Abstract
Vitamin D deficiency can cause severe health conditions such as rickets and osteomalacia. Certain ethnic groups are more at risk for vitamin D deficiency due to modest dress and long indoor hours. Therefore, we suspected that cultures and communities such as Orthodox Jews and those who wear Hijabs would be one of the ethnic minorities at risk for Vitamin D deficiency since their lifestyle includes the risk factors mentioned. This review aims to examine the current literature on vitamin D deficiency in these populations to determine if this group is indeed at risk.

Methods - Articles were individually retrieved through June and July 2022 by search in PubMed and Google Scholar. Papers were searched for by the keywords "Vitamin D Deficiency," "Jewish," "Orthodox," "Dress," and or "Hijab" excluding articles not in English. When searching these keywords in PubMed and Google Scholar, 1 page of results was generated with seven articles. All seven articles were then analyzed for relevance to the discussion of Vitamin D status and the role of Orthodox Jewish culture. All three articles were found to be relevant and were used for analysis.

Results – The studies examined the relationship between the Orthodox Jewish lifestyle and Vitamin D status. Study one found lower vitamin D levels in post-partum orthodox Jewish Mothers. Study two found differences in vitamin D deficiency in children based on age. In addition, they found a high prevalence of vitamin D deficiency in ultra-orthodox and orthodox communities. However, they did not find a significant difference between ultra-orthodox and orthodox and secular patients. Finally, study three found that among young orthodox Jewish males, those with more indoor hours and restrictive dress were more vitamin D deficient. With regards to the 4 studies conducted on those who wear Niqabs or Hijabs (who likely have different cultural factors), two studies showed that women wearing a Niqab or Hijab had a higher odds of developing Vitamin D deficiency. However, another found no such association. One study did no analysis was directly regarding modest dress.

Discussion
There is some consistency between studies that Orthodox Jews and those who wear Hijabs are at a greater risk of Vitamin D deficiency. However, each study focused on a different subgroup of the population. It is unclear what factors within these subgroups contributed to their deficiency. Additionally, there was conflicting data regarding the use of modest dress in the form of wearing Hijabs or Niqabs. More research is needed to describe the nuances of Vitamin D deficiency in these communities.

**Conclusion**
this research highlights the risk of vitamin D deficiency among ethnic and cultural minority groups, specifically the Orthodox Jewish community and individuals who wear hijabs. Modest dress and cultural practices can limit sunlight exposure, increasing the likelihood of deficiency. It is crucial to raise awareness, provide education, and equip healthcare professionals to address this issue. Tailored interventions and collaborative efforts can help bridge the gap between cultural practices and health requirements, ensuring the well-being of these communities.

**Introduction**
Vitamin D deficiency causes rickets in children and osteomalacia in children and adults. Both conditions cause softening of the bone and pain. Low vitamin D has also been linked with an increased risk of other diseases, such as osteoporosis, cardiovascular disease, diabetes, some cancers, and infectious diseases, such as tuberculosis. Rickets and osteomalacia due to vitamin D deficiency have been largely eradicated from the general population.

25-Hydroxyvitamin D (also often referred to as 25-OHD) is the major circulating metabolite of vitamin D. It is a precursor of the active dihydroxy metabolites, 1,25-dihydroxy vitamin D and 24,25-dihydroxy vitamin D. Serum 25-OHD levels are determined more by skin sunlight exposure than by dietary intake of vitamin D. This makes it a good proxy of Vitamin D absorption by sunlight which is why it is measured in most studies evaluating vitamin D status.

Recently, rickets has seen a resurgence among ethnic and cultural minority groups in some Northern European countries, such as the United Kingdom, The Netherlands, Denmark, and Australasia. The global prevalence of osteomalacia in adults is more difficult to gauge...
because there are fewer reports and because if asymptomatic, it can go undetected. However, it is reasonable to assume that in regions where rickets is prevalent in children, osteomalacia would be expected in adults, especially among pregnant women and the elderly.

