2.REVIEW OF LITERATURE

The review of literature appertaining to the present study entitled "**Impact of Nutrition Intervention and Dress Code on Vitamin D Nutriture of Muslim Women**" is discussed under the following heads:

2.1.Lifestyle Pattern and Cultural Practices among Muslim Women

2.2. Health and Nutritional Status of Muslim Women

2.3. Vitamin D Nutriture among Muslim Women

2.4. Strategies to Combat Vitamin D Deficiency

2.5. Digital Health Intervention

2.1. Lifestyle Pattern and Cultural Practices among Muslim Women

2.1.1 Demography and cultural background

Culture and demography play a vital role in shaping the behaviour and lifestyle of an individual, thereby the experiences of Muslim women vary widely between and within different societies. At the same time, their adherence to Islam is a shared factor that affects their lives to a varying degree and gives them a common identity that may serve to bridge the wide cultural, social, and economic differences between them (Bachrach, 2014; https://www.legalserviceindia.com/legal/article-3659-status-of-women-in-islam.html). More than half a billion women in the world are Muslims, with a major portion living in the Middle East, North and Central Africa and Southeast Asia. Muslim women aged between 15 to 64 years constitute about 8% of the world's total population.Muslim women and girls of all ages make up approximately 12% of the world's population as of 2015 (Azid, 2020) India contributes 200 million counts towards the world Muslim population. According to the last census of India in 2011, the Muslim population was the second-largest after the Hindu population, though India is among Muslim minority country it has the third highest Muslim population in the world with 5.86 per cent of the population in Tamilnadu Under National Commission for Minorities Act in India (1992), Muslims are one among the five groups ascertained as the minority (Alan, 2018; Jayal, 2006).

The lifestyle of Muslim men and women worldwide is derived from the universal Islamic laws, in accordance with which the role played by the women in the family forms the basis for the laws pertaining to them, considering the family as the central unit of the society. Certain characteristics of the Muslim Women's lifestyle are unique and

different from other women worldwide. The primary sources that influence the lifestyle of Muslim women are Quran and Hadith and secondary sources are Ijma and Qiyas. The Quran is the holy scripture of the Muslims revealed to Prophet Mohammad (SAW), which is believed to be the direct words of Allah. Quran is considered as decisive authority jurisdiction in matters of Islamic practice. The fourth chapter in the Quran named Surah- Nisa which means women discusses the laws and problems related to Muslim women (Bassiouni, 2012; Esposito *et al*., 2007).Hadith is a collection of teachings, lifestyle and practices of the Prophet recorded in Islamic Hadith literature, in which matters are not mentioned in the Quran the practices observed in the life of the prophet and his wives recorded in the Hadith are followed and is thus recognised as the successive source of influence (Kenneth, 2020). The secondary influence of Ijma is seeking consensus of Scholars in the community and Qiyas is analogy logic applying general principles of Islam (Jasleen, 2021; Qureshi, 2020). Lifestyle based on these principles followed by Muslim women are majorly considerate about women's operation is the home in which she is the dominant figure. In the Muslim community, women's major role is in domestic life aspects as ritual specialists, healers and caretakers of their homes. The prophet said that Paradise is under the feet of mothers. Hence a Muslim women's major roles are marriage, childbearing and child rearing (Meyer *et al*., 2016). The Islamic laws also emphasise women carrying out their duties being at distance from other men. Therefore, Muslim women prefer women institutions, women physicians and women teachers. Studies among Indian Muslim women comparing the women of minority communities has revealed that 43 per cent to be economically backward, literacy levels below the national average and thereby low employment, highest teenage pregnancy and high childbearing rate, it also suggested providing Muslim women teachers may improve education among these (Attum*et al*., 2019). Hence, the present day scenario of men and women working and studying together may affect different aspects of Muslim Women's life such as education, dress code, employment, diet etc. (Siraj and Sanwar, 2021).

2.1.2 Marriage and children

In Islam, nikah (marriage) is an outstandingly serious understanding. Islam hasn't provided a definite age, whether for the men or even for the women. As per the Quran, every individual who is genuinely, intellectually and monetarily prepared to do so doing commits going into a marriage (Qur'an 4:58). Islam has lately recommended considering

marriage at a young age. Since marriage may keep a person from sins at a youthful age. (Garg, 2021). Hence, early marriages are more prevalent in the Muslim community. Islamic laws have no specification on the number of children but on the ground of Islamic laws that prohibits acts causing harm or hardship to an individual. The number of children can be planned considering the health, financial and child rearing capacity of the women (Roudi-Fahimi, 2004) Data obtained from 2000 and 2004 for Malawi Demographic and Health surveys conveyed mean age at marriage to be as low as 17.3 ±3.6 in 2000 and 17.1± 3.5 among the Muslim women. In general, among the mainstream religious groupings, Muslims were more likely to marry at an earlier age (<18 years) than other religious groups in Malawi (Palamuleni, 2011). A household survey was conducted in Imphal East and Thoubal districts among 512 Muslim women the results confirmed a secular trend among Manipuri Muslims in the last decade showing a delayed in the age at marriage and age at first conception and reduced mean live birth and mean conception. The age at marriage, age at first conception, education, occupation and types of the family have a significant effect on fertility, also a preference for more sons was observed in this study leading to an increase in the overall fertility rate (Asghar*et al*., 2014). Census data of 2001 and 2011 shows interesting and striking information about the changing situation of marital status among the different religions of Assam, Hindu women have the highest married proportion followed by Christian while Muslims was the lowest, depending on the socio-cultural practices, economic conditions and the level of educational attainment, the age at marriage varies among the religious groups. The proportion of women being married at a younger age has been less (Das and Das, 2018). These studies supported a rise in the age at marriage among Muslim women.Alomair*et al*. (2021) in a review involving 22 countries observed multiple factors influencing the reproductive health of Muslim women. Contributing factors identified were poor reproductive health knowledge, practices, fear of side effects, particularly fear of infertility, socio-cultural, religious and psychosocial factors such as shyness, modesty, belief that it was against their religion to decide on how many children to have and contribution of Muslim women on their own fertility choices was less significant concerning other family members. These interrelated factors contributed to more high fertility, the number of children and poor reproductive health among Muslim women.

