Nair, P., Obeid, T., Al Ali, M. T., Al Khaja, N., Hamamy, H. A., "Consanguinity and reproductive health among Arabs," Reproductive Health, vol. 6, no. 1, pp. 17, 2009. DOI: 10.1186/1742-4755-6-17

[4] Elhadi, Y.A.M., Alrawa, S.S., Alfadul, E.S.A., Mahgoub, E.A.A., El-Osta, A., Belal, S.A., Lucero-Prisno, D.E., El Dabbah, N.A., Yahia, A., "Consanguinity and willingness to perform premarital genetic screening in Sudan," European Journal of Human Genetics, vol. 31, no. 4, 2023. DOI: 10.1038/s41431-023-01438-1

[5] Islam M. M., Ababneh F. M., Khan M. H. R., "Consanguineous Marriage in Jordan: An Update," Journal of Biosocial Science, vol. 50, no. 4, pp. 573–578, 2018. DOI: 10.1017/S0021932017000372

[6] Obeidat, B. R., Khader, Y. S., Amarin, Z. O., Kassawneh, M., Al Omari, M., "Consanguinity and Adverse Pregnancy Outcomes: The North of Jordan Experience," Maternal and Child Health Journal, vol. 14, no. 2, pp. 283–289, 2010. DOI: 10.1007/s10995-008-0426-1

[7] Jurdi R., Saxena P. C., "The Prevalence and Correlates of Consanguineous Marriages in Yemen: Similarities and Contrasts with Other Arab Countries," Journal of Biosocial Science, vol. 35, no.1, pp. 1–13, 2003. DOI: 10.1017/s0021932003000014

[8] El Goundali, K., Chebabe, M., Zahra Laamiri, F., Hilali, A., "The Determinants of Consanguineous Marriages among the Arab Population: A Systematic Review," Iranian Journal of Public Health, vol. 51, no. 2, pp. 253–265, 2022. DOI: 10.18502/ijph.v51i2.8679

[9] Jaber L., Halpern G. J., Shohat M., "The Impact of Consanguinity Worldwide," Public Health Genomics, vol. 1, no. 1, pp. 12–17, 1998. DOI: 10.1159/000016130

[10] Temaj, G., Nuhii, N., Sayer, J.A., "The impact of consanguinity on human health and disease with an emphasis on rare diseases," Journal of Rare Diseases, vol. 1, no. 2, 2022. DOI: 10.1007/s44162-022-00004-5

[11] Mobarak, A. M., Chaudhry, T., Brown, J., Zelenska, T., Khan, M. N., Chaudry, S., Wajid, R. A., Bittles, A. H., Li, S., "Estimating the Health and Socioeconomic Effects of Cousin Marriage in South Asia," Journal of Biosocial Science, vol. 51, no. 3, pp. 418–435, 2019. DOI: 10.1017/S0021932018000275

[12] Korver, A. M., Smith, R. J., Van Camp, G., Schleiss, M. R., Bitner-Glindzicz, M. A., Lustig, L. R., Usami, S. I., Boudewyns, A. N., "Congenital hearing loss," Nature Reviews Disease Primers, vol. 3, no. 1, pp. 16094, 2017. DOI: 10.1038/nrdp.2016.94

[13] Young A., Ng M., "Genetic Hearing Loss," StatPearls [Internet], https://www.ncbi.nlm.nih.gov/books/NBK580517/ (accessed Mar. 7, 2024)

[14] Morton C. C., Nance W. E., "Newborn Hearing Screening — A Silent Revolution," New England Journal of Medicine, vol. 354, no. 20, pp. 2151–2164, 2006. DOI: 10.1056/NEJMra050700

[15] Abu-Shaheen, A., Al-Masri, M., El-Bakri, N., Batieha, A., Nofal, A., Abdelmoety, D., "Prevalence and risk factors of hearing loss among infants in Jordan: Initial results from universal neonatal screening," International Journal of Audiology, vol. 53, no. 12, pp. 915–920, 2014. DOI: 10.3109/14992027.2014.944275

[16] Almazroua, A. M., Alsughayer, L., Ababtain, R., Al-Shawi, Y., Hagr, A. A., "The association between consanguineous marriage and offspring with congenital hearing loss," Annals of Saudi Medicine, vol. 40, no. 6, pp. 456–461, 2020. DOI: 10.5144/0256-4947.2020.456