The dress code required by religious tradition in Asian immigrants in the United Kingdom9 and Pakistani women living in Norway has been shown to cause low serum levels of 25 - OHD and Osteomalacia10. For this reason, there is reason to believe culture, including modest dress, may play a role in developing Vitamin D deficiency even in a sunny country (defined by more than 3000 Sun-Hours a year) such as Israel. Therefore, this literature review aims to evaluate the role of modest dress and culture on vitamin D status in groups such as Orthodox Jews and those who wear Niqabs or Hijabs.

**Methods**

Articles were individually retrieved through June and July 2022 by search in PubMed and Google Scholar. Papers were searched for by the keywords "Vitamin D Deficiency," "Jewish," "Orthodox," "Dress," and or "Hijab" excluding articles not in English. When searching these keywords in PubMed and Google Scholar, 1 page of results was generated with seven articles. All seven articles were then analyzed for relevance to the discussion of Vitamin D status and the role of Orthodox Jewish culture. All three articles were found to be relevant and were used for analysis.

**Review**

Mukamel et al. researched the vitamin D nutritional status of orthodox Jewish mothers and non-orthodox mothers living in proximity in Israel. They measured the concentration of 25-OHD serum samples obtained 48 - 72 hours after childbirth.

Serum was collected from 185 non-orthodox mothers at the Lis Maternity Hospital, Tel Aviv, and 156 samples were collected from orthodox mothers at the Ma'anei Hayeshua Hospital, Bnei Brak. Dietary vitamin D was less than 150 units daily in all women except for 46 orthodox mothers and 37 non-orthodox mothers who, during pregnancy, received daily multivitamin
supplements containing 400 units of vitamin D. None of the mothers received drugs known to alter vitamin D metabolism and none had malabsorption or hepatic/renal disease.

They found that the mean serum concentration of 25-OHD was significantly lower in the orthodox Jewish mothers at 48 - 72 hours after delivery at a level of 13.5ng/ml compared to that of the mixed non-orthodox population with a level of 18.5 with a P-value of <0.002. Vitamin D deficiency (< 5 ng/ml) and insufficiency (< 10 ng/ml) were more common in orthodox mothers (5.1% and 32.7%, respectively) than in non-orthodox mothers (2.7% and 13.5%, respectively). They also found that vitamin D insufficiency was more common in the winter than in the summer among non-orthodox mothers.

Since the orthodox and non-orthodox populations of this study lived in the same metropolitan area, and since dietary behavior patterns contribute little to the nutritional status of vitamin D, they attributed the higher prevalence of vitamin D deficiency and insufficiency among the orthodox women to their modest dress code, which decreases exposure of the skin to sunlight.

It is important to note that Mukamel et al. defined vitamin D deficiency as < 5 ng/ml and insufficiency as < 10 ng/ml. However, as seen in the other studies, it is scientifically accepted to define deficiency as less than < 20 ng/ml. The consequence of defining deficiency this way is that those labeled deficient are likely considered severely deficient. Thus, orthodox Jewish mothers are likely more severely Vitamin D deficient than non-severely vitamin D deficient (as seen in figure 1).

In 2008 the American Association of Pediatrics released new guidelines for Vitamin D supplementation for infants, children, and adolescents. At that time, the ministry of health in Israel adopted similar guidelines but no recommendation for children over 1-year-old. For this reason, Korchia et al. decided to evaluate vitamin D deficiency in children that may benefit from improved supplementation guidelines.

They conducted a prospective cross-sectional study from October 2009 to November 2010. They studied children from 1.5 years old to 6 years old. The children came from five different primary
care clinics of the Meuhedet Health Services: four were from the Jewish sector, and one was in a primarily ultra-orthodox city. All children visited the clinics for primary health care. However, children with chronic diseases or prematurity were excluded.

Blood samples were obtained from each participant for several routine labs, including 25-OHD levels. A commercially available kit determined 25-OHD levels. Parents of the children who had their blood samples run were interviewed utilizing a questionnaire. The questionnaire included personal and demographic details, medical history, sun exposure, and dietary habits.