2.1.3 Education

According to Islamic laws for educating females is not different from males as it is considered fundamental to enable them to understand, believe and follow the principles of the religion. Quran had encouraged aspiration for knowledge irrespective of gender and Prophet Mohammed (SAW) has stated that " Seeking knowledge is mandatory for every Muslim" Many of the women in Islam including the prophet's wives have been influential scholars and jurists, women education in different fields was recognised (Abukari, 2014). Even though the religion exhibited a positive outlook towards education, studies conducted in 151 countries revealed low educational status among Muslim women when compared with men and women of other religions. In sub Sahara region of Africa young Muslim women between 25 to 35 years had not attended school. Also, Muslim majority countries like Morocco, Pakistan, Bangladesh, Yemen, Gambia etc. had lower levels of education and gender gap when compared with Muslim minority countries. (McClendon *et al*., 2018). However, the World Bank and UNSECO (2018) indicated several Muslim majority countries along with Saudi Arabia, Indonesia, UAE, Iran, Jordan, Malaysia and Turkey have achieved 90 per cent literacy with a rise in females showing a difference of seven per cent between genders. (Farooqi, 2020). On the other hand, Pakistan in 2017 had a Women literacy rate of 47 per cent. (Aaron, 2020). In India, the Muslim illiteracy rate (42.7%) was the highest single religion community illiteracy rate which was above the national rate. The Muslim female literacy rate was the lowest (51.9 %) followed by Hindu females (55.98%) in the country (Bano, 2017). A review study by Nasrin (2013) with secondary data from on education of Muslim women from Independence has pointed at the remoteness of schools, financial issues, discrimination and poverty to account for the low educational status among the Muslim women. In another study in the Malda district of West Bengal, the average female literacy rate was 57.84 per cent which was much low compared to the non-Muslim women population. The study suggested low literacy among Muslim women to be due to poverty, household course, male preference and early age at marriage. (Islam and Lubna, 2016). Literacy rates above 70 per cent in Muslim women have been recorded in two South Indian states, Kerala and Tamilnadu (Census of India, 2011).

2.1.3 Dress code

The dressing is designed to reveal aspects of the personality of the woman who wears it. Who is she, where she comes from, what is her social position and what she had achieved in the past? Especially, a traditional costume creates pride and identity of origin for the woman who wears it (Arvanitidou and Gasouka, 2011). For Muslim women adhering to modesty, the way of dressing has been commanded by God to be obligatory over both men and women, like the other Islamic laws, the dress code of Muslims is influenced by the two noble books the Quran and the Hadith. Two verses in Quran certainly states about the Islam dress code Quran 24: 31 which states "And tell the believing women to lower their gaze and guard their chastity, and not to reveal their adornmentsexcept what normally appears. Let them draw their veils over their chests, and not reveal their ˹ hidden˺ adornmentsexcept to their husbands, their fathers, their fathers-in-law, their sons, their stepsons, their brothers, their brothers' sons or sisters' sons, their fellow women, those ˹ bondwomen˺ in their possession, male attendants with no desire, or children who are still unaware of women's nakedness. Let them not stamp their feet, drawing attention to their hidden adornments" and Quran 33:59 states "O Prophet! Enjoin your wives, your daughters, and the wives of true believers that they should cast their outer garments over their persons: That is most convenient, that they may be distinguished and not be harassed". (Rizvi, 2021) According to Hadith, the prophet instructed women to cover their bodies except for their face and hands. Therefore it was not mandatory for all Muslim women other than the Prophet wives to veiling, but at present Muslim women prefer covering the whole body with a veil over face and hands like the wives of the prophet. Also clothes loose enough to not distinguish body shape, thick, decent and plain are some of the requisite suggested in view of Hadith (Huda, 2019). Based on the direction of modesty many dress patterns were developed covering partly or fully in different geographically diverse parts of the Islamic world. Six major forms of dress code were identified namely Shayla (Dupatta), Hijab, Jilbab (Abaya), Chaddar, Niqab and Burqa. Shalya is a scarf worn over normal clothing, The Hijab is a headscarf covering the head and neck, it is worn on regular clothing in many different shades mostly coloured.A Jilbab is a very full loose outer garment worn with a headcover such that face is exposed and hair covered The chador is a body-length cloak that covers the body and the head open in the front and usually black in colour, the niqab is a combination of a headcover and a very loose dress with a scarf

covering face except for eyes. The niqab and burqa are similar dresses except that a burqa covers the whole body from the head to ground even covering the eyes and it is the most concealing Islamic dress (Amer, 2014; Abdulla, 2012) (Figure 1).

Source: Rumaney and Sriram (2021)

Figure 1: Different types of Islamic Dress Practices among Muslim Women

The type of Islamic dress chosen by the women is influenced by factors such as geography, occupation, family etc. A study conducted by The University of Michigan's Institute for Social Research on the preference on the type of Islamic dress showed 63 per cent of women in Saudi Arabia and Persian Gulf Arab countries preferred niqab,burqa was popular among the Afghan women. In Pakistan, the preference for hijab, niqab and chaddar was similar. A hijab was preferred by the majority of the women in Iran and Turkey indicating a higher preference for head cover among modern women (https://www.huffpost.com/entry/female-muslim-dress-survey_n_4564188). Statistics by statista research department in France, indicated that 31 per cent of Muslim women in wore a hijab or niqab by 2019 (Statista, 2021). In Pakistan, among the university students of the Islamia University of Bahawalpur in Punjab, the majority of them wore Islamic dress from society in which the practice of Islamic dress code was

predominant. They also agreed that the dress did not affect their learning and provided security. (Arshad*et al*., 2012) in India women wearing a headcover is common among 84 per cent of the Muslims from which 64 per cent wear a burqa, 12 per cent niqab, 8 per cent Hijab and the remaining 11 per cent did not wear Islamic dress. The use of hijab (23%) was higher in South India when compared with other parts of India (4 – 7%) but the use of Burqa was less likely in women facing financial issues they preferred a niqab to burqa(Pew research centre report, 2021). Studies on Malay Muslim women reveal that most of these women took the hijab as a religious obligation instead of fashion motivation. Muslim women are still taking on the religious obligation of styling up the hijab. In Mumbai, India, among Muslim women, between the ages of 18 and 25 years, the veil was embedded with many meanings, including modesty, a means of connecting with the Muslim community, and a symbol of resistance. It was purposefully worn to promote a positive image of Islam and exhibit the self-efficacy of the Muslim community (Rumaney*et al*., 2021; Grine and Saeed, 2017). From the year 2013, February 1st of every year is celebrated as World Hijab Day to recognise millions of Muslims who choose to wear hijab as a sign of modesty (Raihanah, 2017).

