

Introduction Consanguinity is used to describe a marriage relationship between a man and a woman with at least one common ancestor (1). A previous study indicated a high rate of CM in the southern region (69%) and the northern region (60%) (21). CM in the form of cousin marriages revolved around the beliefs of assuring a better married life, as consanguinity strengthens family ties, enforces family solidarity, and provides excellent opportunities for the transmission of cultural values and continuity (4). Despite being illegal in some religions, including Catholicism and Hinduism, and prohibited by law in other countries, CMs are widely practiced in the Middle East, Northern Africa, and South Asia with variable rates that can reach 70% in some regions (2). Autosomal recessively inherited diseases include metabolic disorders, liver disease (Wilson), blood diseases, polycystic kidney disease, phenylketonuria (PKU), and immunodeficiency disorders, which are common among CM communities (6). Among blood diseases are sickle cell disease (SCD) and Mediterranean anemia (thalassemia), which are the most common favorably reported severe blood disorders in Saudi Arabia (7). However, despite the socioeconomic benefits of CM, it is positively linked to an increased risk of autosomal recessive genetic diseases in resulting offspring. Alongside autosomal inherited diseases, mental illnesses were also higher in CM families, such as depression, autism, schizophrenia, and anxiety disorders (9). The study's main objective is to determine the prevalence of CMs and the level of awareness among well-educated female students of Princess Nourah Bint Abdul Rahman University (PNU). Studies from several Arab countries, including Jordan, Yemen, and Tunisia, showed reduced consanguinity rates among educated males and females (16). The ongoing developments in genetic diagnostic tests in cities and the advanced technologies to detect genetic disorders, and awareness programs are all well established in cities (18). When the correlation between university programs studied by participants and their levels of awareness was addressed, we found that Medicine students had better awareness about CM and its association with genetic diseases than Science and Humanities students. Sociocultural factors, including similar culture, religion, ethnicity, and geography, play a crucial role in the preference of consanguinity in Arab and Middle Eastern populations (3).

Subjects and Methods This cross-sectional survey was conducted among 637 students attending PNU for about 4 weeks, starting from October 3 and ending on November 2, 2019. The questionnaires were distributed through PNU's different faculties, including Medicine, Science, and Humanities, and communication between the researchers and the participants was in Arabic or English if needed. Correspondingly, the association between consanguinity and genetic disorders was addressed through methodical surveys of the selected participants. Different reports addressing the phenomena have associated higher rates of CM with poor socio-economical and educational factors (15). However, when participants were asked if raising awareness will decrease CM rates in Saudi, 19% were negative, suggesting that they think that people's preferences will not change toward cousin's marriages even with awareness programs. This study's overall goal was to shed light on the prevalence of consanguinity regarding socio-demographic factors and the associated genetic diseases. Ethical approval was obtained from the Institutional Review Board's Committee of Princess Nourah bint Abdulrahman University (PNU) (IRB-19-0073). All methods were carried out in accordance with the relevant guidelines and regulations of the National Committee of Bioethics, Saudi Arabia. Additionally, a group of autosomal recessive genetic diseases was listed, including inherited

blood diseases, gastrointestinal diseases, hearing impairments, and cancer. The researchers distributed the questionnaires, which were filled by the participants online through Google Forms; the researcher's clarified questions for the participants if needed. Multivariable data analysis was conducted, and the odds ratio (OR) and their corresponding 95% confidence interval (CI), and p-value were calculated. Approximately 68.13% (n = 284) of the respondents' mothers received higher education, while 84.30% (n = 345) of the fathers received higher education (Figure 1). Most of the participants, 91.37% (n = 528), are aware and well informed of the link between genetic diseases and CM. About half of the participants, 55.57% (n = 354), supported premarital counseling. Additionally, reports from Middle Eastern countries showed lower consanguinity rates in urban compared to rural settings (17). In this study, we found a positive correlation between high income and awareness about CM. Better socioeconomic conditions can reduce CM rates, as parents will not tend to accept CM to reduce marriage expenses (15). Historically, consanguineous marriages (CMs) have been widespread in many communities throughout the world. Moreover, CM has been recently practiced in Europe and North America among emigrants from communities with high consanguinity rates (1). Saudi Arabia is one of the highest countries in practicing CM; recent reports indicated high rates, reaching 60% and 70% (5). Also, CM can increase the risk of developmental genetic disorders, as reported in a study that found an increased number of children with Down syndrome (DS) in CM families, despite the fact that more research is needed to prove the link between DS and CM (3,8). The questionnaire was designed in accordance with previously published studies in which questions were addressed and validated (3,11). The survey was conducted in English and Arabic, depending on the respondent's preference, and took about 5–7 minutes to be completed. To identify factors associated with CM and health outcomes, data were analyzed using R Software (R 3.5.3 for Windows 64 bit)/2018 with (fmsb package). All variables showed association with practices at the bivariate level, with a p-value less than 0.05 were considered statistically significant and highly significant, respectively, and the 95% confidence level. Analyzing the data found that medical students in CM were more likely to have more awareness of the risk factors connected to consanguinity than humanities students (OR 3.55 95% CI 0.13, 90.9). The OR of participants supporting consanguinity was slightly higher among those whose parents were in CM of first cousins (OR 2.83, 95% CI 1.77, 4.54) more than students with non-consanguineous parents.