Serum 25-OHD levels were obtained from 247 children (144 males and 103 females). There were 188 children (76%) from ultra-orthodox Jewish families and 59 (24%) from Orthodox or secular homes. Parents of 230 of the children (93%) completed the questionnaires. Vitamin D sufficiency was defined as a 25-OHD level > 30 ng/ml, insufficient was defined as a level between 20 and 30 ng/ml, and deficiency was defined as a level < 20 ng/ml.

The mean 25-OHD level was 25.7 ng/ml. 25-OHD was sufficient (> 30 ng/ml) in only 73 children, insufficient (20–30 ng/ml) in 104 (42.1%), and deficient (< 20 ng/ml) in 70. The mean 25-OHD level in the age group 1.5 to 3 years was 28.6 ± 10.7 ng/ml, significantly higher than that of 3 to 6 years, which was 24 ± 9.2 ng/ml. This indicates that the prevalence of vitamin D insufficiency was more common in 3 to 6-year-olds than in 1.5 to 3-year-olds. The same finding was seen with Vitamin D deficiency. Vitamin D deficiency was more common in the winter and autumn than in summer and spring. There was no statistically significant association between serum vitamin D level and the duration of sun exposure in hours/day. Children with more siblings were found to have lower levels of Vitamin D.

Serum 25-OHD levels of children attending kindergartens with long hours were significantly higher than those attending kindergartens with fewer hours or those who stayed at home. In addition, the prevalence of vitamin D deficiency was higher in children from ultra-orthodox families than in others, but this difference was not statistically significant.
However, this study differentiated between orthodox and Ultra-orthodox Jews, which is not commonly done. Ultraorthodox and orthodox Jews share common values, including dress and ample indoor time. The distribution of the results (as seen in Figure 2) show widespread Vitamin D deficiency, which we expect since the entire cohort comprises both orthodox and Ultra-orthodox Jews.

Tsur et al. researched the effect of different modes of dress on vitamin D levels in healthy young Orthodox and ultra-orthodox male students in Israel. Ultra-orthodox Jewish lifestyle encourages modest dress and indoor scholarly activity. It represents a risk factor for vitamin-D deficiency and a worldwide problem previously underestimated in sunny countries. This study aimed to characterize the vitamin-D status of religious Jewish males according to sun exposure and outdoor activity and the correlation between serum 25-OHD and PTH levels.

Seventy-four young adult males were recruited from three Jewish higher education institutions in Jerusalem. In the first school, ultra-orthodox students wear traditional clothing, live in dormitories, and stay mostly indoors. In the second school, ultra-orthodox students were dressed similarly but had regular outdoor activities. Finally, religious students participate in a mixed army/school program in the third school. A questionnaire estimated weekly outdoor activity time and degree of sun exposure.

All participants completed a questionnaire, and blood samples were drawn for serum calcium, phosphorus, parathyroid hormone (PTH), albumin, and 25-OHD levels. The questionnaire included short-sleeve wearing, level of outdoor activity, weekly sunlight exposure time, and skin type (fair, dark, intermediate). An "index of sunlight exposure" (SEI) was calculated as the product of the responses to four questions related to duration and degree of sun exposure and skin type. Laboratory tests were conducted by standard technique. Levels below 20 ng/ml were defined as vitamin D deficiency, and levels below 10 ng/ml as severe vitamin D deficiency. Bone density measurements were performed by dual-energy X-ray absorptiometry (DEXA). The index of sunlight exposure was positively correlated with 25(OH)D ($r=0.54$, $p < 0.0001$) and was significantly lower in Schools 1 and 2 compared to School 3 subjects. 25 (OH)D levels were 8.9 ± 3.6, 10.2 ± 5.7, and 21.7±10.4 ng/ml (mean ± SD) for the three schools, respectively.
After adjusting for differences in sun exposure, differences in 25-OHD levels (9.2, 10.0, and 16.8 ng/ml for the three schools, respectively) remained significant.