2.1.4 Employment

According to Islamic history, Muslim society gave the right to women in education and development allowing them to take part in many spheres of society like military, civil, literature, administration, spiritualism, poetry etc. There are pieces of evidence of Khadijah the first wife of the prophet who was a merchant, Aisha one of the wives of the prophet and UmmeAtyqah and Wairyh among the followers who took part in the battles. Zainab, the granddaughter of the prophet was an Islamic scholar of theology. In administration, women accompanied their husband implying no restrictions on employment of the women (Elius, 2011) In spite of this, the employment of Muslim women has been low worldwide both in Muslim dominant countries and Muslim minority countries, A study using data from World Values survey 2010 to 2014 found low levels of employment among Muslim women when compared with non Muslim women, also there was not much of difference in education, status and employment between Muslim women in countries with 90 to 100 percent Muslim population and less than 20 percentage Muslim population and found no evidence suggesting Islamic law and value to influence lower employment of Muslim women.(Abdelhadi and England, 2019), According to the global gender report 2012 on female employment rate among

major Muslim nation in 2010, the female employment was near 50 percent (48 – 57%) in Indonesia, Nigeria and Bangladesh, between 13 to 17 percent in Afghanistan, Syria, Iran, Iraq and Saudi Arabia. (Hausmann*et al*., 2012) In India, according to the National Sample survey 1993 - 94 about 16 per cent of the Muslim women were employed. This low level of employment was attributed to low educational status, lack of interest and cultural norms (Maitreyi, 2004).

2.1.5 Diet

Among the many different factors, culture and region are two very important factors that can determine the diet of an individual or a community as such. The regional determinants include cuisine, food production and availability of foods, where the cultural determinants are specific to each religion (Monterrosa*et al*., 2020). Similarly, Islamic culture affects the diet of Muslims. According to the Quran, some foods are prohibited for Muslims. The Arabic word 'halal' which means lawful for permitted foods and 'haram' which means unlawful for forbidden foods is specified. Two main verses speak about the forbidden foods in the Quran (5: 3) " Forbidden to you is that which dies of itself, and blood, and flesh of swine, and that on which any other name than that of Allah has been invoked, and the strangled (animal) and that beaten to death, and that killed by a fall and that killed by being smitten with the horn, and that which wild beasts have eaten, except what you slaughter, and what is sacrificed on stones set up (for idols) and that you divide by the arrows; that is a transgression. This day have those who disbelieve despaired of your religion, so fear them not, and fear me. This day have I perfected for you your religion and completed My favour on you and chosen for you Islam as a religion; but whoever is compelled by hunger, not inclining willfully to sin, then surely Allah is most-Forgiving, most-Merciful" and Quran (2:219) "They ask you about alcohol and gambling. Say, in both, there is great sin and some benefits for people. And their sin is greater than their benefit." According to these verses alcohol, blood, pork, dead animals, flesh eating animals and birds are prohibited according to Islam apart from which all other foods were allowed (Armanios and Ergene, 2018). The Muslims are also commanded to fast during the month of Ramadan the 9^{th} lunar month of the Islamic calendar. Fasting is abstinence from food and drinks between sunrises to sunset. Fasting during Ramadan being the third pillar of Islam is made obligatory for all Muslims except the sick, travelling, children, elderly and during menstruation in women (Elnakib, 2021; Abolaban and Al-Moujahed, 2017). Majority of Muslims prefer the consumption

of halal foods and consider the concept very important according to a study 66.8 per cent of the Muslims preferred halal products while travelling, studies in China and Indonesia has shown interest of Muslim women in consumption of halal foods. Halal food consumption in chain restaurants among global consumers has predicted religiosity as an important factor through a theory of planned behaviour (Asnawi*et al*., 2018).

2.2Health and Nutritional Status of Muslim Women

According to WHO (2006) "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity", Nutritional status maintained by a balance in food intake and proper utilization of nutrients is a primary requisite for healthy living of an individual and a deviation from this may result in lifestyle disease. these lifestyle diseases is a condition associated with the habits of an individual or group of individuals lives such as unhealthy diet, physical inactivity and smoking which for a long time may manifest as non-communicable diseases specifically obesity, diabetes mellitus, hypertension, heart disease, cancer, infertility, osteoporosis etc. leading to mortal consequences. WHO has attributed 49 per cent of diseases and 35 million deaths by 2005 to be due to lifestyle diseases (WHO, 2005; Tabish, 2017). Women form the centre of a family, in the process of caring for the members they are more likely to ignore their health adding to this burden their health is affected by physiological factors such as pregnancy, lactation and number of childbirths and social and cultural factors which limit health and healthcare (Braveman and Gottlieb, 2014;Moya*et al*., 2014). Muslim immigrant women in Canada experienced low emotional, culturally and linguistically support due to a lack of knowledge about their religious and cultural practices among the native health services which caused a significant gap to meet their needs during pregnancy, labour and delivery, and postpartum phases (Reitmanova and Gustafson, 2008). Although an active, social lifestyle and a healthy diet do not contradict the Muslim way of life, Muslim women are expected to conform to norms and traditions such as remaining at home, dressing modestly, and considering their family and community needs before their own. This unique lifestyle of Muslim women may contribute to lifestyle diseases (Hassan *et al* 2021, Mpandzou*et al* 2016; Kalter-Leibovici*et al*., 2010).

Ganle (2015) perceived very low utilization of skilled maternal health services among Muslim women due to a religious obligation to maintain bodily sanctity through modest dressing and avoid bodily exposure, lack of privacy or contact with certain

people including male or alien caregivers. A similar hesitance was observed among Arab Muslim women immigrants in New Zealand in encountering the health system raising issues of culture and identity among the women, (Desouza, 2006). From District Level Household and Facility Survey (DLHS-4) survey, and National Family Health Survey (NFHS-3) 2005–2006. In Telangana, the nutritional status of children based on anthropometric measures was better for Muslims compared to other socio-religious communities, on contrary Muslim women of the reproductive ages were found to bear the burden of malnutrition and lifestyle diseases influenced by their distinct socio-cultural lifestyles (Unisa and Usman, 2021). Maternal mortality is the major cause of death in South East Asian countries and Nepal, a study among Muslim women has reported overall 24.5 per cent institutional delivery in Muslim women, the factors identified were women's autonomy, availability of health facilities, prohibition of the head of the family, less education and low family income among them (Pokhrel*et al*., 2012). Abdi*et al*. (2020) among Muslim communities in Kenya identified three key factors, misinterpretation of Islamic teaching on contraception, cultural beliefs and lack of women's decision power on fertility preferences as a key inhibitor to family planning among Muslim women leading to consequent unplanned pregnancies, increased maternal and infant mortality rates affecting the health of Muslim women, these studies also suggest designing health care understanding the communities concerns may help in improving health care access to these women. Supplementing this aspect a study was conducted in Assam among 1034 Muslim women belonging to the age group of 19 years and above of Kamrup district. The fertility of mothers by BMI range was found to be highest amongst underweight mothers and analysis for haemoglobin and BMI range shows the significant difference between normal, overweight and underweight women, revealing a trend in high fertility leading to poor nutritional status among the Muslim women (Haloi and Limbu, 2013).