[17] Alkowari, M. K., Vozzi, D., Bhagat, S., Krishnamoorthy, N., Morgan, A., Hayder, Y., Logendra, B., Najjar, N., Gandin, I., Gasparini, P., Badii, R., Girotto, G., Abdulhadi, K., "Targeted sequencing identifies novel variants involved in autosomal recessive hereditary hearing loss in Qatari families," Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis, vol. 80, no. 2, pp. 29–36, 2017. DOI: 10.1016/j.mrfmmm.2017.05.001

[18] Al Khabori M., Patton M. A., "Consanguinity and deafness in Omani children," International Journal of Audiology, vol. 47, no. 1, pp. 30–33, 2008. DOI: 10.1080/14992020701703539

[19] Bener A., EIHakeem A. A. M., Abdulhadi K., "Is there any association between consanguinity and hearing loss," International Journal of Pediatric Otorhinolaryngology, vol. 69, no. 3, pp. 327–333, 2005. DOI: 10.1016/j.ijporl.2004.10.004

[20] World Medical Association, "World Medical Association Declaration of Helsinki," Journal of the American Medical Association, vol. 310, no. 2, pp. 2191, 2013. DOI: 10.1001/jama.2013.281053

[21] Hamamy H., "Consanguineous marriages," Journal of Community Genetics, vol. 3, no. 3, pp. 185–192, 2012. DOI: 10.1007/s12687-011-0072-y

[22] Bromiker R., Glam-Baruch M., Gofin R., Hammerman, C., Amitai, Y., "Association of parental consanguinity with congenital malformations among Arab newborns in Jerusalem," Clinical Genetics, vol. 66, no. 1, pp. 63–66, 2004. DOI: 10.1111/j.0009-9163.2004.00264.x

[23] Smith R. J., Bale J. F., White K. R., "Sensorineural hearing loss in children," The Lancet, vol. 365, no. 9462, pp. 879–890, 2005. DOI: 10.1016/S0140-6736(05)71047-3

[24] Bittles A., "Consanguinity and its relevance to clinical genetics," Clinical Genetics, vol. 60, no. 1, pp. 89–98, 2001. DOI: 10.1034/j.1399-0004.2001.600201.x

[25] Zakzouk S., El-Sayed Y., Bafaqeeh S. A., "Consanguinity and Hereditary Hearing Impairment Among Saudi Population," Annals of Saudi Medicine, vol. 13, no. 5, pp. 447–450, 1993. DOI: 10.5144/0256-4947.1993.447

[26] AlSalloum, A., El Mouzan, M. I., AlHerbish, A., AlOmer, A., Qurashi, M., "Prevalence of selected congenital anomalies in Saudi children: a community-based study," Annals of Saudi Medicine, vol. 35, pp. 107–110, 2015. DOI: 10.5144/0256-4947.2015.107

[27] Bennett, R. L., Motulsky, A. G., Bittles, A., Hudgins, L., Uhrich, S., Doyle, D. L., Silvey, K., Scott, C. R., Cheng, E., McGillivray, B., Steiner, R. D., Olson, D., "Genetic Counseling and Screening of Consanguineous Couples and Their Offspring: Recommendations of the National Society

of Genetic Counselors," Journal of genetic counseling, vol. 11, no. 2, pp. 97–119, 2002. DOI: 10.1023/A:1014593404915

[28] Jakubíková, J., Kabátová, Z., Pavlovcinová, G., Profant, M.., "Newborn hearing screening and strategy for early detection of hearing loss in infants," International journal of pediatric otorhinolaryngology, vol. 73, no. 4, pp. 607–612, 2009. DOI: 10.1016/j.ijporl.2008.12.006

[29] Kenneson, A., Van Naarden Braun, K., Boyle, C., "GJB2 (connexin 26) variants and nonsyndromic sensorineural hearing loss: a HuGE review," Genetics in Medicine, vol. 4, no. 4, pp. 258–274, 2002. DOI: 10.1097/00125817-200207000-00004

[30] Katsanis S. H., Katsanis N., "Molecular genetic testing and the future of clinical genomics," Nature reviews Genetics, vol. 14, no. 6, pp. 415–426, 2013.