Defining vitamin D deficiency as serum 25(OH) D levels below 20 ng/ml implies that 100% of school one, 91% of School two, and 51% of school three students were deficient. Defining severe vitamin D deficiency as 25(OH)D below 10 ng/ml implies that 65% of school one, 65% of school two, and 12% of school three students were severely vitamin-D deficient.

Out of 74 subjects, only four (4.5%) had a serum 25-OHD level above 30 ng/ml, and only seven (9.5%) had a level above 20 ng/ml. Thirty-five (47%) subjects had levels below 10 ng/ml. They concluded that severe vitamin D deficiency is highly prevalent in ultra-orthodox males. Despite rare secondary hyperparathyroidism, they represent a significant, previously unrecognized, high-risk group for metabolic bone disease.

Although not directly aimed at assessing Vitamin D deficiency, a study by Taha et al. could show the consequences of low Vitamin D levels. This study aimed to examine bone mineral density (as measured by DEXA scan) due to the Ultra-orthodox Jewish lifestyle. 50 healthy, ultra-orthodox Jews were recruited, ages 15 to 19 years (30 males and 20 females). Calcium, protein, vitamin D intake, and weight-bearing exercise were assessed using a questionnaire. In addition, serum levels of calcium, parathyroid hormone, and 25-OHD were measured in serum. Lumbar spine bone mineral density was also assessed. Bone mineral density of vertebrae L2 to L4 was significantly decreased in the ultra-orthodox population compared with the standard population. Eight boys (27%) had L2 to L4 bone mineral density scores low enough to be defined as osteoporosis in adulthood. The mean serum 25-OHD level was 18.4 ng/mL.

Though not explicitly stated in the study, a mean 25-OHD of 18.4 ng/mL would be considered deficient by most standards. It is reasonable to say that the Vitamin D deficiency seen can be a contributing factor, considering the disproportionate number of participants with low bone mineral density.
These studies provide some insight (though only minimal) regarding the status of Vitamin D among orthodox Jews. However, we will also look at studies of similar lifestyles and Vitamin D status in the non-Jewish population to better understand the relationship between indoor activity and modest dress on Vitamin D. The studies below discuss the role of wearing a Hijab or Niqab. The Hijab is a black dress covering the whole body, whereas the niqab covers the whole body except the face and hands.

Batieha et al. aimed to study the Vitamin D status in Jordan due to dress style and gender discrepancies. A national population-based household sample was used to recruit participants. This sample spanned 12 governorates across Jordan. The health director in each governorate was asked to identify a minimum of 2 health centers for participants to study. A systematic sample of households was selected from the aforementioned health centers. A questionnaire was administered to collect information about socioeconomic factors and anything that may influence serum 25-OHD concentrations. Participants were therefore questioned regarding sun exposure, use of sunscreen, and the extensiveness of body covering. Vitamin D status was then assessed in a sample of 4,590 participants aged 18 years or older (1,128 males and 3,462 females).

The prevalence of low vitamin D status (defined as a level of 25-OHD <30 ng/ml) was 37.3% in females and only 5.1% in males. They concluded that the likely reason for this finding was the difference in dress between women and men in Jordan and the social norms that women stay indoors and leave the house only when necessary (often only with their husbands' permission). Dress style in females was also independently related to low vitamin D levels. Women wearing a Hijab had an adjusted OR of 1.7 (p = 0.004) for developing low Vitamin D levels. Women wearing a 'Niqab' had an adjusted OR of 1.5 (p = 0.061) for low vitamin D levels compared to western-dressed women.

Odhaib et al. conducted a cross-sectional study of premenopausal women who wore a niqab (n = 64) of comparable age and a weight-matched control group of women who only wore the Hijab (n = 60). Serum 25-OHD, calcium, parathyroid hormone (PTH), phosphorus, and alkaline phosphatase were measured. Statistical analysis was then conducted using an independent sample t-test and Mann-Whitney-U test.
They found no significant difference between the Vitamin D levels of the two groups. However, they found that non-obese women who wore niqabs were seven times more prone to vitamin D deficiency than non-obese women who wore hijabs. Though there was no statistical significance between Hijab and niqab (aside from the non-obese women), they acknowledged that both hijab and niqab-wearing women are likely at risk for vitamin D deficiency compared to the standard population due to their modest dress. This study proved that the nuanced difference in traditional garb did not significantly affect that relationship.