Body Mass index along with weight and height are physiological indicators of an individual’s health and nutritional status. Delbiso*et al*. (2016) in Ethiopia found that Muslim women were more likely to be underweight; one possible reason suggested was high fertility rate and shorter birth interval among the Muslim women, which worsened their nutritional status. In the North African city of Melilla, intermittent fasting during Ramzan among Muslim women produced important changes in the nutritional status and body composition. More specifically, there was a significant reduction in total body

weight values, BMI, body fat percentage measured by bioimpedance and hip circumference. Significant differences were found in anthropometric values and body composition. These changes were more pronounced in the group of women over thirty years of age (López-Bueno*et al*., 2014) Among Muslim women in Bangladesh 36.5 per cent were underweight, 56 per cent were normal and 7.5 per cent were overweight, further lower risk of moderate to severe stunting was observed in comparison with non-Muslim women this was attributed to socioeconomic status or being Muslim majority state and not influence of culture on the women (Khanam*et al.,* 2018), Shankar et al. (2010) among Muslim women from Allahabad, found 70 per cent to be healthy and the remaining 30 per cent were underweight, No woman was found to be severely underweight among the Muslim women.Talukdar and Das (2016) assessed the nutritional status and morbidity patterns among 214 non-pregnant and non-lactating rural Muslim married women of different age groups in the Cachar district. The study revealed that most of the women from the reproductive group suffer from acute malnutrition problems while women belonging to the pre-menopause and menopause group face the problem of overweight and obesity mostly. The study also revealed that women under old age were suffering from more diseases than the other groups of women. Due to the biological changes in their different phases of life, the morbidity rate of the women is different for different phases. The morbidity rate increases according to their increase in age.

Literature indicated low physical activity among Muslim women and significant contribution of religion and cultural practices to the women's preferences for participation in physical activity (Miles and Benn, 2016). A study examining the physical activity pattern among Muslim women from 38 Muslim countries uncovered 43.7 per cent inactivity among the female population of the Muslim world, Further, a review of adult physical activity among 5 countries of the Arabian Gulf region revealed physical inactivity prevalence as high as 61.0% and 73.7% for males and females, respectively which may lead to obese or overweight individuals (Mabry *et al*., 2009; Kahan, 2015). Several studies have even pointed out overweight and obesity among the Arab population. In a study conducted in the Hadera district of Israel, the prevalence of obesity was 52 per cent among the Arab Women which was much higher in comparison with Jewish women (31%) and Arab Men (25%) and this prevalence was attributed to their lifestyle characteristics (Kalter-Leibovici*et al*, 2007), In Syria, obesity was the major health issue with the prevalence in Women 38.2 per cent higher than men particularly in

the age group between 46 to 45 years. Forty per cent of the Arab women were obese, an association was observed between obesity with age, consumption of certain foods, marital status and multiparity (Fouad*et al.*, 2006). A study analyzing the prevalence in 46 Muslim countries showed overall obesity to be 37.4 per cent from which 42.1 per cent of women were overweight. It also detected that women had a 1.48 times higher risk of obesity when compared with men (Kahan, 2015). Among Muslim Uyghur women in far western China, the prevalence of obesity was 15.1 per cent and overweight was 28.9 per cent. The BMI of these rural Muslim women correlated with blood parameters associated with diabetes and cardiovascular disease (Cong*et al*., 2014). In a study in Selangor, Malaysia among 547 Muslim women studied 19.4 per cent were obese and in the US when checked the anti belief among Muslim women a fat-positive belief was observed favouring obesity (Brewis and Wutich, 2014; Sidik and Rampal, 2009). From a cross sectional survey in the Kalutara district of Sri Lanka studying the social, cultural and economic determinants of obesity a social and cultural association with lifestyle and diet was observed showing high prevalence with 61.3 per cent of Muslim women exhibiting abdominal obesity, 39.6 per cent Obese and 34.4 per cent being overweight. (De Silva, 2015). In India, a study comparing the national family survey data from 1998 to 2016 to predict the course of overweight and obesity indicated that Muslim women had two times higher probability of becoming overweight or obese when compared with Hindu women, this higher risk of developing obesity may be due to less outdoor movements and high calorie food intake observed in these women (Shannawaz and Arokiasamy, 2018; Garg*et al*., 2010). Assessment in an urban slum of Chennai showed 88.9 per cent abdominal obesity among Muslim women and the association between abdominal obesity and religion was found to be highly significant (Anuradha*et al*, 2012). With this double burden of being Underweight on one hand and obesity on the other, Muslim women are prone to deficiency conditions and chronic lifestyle related illnesses.

In Ethiopia, an investigation on demographic and health-related risk factors of subclinical vitamin A deficiency revealed an association between higher subclinical vitamin A deficiency with not receiving vitamin A supplement over the year, also being from a Muslim household was strongly associated with higher levels of subclinical vitamin A deficiency. Among the risk factors identified, low levels of vaccination, high parity, and low levels of maternal awareness of vitamin A contributed to higher risks of vitamin A deficiency among Muslim children (Demissie*et al*., 2009) and among Muslim

women of Malda district exhibited diseases like anaemia (38.7%), goitre (5.4%), night blindness (6.31%), scurvy (4.5%) and another 6.3 per cent were affected by beriberi, pellagra, malaria, diarrhoea, jaundice, iron deficiency, cancer, typhoid, fever etc. due to low socio economic status and lack of health facilities (Ismail and Mustaquim, 2013).

Bansal*et al*. (2013) in a study undertaken in the Department of Physiology in collaboration with the Department of Pathology, Dr.S.N. Medical College and Umaid Hospital, Jodhpur, Western Rajasthan, India, using WHO classification detected a high prevalence of anaemia among the Muslim women (92.3%) less health awareness, extreme poverty, large family size, Multiparous and overcrowding leading to recurrent infection were identified as risk contributing to the condition. In Jodhpur, the prevalence of anaemia among Muslim women (92 %) was much higher than non-Muslim women (81%) on the contrary Thai Muslim women demonstrated a 37.8 percentage prevalence of Iron deficiency anaemia (Rattanawan*et al*., 2021). Though anaemia was not widespread in Israel, Bedouin Muslim women showed a higher prevalence of anaemia with haemoglobin levels below 8g/dl, when compared to Jewish women. The risk factor for severe anaemia among these women was due to more children, pregnancy and low adherence to treatment (Treister-Goltzman*et al*., 2015). A study conducted involving women visiting antenatal clinics of one hospital in Mysore, India on GDM disclosed higher Vitamin B12 levels among Muslim women (180 pmol/l) with 31.8 per cent deficiency compared to Hindu women (148.5 pmol/l) andfolate concentrations were lowest among Muslim women of 24.2 nmol/l this was attributed to major non vegetarian and low vegetable (folate) consumption (Krishnaveni*et al*., 2009) similarly in another study on the association between high maternal folate and better cognitive scores in children, low maternal folate concentrations was higher among Muslim women (6.0%) with a concentration mean of 28.5 ± 17.9 nmol/L (Sargoor*et al*., 2010).