Discussion

The prevalence of consanguinity in communities is an important phenomenon to be addressed, particularly in Saudi Arabia. Eliminating such burdens of genetic disorders is positively linked to improving public knowledge and practice toward CM (12). In countries where people are practicing CMs, including Saudi Arabia, more genetic disorders were reported (14). Living in urban areas is another factor that can help to reduce CMs and associated genetic diseases. The primary source of information about CM in Saudi Arabia is mass media and medical personnel from hospitals and local general practices. All participants signed a consent form before filling the questionnaire to inform their willingness to participate in the study. The questionnaire consisted of 30 questions in total and categorized into two sections; the first section focused on socioeconomic information, including age, education level, and marital status. First, a pilot study of the questionnaire was conducted using 70 participants to check for any misinterpretation or difficulty in understanding the survey questions. The OR of having an awareness of

consanguinity among sciences students involved in non-CM was higher (OR 3.42, 95% CI 0.10, 15.8) than humanities students. Students who had diseases linked to consanguinity were found more likely to be involved in a family of CM of first cousins (OR 1.01, 95% CI 0.67– 1.52) than those who had non-CM (Table 2). Cultural norms still encourage relative's marriage despite the high incidents of different genetic diseases. CM and its association with genetic diseases has been addressed lately in Saudi Arabia (13). Nearly all of the participants, 97.1%, showed their support for premarital counseling, highlighting the importance of education to alter people's behavior. These factors are likely to provide new couples with information related to their carrier status of autosomal recessive disorders and also to educate and prepare them (19). In terms of the most prevalent causes of CMs concerning regions, the southwestern region was the highest in the rate of CMs with 80.6%. Additionally, couples' examination can predict the possibility of inheriting disease(s), and individuals can be aware of their conditions and disease-related consequences. Despite the general increase in awareness and the establishment of premarital testing in 2003, still reports suggested high CM levels. Simultaneously, the second section focused on the participants' awareness and knowledge about the link between consanguinity and genetic diseases. Respondents were asked about the level of consanguinity in their families, given the following four choices: first-degree cousins, second-degree cousins, a distant relative relationship, or no blood relationship. Also, multifactorial diseases, including diabetes and mental diseases, were added to the questionnaire and participants were asked if they or their family members have them. The sample size was calculated based on the total number of students in the Science (4,600), Medicine (375), and Humanities (3,400) faculties, which is in total 8,375 students; the dean of each Faculty retrieved the number of students. The OR of medical students involved in non-CM supporting consanguinity was slightly higher, 4.66 (95% CI 0.29, 73.3), than humanities students. Medical students who have had non-CM were found more likely (OR 1.42 (95% CI 0.03, 51.4) to have an awareness of consanguinity than humanities students. Participants whose husbands' income was high or average were found more likely [(OR 1.75, 95% CI 0.15, 20.2) and (OR 1.32, 95% CI 0.12, 14.1)] to support consanguinity than students whose husband's income was less than average (Table 1). CM has been reported to increase the occurrence of genetic mutations compared to the general population. A significant number of the participants were interested in the subject, and 91.37% were aware of the correlation between CM and genetic disorders. The recent increased attention on providing information to new couples was through pre-marriage counseling and premarital medical examination. However, better income can be linked to higher CMs rates, as wealthy parents prefer to keep money within their families, as also found in this study. However, unexpectedly, despite their high level of awareness, they were the most group supporting CMs, despite knowing the risks involved, as they had the highest percentage of CMs. The more the population is ethnically similar, the higher the risk of developing such diseases. Participants who did not consent to participate in the study and/or did not answer the study's questions were excluded from the study. In light of the feedback from all the 70 participants, some questions were amended or clarified. Subjects were assured confidentiality of their answers and were not requested to provide any personal information. In this study, participants were not provided with any vouchers or given money for filling the questionnaire. Medical students in CM were more likely to support consanguinity (OR

8.95% CI 1.00 63.9) compared to sciences students in CM (OR 3.95% CI 0.58, 15.3). On the other hand, science students who have had non-CM were found more likely to support consanguinity by OR 0.29 (95% CI 0.008, 9.857) than humanities students. On the contrary, CMs of third cousins (OR 1.84, 95% CI 1.06, 3.20) were less likely to support CM than students with non-CM (Table 2). This study investigated the prevalence and attitude toward CMs among PNU students. These results place Saudi Arabia among the countries of the world with a high rate of consanguinity. A recent study found a lack of knowledge about the link between CM and genetic diseases among participants, despite their high education level (10). Participants were given the freedom to terminate the survey anytime. Before the participant started to give their feedback, they were given a short introduction about the study and its purpose. Data were refined and organized by Excel version (16.0.6769.2017)/2016 and were cross-checked before and after data entry. Results In this study, a total of 637 students from Princess Nourah University responded to the questionnaire. Among all the CMs, first cousins' marriages were the highest with 48.79% (n = 161), then third cousins' marriages with 34.24% (n = 113), and finally, second cousins' marriages with 16.97% (n = 56). The OR of having awareness among students whose parents were in CM third cousin was (OR 1.01, 95% CI 0.43, 2.34) greater than students with non-CM (Table 2). Nevertheless, more public awareness is still needed, especially among young generations. In our study, 51.8% of the participants were in CM families, which was lower than an older study as 57.7% of the participants were in CMs (20). The sample size used to conduct this research was 637, with a 3.1% margin of error and a 90% confidence level. Simple Random Imputation Approach was used to impute missing values (random. More than third 36.42% (n = 232) of the participants were among the age group 19–20 years, and the majority 59.3% (n = 378) were between 21 and 25 years. 43.80% (n = 279) were from the Faculty of Science, while 34% (n = 217) were from the Faculty of Medicine and 22.1% (n = 141) from the Faculty of humanities. About three-quarters of the participants, 75.82% (n = 482), were from an average income family, while 21.9% (n = 139) were from high-income families. The subjects' ages were between 19 and 26 years. imp R package). From this number, 51.81% (n = 330) of the students' or/and their families were .consanguineous