Hussain et al. studied the relationship between Vitamin D Deficiency and the risk factors in Muslim housewives of Quetta. Housewives in Quetta are at risk for several reasons. First, they spend much of their day cooking and cleaning, among other household chores. Thus, they have minimal outdoor activity. Additionally, they wear hijabs and have minimal exposure to sunlight. A cross-sectional study was performed in which housewives aged 18 or older from the outpatient department of a hospital in Quetta were recruited. The sociodemographic and daily duration of sunlight exposure were collected in addition to serum 25-OHD levels.

Among 151 housewives, 58.9% had Vitamin D deficiency (defined as <20 ng/mL). Of those with Vitamin D Deficiency, there was a higher proportion of females aged 18-30 years and a lower proportion of college graduates. They concluded that Vitamin D deficiency is highly prevalent (58.9%) in housewives of Quetta and is associated with educational standing and milk consumption. However, since most, if not all, participants were Hijab wearers, no analysis was conducted directly regarding modest dress. A high deficiency prevalence indicates that decreased sun exposure is likely a driving cause of deficiency among the factors they analyzed.

Ojah et al. studied the effects of wearing a hijab compared to western wear on Vitamin D status in Nova Scotian Women. This study used a cross-sectional, matched pair design. A sample of 11 women dressed in head-to-toe garments was compared to 11 women who were matched to a study subject and wore a western-style dress (defined by openness to expose skin on the arms, legs, and face). Participants were recruited via mass emails, flyers, brochures, posters, or brief presentations at the Muslim Student Association. Comparison group women were recruited via
flyers, posters, and word of mouth from interested women to others. Confounding variables such as BMI and physical activity level were also analyzed.

They found that serum 25-OHD measured in women in Nova Scotia who wore concealing clothes was lower compared to the secularly dressed women. Therefore, they concluded that their lower 25-OHD could be attributed to their attire. Though a small sample size, this study demonstrates what has been seen in similar prior studies.

**Results**

The effects of modest dress and culture such as that of Orthodox Judaism and the wearing of Hijabs/Niqabs on vitamin D deficiency have not been extensively studied. However, the articles above serve as a foundation for future projects. All the studies discussed above demonstrated Vitamin D insufficiency and deficiency in one or more subpopulations of the orthodox Jewish community and those wearing Hijabs/Niqabs.

Mukamel et al. discovered post-partum women within the orthodox community to be more vitamin D deficient when compared to their Arab counterparts. They described their findings to be a manifestation of their dress. Korchia et al. discovered differences in children of different ages and showed a high deficiency prevalence in ultra-orthodox and orthodox patients. However, they found no significant difference comparing ultra-orthodox to orthodox/secular patients. The lack of significant difference can be due to the unprecedented differentiation of orthodox vs. ultra-orthodox Jews. Tsur et al. discovered that severe vitamin-D deficiency is highly prevalent in ultra-orthodox males and statistically correlated to sun exposure based on religious customs. Lastly, Taha et al. observed decreased bone mineral density in ultra-orthodox teenagers / young adults, possibly due to low vitamin D levels.

Several studies regarding Hijab and other traditional dress wear have been discussed to support the notion that dress heavily affects vitamin D levels. Some of these studies regarding this form of skin-concealing clothing have demonstrated the effects of lower 25-OHD levels. However,
some of these studies have not proven directly but demonstrated widespread deficiency in these populations, likely due to dress and lifestyle.