In the Arab world, a high risk of Diabetes with CVD and obesity leading to metabolic syndrome was observed among Muslim women. In a systematic review study, the prevalence of metabolic syndrome among women Gulf Cooperative Council countries has shown prevalence ranging between 32.1 per cent to 42.7 percentage according to the third adult treatment panel and 36.1 to 45.9 per cent according to International Diabetes Federation (IDF) definition which was higher compared to other developed countries(Musaiger*et al*., 2012, Mabry *et al*., 2010). A population based retrospective research involving Muslims in 13 countries namely Algeria, Bangladesh,

Egypt, India, Indonesia, Jordan, Lebanon, Malaysia, Morocco, Pakistan, Saudi Arabia, Tunisia, and Turkey it appeared that type 2 diabetes was more common among women than men (Salti*et al*., 2004). In Morocco, among 15 year and older Sahraoui women, 6.4 percentage were diabetic and 5.5 per cent had impaired glucose tolerance age, obesity, hypertension and family history were identified as influencing factors (Rguibi and Belahsen, 2006). In another study conducted among the Muslim population in Manipur, the prevalence of diabetes was 15.3% among the female population (Shah and Afzal, 2013). Spatial clustering of Diabetic women from reproductive age group at the district level in 99 districts in South India, Kerala and Tamilnadu were two hot spots identified with high blood glucose and very high blood glucose, also Muslim women with normal BMI had shown a positive correlation with prevalence of high blood glucose levels.(Biradara and Singh, 2020).In a study conducted in rural Assam GDM prevalence, of16.67% in Women (26–30 years) belonging to the Muslim religion and above the poverty line showed a significantly increased likelihood of developing GDM among these women (Chandra *et al*., 2020).

The health and nutritional status of the Middle East Arab and North African population revealed increased incidences of Hypertension and cardiovascular diseases as a result of the replacement of traditional diet with western diet containing increased processed food with high sugars, saturated fats and salt. Daily fat supplies were found to be high in Arab Middle east countries, ranging from 13.6% in Sudan to 143.3% in Saudi Arabia. (Fahed*et al*, 2012; Musaiger, 2002). Prevalence of cardiovascular risk factors among women in Saudi Arabia identified obesity (42%) and low physical activity (53 to 98%) to be high while moderate levels of hypertension(21.8%) and Hypercholesterolemia(25%) was also observed (Alshaikh*et al*., 2016). The prevalence of hypertension among Arab American women was 26.1 per cent and 48 per cent were pre hypertensive. This level was comparatively lower than men which were 45.9 per cent (Tailakh*et al*., 2013). In India, an analysis of the National Family Health Survey (NFHS-4, 2015–16) showed the existence of known 12.6 per cent hypertensive cases among the Indian Muslim Women (15 – 49 years) population (Kumar and Misra, 2021). The Muslim women living in Urban Slum Narkeldanga in Kolkata in the age group of 15 to 44 years, 19 per cent were hypertensive and 23 per cent were prehypertensive and the mean age of the hypertensive women was significantly higher than normal women (Kalam*et al*., 2019). In Delhi, in the Sunni Muslim population, a strong correlation was

absorbed between waist hip ratio and cumulative cardiovascular risks among the female group (Bansal and Joshi, 2016).

Gyedu*et al*., 2018 studying the perception of breast cancer among Muslim women found only 31 per cent to know about breast cancer and 16 per cent had examined for a concerning mass. Muslim and Buddhist subpopulation studies in Songkhla Thailand showed low cases of cervical and breast cancer were observed in the Muslim population with an odds ratio of 0.54 and 0.51 (Sriplung*et al*., 2014). A case control study of breast cancer in first generation migrant South Asian female population in England assessment under ethnic groups showed great heterogeneity in risk within the south Asian population and Pakistani and Indian Muslim women were found to be the highest risk compared to all other ethnic subgroups. Bangladeshi Muslims women were in the third position (McCormack, 2004). In Canada, despite a decrease in incidences of mortality with appropriate screening the Muslim immigrant population showed a high rate of cervical rate mortality with low incidence due to low screening influenced by cultural barriers, male physicians and lack of a family physician. (Vahabi and Lofters, 2016). In Indian Muslim women of reproductive age between 35 to 49 years using national family Health Survey data (2015 -2016) the incidences of cancer was in 242 per lakh Muslim women (Singh *et al*., 2021) In a study, at Chennai very low levels of cervical cancer was found among the Muslim women in all age groups between 19 to 75 years (Gajalakshmi and Shanta, 1993).

Research in the Iranian population has shown the overall prevalence of osteoporosis and osteopenia was 22.2 percentage of which 60 per cent of women were 50 years of age and above, In women below 50 years, 33 per cent had low bone mineral density, age standardized incidence rate was 215 per lakh women. It conferred 0.85 per cent of world hip fracture cases and 2.4 per cent cases were from the Middle East population (Shahnazari*et al*., 2013; Beyranvand and Mohammadi., 2009). A cross sectional analysis of Muslim women between 20 to 65 years in south west Sydney higher turnover in Muslim women which correlated with their Vitamin D levels (Osteoporosis International, 2018) In Morocco, the bone mineral density of postmenopausal women wearing a traditional concealing clothing covering the head, arms and leg and a family history of peripheral osteoporotic fractures showed an increased risk of osteoporosis (Allali*et al*., 2006). In Pakistan among young female students wearing Islamic clothes from the Dow university of health sciences, Karachi between 20 to 30 years of age

overall 70 per cent was osteopenic supportively another study in Karachi osteopenia was prevalent in 64 per cent of women below 30 years and 55 per cent of women above 45 years. In Khyber Pakhtunkhwa, 25 per cent were osteoporotic and 48 per cent were osteopenic, among perimenopausal and postmenopausal women in Peshawar a significant decrease in bone mineral density with increasing age was observed constituting a high risk of osteoporosis in future (Soomro*et al*., 2017; Fahimi,, 2004). In Kerala and Bangalore, India among the Muslim majority population in women above 40 years, 35 per cent had osteopenia in Kerala women which increased with age and 55 per cent osteopenia and 33 per cent osteoporosis among Bangalore women was evident (Seema*et al*., 2021; Babu*et al*., 2009).

Childbearing being an important aspect in the life of Muslim women of Jordan, a primary infertility rate of 3.5 per cent and secondary rate of 13.5 per cent has significantly influenced their physical, emotional, social, and spiritual health compromising the quality of their lives (Obeidat*et al*., 2014). In Pakistan, a study conducted in unit III of gynaecology and obstetrics showed the frequency of infertility to be 7 per cent of which the identified causes were an ovulatory failure in 22.1 per cent, Normal pelvis in 26.4 %, tubal blockage 14.4% and male factor in 21.9percent (Shaheen*et al*., 2010). In Indian Muslim women data from Indian National Family Health Survey IV, 2015 -2016 indicated the infertility rate to be 1.85 per cent in central, 1.62 per cent in the east, 1.67 per cent in north and 1.9 per cent in the south and 1.55 per cent in the west (Purkayastha and Sharma, 2021). A review study on the prevalence of postpartum depression indicated prevalence in the range of 10 to 52 per cent among the Middle east Arab women were the highest (52%) was in Egypt followed by Iran 40.7 per cent, Turkey, Israel and United Arab Emirates 24 to 27 per cent (Haque*et al*., 2015) Among Saudi primary care attendees 17 per cent had anxiety and depression, In the Middle East and North African women 13 to 18 per cent depression cases were present (Eloul*et al*., 2009). In Isfahan, Iran there were higher incidences of multiple sclerosis among women compared to 2007 showing an increase in the prevalence of the disease (Etemadifar and Maghzi, 2011).

2.3. Vitamin D Nutriture among Muslim Women

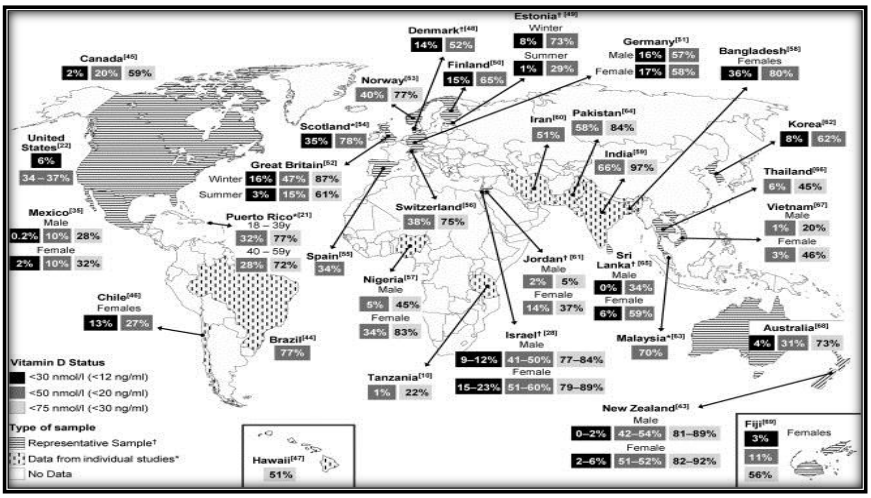
Prevalence

Research by Salek*et al*. (2008) on Iranian pregnant women and their newborns in the city of Isfahan, the presence of Vitamin D deficiency measured using 25 OH Vitamin D levels 26.1 per cent of the mothers and 53.4 per cent of the newborn were deficient. A multicentric study in Tehran Islamic Azad University hospital on 300 Iranian women of reproductive age group between 15 to 45 years, 257women were found to be deficient of which 122 women showed severe Vitamin D deficiency, only 14.8 per cent were normal indicating that majority of Iranian women of reproductive age group were Vitamin D deficient (Emdadi*et al*., 2016). A review applying the random effect model revealed significant incidences of Vitamin D deficiency as high as 61.9 per cent in Iranian women and 60.5 per cent in Iranian pregnant women calling for appropriate planning to address the issue (Tabrizi*et al*., 2018). Among Arab American women living in Dearborn Michigan in women 18 years and older women who followed Islamic pattern Vitamin D deficiency was endemic with very low levels ranging between 4 to 7ng/ml in the unsupplemented and supplemented group, these levels were much lower than that observed in rickets (8ng/ml) (Hobbs *et al*., 2009). Even when examining Bangladeshi non – pregnant Muslim women of mean age 40.66 ±13.80 years, who visited an endocrine clinic with symptoms of myalgia, fatigue, muscle cramps etc. their mean Vitamin D level was 17.27±7.47ng/ml, 72% were Vitamin D deficient and 22.66 per cent were insufficient (Shefin*et al*., 2018). Literature on the Middle East has revealed that women were more prone to Vitamin D deficiency than men, this low Vitamin D level has been predominant across all age groups. Literature also suggested old age, female gender, multi-parity, winter season, clothing style, low socioeconomic status and urban living have consistently been associated with low levels of Vitamin D in this region (Al-Mohaimeed*et al*., 2012). In the Middle East and North Africa region lowest serum25 OH Vitamin D levels were observed with a mean level between 11 to 20 ng/ml and prevalence of 54-90 per cent in pregnant women and 44–96 per cent in the adult's population and the studies has suggested doses of 1000 to 2000 IU/day to reach the desired levels of 25 OH Vitamin D (Chakhtoura, 2018). In the Gulf Cooperation Council (GCC) countries including United Arab Emirates, Qatar, Kuwait, Bahrain, Saudi Arabia, and Oman, Vitamin D deficiency remained alarmingly high. The prevalence of hypovitaminosis D is significantly high among the population of UAE, Saudi Arabia and many Middle Eastern countries, especially among women, despite abundant sunshine. In

parallel, there was an increase in the prevalence of chronic diseases like autoimmune diseases, cancer, type 1 diabetes mellitus, cardiovascular disease and Inflammatory bowel disease in these countries. Qatar biobank highlights disclosed a prevalence of 80 per cent in the Qatari population of which the higher proportion (65%) was evident in women (Singh *et al*., 2019;Haq*et al*., 2016). Female college students between 19 to 27 years of Qatar University who were natives of Qatar, Bahrain, Oman, Yemen, Syria, Palestine, Jordan, Egypt, Iran, Pakistan, Sudan, and Eritrea were studied the results pointed at a remarkably high prevalence of hypovitaminosis D (97%) with severe deficiency (25 (OH) D <10ng/ml) in 51 per cent of the female (Sharif *et al*., 2011).