**Discussion**

All of these studies indicate a similar theme. Due to modest dress and lifestyle, vitamin D deficiency is more prevalent among the orthodox Jewish population than in other populations. However, there is a minimal amount of data since there are only a few studies, and there are inconsistencies among the few we have discussed. All the studies discussed looked at different populations. The first is women, the second is children ages 1-6, and the third is young adult males. The lifestyle and cultural responsibilities among these sub-populations significantly differ.

Additionally, the populations have several confounding variables. For example, age and gender can impact Vitamin D absorption and metabolism. The study by Mukamel et al. only looked at females, and the study by Tsur et al. only looked at males. These studies are not able to account for gender. In addition, all of these studies had a narrow age range of participants. This makes it difficult for each study to identify different stages of the life cycle and their effects on Vitamin D deficiency. The studies also showed a varied response to the season.

Of note, only one study of orthodox Jews took place outside Israel. Orthodox Jews in other areas are potentially at different risks of Vitamin D deficiency. Additionally, none of the studies quantified modest dress, which can severely impact sun exposure. Notably, only studies 2 and 3 quantified exposure to the sun.

Studies discussing Hijabs and Niqabs shed some light on modest dress and vitamin D status. However, orthodox Jewish dress can vary significantly from other forms of traditional concealing clothing. Additionally, most studies discussing Hijabs and Niqabs had difficulty quantifying the relationship between dress and vitamin D levels. Often, they compared two groups that likely had similar outcomes, had only a minimal number of participants, or could not compare to westernized dress.
There are many limitations due to the lack of data. Only a limited number of studies have explored culture and modest dress Vitamin D deficiency. Unfortunately, not much can be gathered from each study's narrow range of variables. This indicates the need for further study and evaluation of the Orthodox Jewish lifestyle and Hijab wearing on Vitamin D deficiency.

If further research were to be done on this topic, we would suggest a prospective cohort study or cross-sectional study. For example, researchers can examine vitamin D data levels collected at standard well-visit screenings in a family practice office that serves specific communities like the orthodox Jewish community. If a large enough practice is selected, orthodox Jews can be compared to non-orthodox Jews and non-Jews of similar geographic regions. Confounders such as age, gender, season, and ethnic origin (Ashkenazi vs. Sephardic origin) should all be considered. Importantly, this study should be conducted in the United States to compare it to the current studies of orthodox Jews in Israel.

**Conclusion**
This research highlights the potential risk of vitamin D deficiency among ethnic and cultural minority groups, specifically focusing on the Orthodox Jewish community and individuals who wear hijabs. The studies reviewed shed light on the impact of modest dress and cultural practices on vitamin D levels, emphasizing the need for further investigation and awareness in these populations.

Orthodox Jews and hijab-wearing individuals often adhere to dress codes that prioritize modesty, which can limit exposure to sunlight, a primary source of vitamin D. Consequently, these communities may be at a higher risk of developing vitamin D deficiency compared to the general population.

Addressing this issue requires a multifaceted approach that takes into account the cultural, religious, and social aspects associated with modest dress. Education and awareness campaigns within these communities can play a crucial role in promoting the importance of maintaining adequate vitamin D levels and the potential health consequences of deficiency.

Moreover, healthcare professionals should be equipped with the knowledge and tools to identify and address vitamin D deficiency among ethnic and cultural minority groups. Encouraging
regular screening for vitamin D levels and providing appropriate supplementation or dietary advice can help mitigate the risks and improve overall health outcomes.

It is essential to emphasize the importance of maintaining a balance between cultural practices and health requirements. While cultural and religious customs are of significant value, it is crucial to ensure that individuals have access to accurate information and resources to make informed decisions regarding their health.

Further research is needed to explore strategies for increasing vitamin D levels in these communities without compromising their cultural values. Collaborative efforts between healthcare providers, community leaders, and policymakers can help develop tailored interventions that address the unique challenges faced by Orthodox Jews and hijab-wearing individuals in maintaining optimal vitamin D levels.

By acknowledging and addressing the issue of vitamin D deficiency in ethnic and cultural minority groups, we can work towards ensuring the health and well-being of all individuals, irrespective of their cultural backgrounds or religious practices.

References