A systematic review prevalence in the kingdom of Saudi Arabia among population including pregnant women, lactating women, children, adults found 81% to have levels of 25OH Vitamin D less than 20 ng/mL which was similar to other Gulf countries and an association of Vitamin D nutriture bone health and insulin resistance was apparent, another study in King Fahad Medical City in Riyadh, Saudi Arabia among the pregnant women 50 per cent were deficient and 43.8 per cent were insufficient (Nasser and Al-Daghri, 2018; Al-Faris, 2016). Zhang *et al*., 2016 analysed the adult participants of the first National Nutrition Survey of the State of Kuwait Vitamin D levels among women revealed 46.8 per cent to be insufficient (25(OH)D - 12 to19.9ng/ml) and 67.2 per cent (25(OH)D <12 ng/ml) to be deficient. Vitamin D inadequacy and deficiency were also associated with two-fold increased odds of diabetes compared to the Vitamin D sufficient nutriture. In Muscat, Oman in a study associating Vitamin D nutriture with anthropometry in the age group of 18 to 55 years Women (11.28 ± 5.0) as compared to men (14.72 ± 6.7), had markedly lower concentrations of mean 25 OH Vitamin D the total prevalence in the population was 87.5 per cent which was much higher in comparison with British, European, Hispanic, and African Americans (Abiaka*et al*., 2013). A serum 25 OH Vitamin D assessment of semi-nomadic Fulani Muslim women from northern Nigeria, who majorly consumed animal foods rich in Vitamin D 83 per cent of the women showed hypovitaminosis D this high prevalence may be the reason for elevated risk for rickets in children and bone fractures in adults in the region (Glew*et al*., 2010). In Pakistan among the pregnant women in urban Karachi, the incidence of Vitamin D deficiency in both pregnant women and their neonates was 97 per cent; similarly, in Jhelum Pakistan, the Vitamin D deficiency was much higher (89%) among pregnant women when compared with non pregnant women (54%)

(Nasir*et al*., 2018) Gannagé-Yared*et al*., 2009 compared 251 osteoporotic women derived from the Muslim and Christian community in Lebanon who participated in a Vitamin D international epidemiological study the prevalence of Vitamin D inadequacy was 84.5 per cent Muslim participants had lower 25(OH) Vitamin D levels compared with the Christians. In a case control study, the median Vitamin D level among Muslim women was 21.2 ng/ml which was much lower than the level of the total population studied, All the Muslims recruited into the study had Vitamin D levels ≤30 ng/ml (Sebastian *et al*., 2015). Allali*et al*. (2009) undertook research to determine the prevalence and factors influencing Vitamin D nutriture and found the 91percent of women to be Vitamin D insufficient, Lack of sun exposure and veiled clothing style was the most important factors identified, women with hypovitaminosis D also showed a high bone turnover. In India among non- pregnant and non- lactating healthy women in Kashmir valley with a majority Muslim population 94 per cent of women were Vitamin D deficient, this deficiency was equally prevalent in both rural and urban areas, also Serum 25 OH Vitamin D levels showed significant relation with sunlight exposure among the women (Bhat*et al*., 2021).Even in Delhi among pregnant Muslim women between 18 to 40 years recruited from Kasturba hospital 39 per cent were Vitamin D inadequate and 37.5 per cent were Vitamin D deficient, 7.5 per cent of them had preeclampsia of which all were Vitamin D deficient similarly 6.5 per cent had GDM and 2.5 per cent were Vitamin D deficient. An association of Vitamin D nutriture and adverse maternal and fetal outcomes was noticeable (Ajmani*et al*., 2016).



Source: Palacios and Gonzalez, 2014

Figure 2: Global Prevalence of Vitamin D Deficiency

Cultural risk factors influencing Vitamin D nutriture

Vitamin D deficiency is a global health issue. The prevalence of Vitamin D deficiency from different studies showed a pattern of higher incidences in Muslim majority countries and higher incidences among women compared with men. These countries lie in proximity to the Tropic of cancer and receive ample amount of sunlight necessary for the production of Vitamin D. High prevalence of deficiency indicates the contribution of other factors in determining the Vitamin D nutriture of the women (Siddiqee*et al*., 2021; Palacios and Gonzalez, 2014) the identified risk factors in this population are as follows:

Low sunlight exposure

Islamic Dress

With reference to the guidelines offered in Quran and Hadith, Muslim women appear wearing concealed modest clothing when outdoor this cultural practice may limit sunlight exposure and increase the risk of Vitamin D deficiency. A comparative study among Arab premenopausal women (20 – 35 years) between groups wearing Western-style clothing, hijab covering entire body except for face and hands and who wear burqa with an entire body covered proclaimed majority of participants in all three groups exhibited Vitamin D deficiency the lowest Vitamin D levels were observed among women in hijab and burqa group also there was an elevation in bone turnover markers emphasizing the influence of Islamic dress code on Vitamin Dnutriture of the women (Al-Yatama*et al*., 2019). In an identical study conducted in Jordan of Middle east during summer and winter seasons, the prevalence of hypovitaminosis D was 62.3 per cent in the study groups as a whole, both dress styles covering totally or nearly showed significantly lower Vitamin D levels than men, suggesting higher Vitamin D deficiency among the women population (Uzrail*et al*., 2021). Even in a prevalence study among the Jordanian women 60 per cent were deficient and 96 per cent were insufficient, 1.60 times higher prevalence in hijabi and 1.87 times in niqabi women was observed (Nichols *et al*, 2012). Buyukuslu *et al*., 2014 in a cross sectional inquiry among women of mean age 20.9 ± 2.1 years at Istanbul Medipol University differentiated women wearing Muslim style clothing (covered) from the others, the mean serum 25 (OH) Vitamin D of the covered group was 21.1 ± 6.7 which was lower when compared to the other group (29.7 ± 3.1) and the difference in levels was significant and showed negative

correlation with duration of wearing Islamic dress. From a match pair design study comparing Muslim women wearing Islamic concealed dress with women who dressed according to western norms living in northern maritime in Canada the mean Vitamin D levels was 16ng/ml in women wearing Islamic dress and 32.4ng/ml in women wearing western clothing (Ojah and Welch, 2012) A similar study in 13 GP of Rhone Alps area on veiled and unveiled women exhibited as expected, 25(OH)D serum level was significantly lower in veiled women 8.04ng/ml compared to 15.46 ng/ml in unveiled women, though both groups were deficient seniority was higher in the veiled group (Le Goaziou*et al*., 2011). Odhaib*et al*., 2021 carried out observational research among women of median age and BMI 39 and 31.8 kg/m^2 comparing the women wearing niqab with those wearing hijab. Overall, age, marital status, and BMI of women in both groups had no significant relationship with the low Vitamin D and low calcium levels, further when seen between groups wearing niqab or hijab among the Muslim women had no significant statistical difference in Vitamin D_3 metabolic parameters. In the city of Dhaka, Bangladesh among women between 18 to 60 years divided into three groups veiled women, non veiled women and non veiled diabetic women mean value of 25-OH Vitamin D was not significantly different between the groups, 30 per cent in the veiled group and 38 per cent in the unveiled group showed levels below 10ng/ml. Vitamin D insufficiency levels <16ng/ml about 78 per cent in unveiled, 83 per cent in veiled and 76% in unveiled diabetic groups were observed. This insufficiency was higher in the veiled group when compared with the other two groups (Akter*et al*., 2020). In Turkey among the adolescent girls, 44 per cent were insufficient and 21 per cent were deficient the mean serum 25 OH Vitamin D concentration was lower in the participants wearing concealing clothing (Almuhairi*et al*., 2013). On the contrary in a study conducted among the pregnant women in Lucknow, North India 84 per cent of the women were found to be deficient with mean maternal Vitamin D levels 14 ± 9.3 ng/ml but there was not much difference in low Vitamin D levels and rise in PTH levels between the women wearing and not wearing pardah (Kumari*et al*, 2021).

Other factors

Sunlight production being the major source of Vitamin D apart from the style of dressing at the individual level can also be affected by other factors such as indoor lifestyle, skin complexion, low physical activity and usage of sunscreens which may lead to Vitamin D insufficiency among the Muslim women (Engelsen, 2010). In a study on

Turkish Muslim women near 66.7 per cent who claimed of never being exposed to direct sunlight, due to majorly leading an indoor and physically less active lifestyle showed Vitamin D concentration as low as 16ng/ml (Andıran*et al*., 2012). In a study on veiled women, two independent risk factors identified influencing the Vitamin D nutriture apart from concealing clothing were dark complexion which showed highly significant association with Vitamin D levels and another risk factor was no outdoor physical activities among the Muslim women (Le Goaziou *et al*., 2011). Bawaskar*et al*., 2017 in a study in general hospital Mahad India among patients of medicine OPD Vitamin D levels in Muslim women showed dark complexion and cloth selection was associated with severe and significant Vitamin D deficiency. A comparative study between Muslim women living an indoor lifestyle with non-Muslim women of low socioeconomic status indulging in outdoor work revealed high mean BMI (29.19) and low Vitamin D (22.35) in the Muslim women group compared with the non-Muslim women group (BMI 24.84, 25 (OH) D 25.51) the magnitude of deficiency was more among the indoor living Muslim women (Subramaniam and Babu, 2017). In Kuwait, when the relationship between the use of sunscreen and Vitamin D level was examined both participants who used sunscreen and who never used it had low Vitamin D levels in general, irrespective of the SPF level they used (Al-Mutairi*et al*., 2012)

Low Dietary consumption

The second contribution of Vitamin D is through diet, this vitamin should also be taken through diet to prevent Vitamin D deficiency or sufficiency. Intake as high as 250mcg in human clinical trials has supported in reduction of Vitamin D deficiency without causing toxicity (Heaney, 2007). Among Muslim Nova Scotian women from 24 hour dietary recall, it was evident that the mean consumption of Vitamin D was 316 IU among the Muslim women which were half when compared with the intake of other women (601 IU). Also, daily consumption of milk, margarine and fortified juice were not significantly different in both women and severe Vitamin D deficiency was not observed in those who included foods rich in vitamin and fish oils pointing at its importance in improving Vitamin D levels (Ojah and Welch, 2012). Among medical students in Saudi Arabia, 99 per cent of the female population was deficient despite high consumption of seafood among women this may be related to the difference in intake from other dietary sources and food fortification (Al-Elq, 2012). The prevalence of Vitamin D deficiency was found to be high among Qatari females (51.4 %), there was a

significant difference between Vitamin D deficiency and normal subjects appearing to result from a low oral intake of Vitamin D along with other factors (Bener*et al*., 2009). In Malaysia, a Muslim majority country in a study to determine the Vitamin D status and its associated factors among third trimester pregnant women attending government health clinics in Selangor and Kuala Lumpur, 42.6 per cent were found to be Vitamin D deficient with an average consumption of 8.7mcg which was very low, 80 per cent of this was obtained from Vitamin D containing food sources especially fish and fish products contributed to 36 per cent of Vitamin D intake (Woon*et al*., 2019).Saikh and Bellare (2020)analysed the relationship between different dress style and dietary habits in Mumbai found an increase Vitamin D levels with the extent of covering between the non hijabi (14.6 ng/ml), hijabi (18.1 ng/ml) and niqabi (18.6ng/ml) groups, which correlated with Vitamin D_3 intake being 0.83 mcg in the niqabi group, 0.53 mcg in hijabi group and 0.41mcg in non hijabi group indicating an effect of diet in increasing Vitamin D levels irrespective of sunlight exposure. Even in the adolescent female of Jeddah 81 per cent showed low levels of Vitamin D of which 61 per cent were asymptomatic. Milk being a source of calcium and Vitamin D, low intake of calcium and inadequate intake of milk was observed among these females (Bindayel, 2021). A Norwegian study has observed a high prevalence of Vitamin D deficiency among immigrants of Pakistani, Turkey, Srilanka, Iran, and Vietnam origin living in Oslo showing prevalence up to 64.9 percentage, use of fatty fish and cod liver oil had a strong positive association with Vitamin D levels among the women (Darling, 2020) Even in East African immigrants living in Washington all the women participants were found to exhibit low levels of Vitamin D when adjusted for age 66 per cent of the participants with 25 (OH)D levels <15ng/ml drank milk less often than women with levels >15ng/ml (Reed *et al*, 2007). In Bangladesh in two cities Dhaka and Betagair union, women between the age of 16 to 40 years the area under study is in north coastal region fish consumption were low, Vitamin D fortification was very low and source of consumption was from milk, also the habitual cereal based food choices contain phytic acid interfering with calcium and Vitamin D absorption influencing Vitamin D levels among these women (Roth *et al*., 2010). Among premenopausal Saudi women, the Vitamin D intake was below the Estimated Average Requirement in 65 per cent of women, Dairy products, and fish contributed a major portion of the Vitamin D intake further age was significantly associated with sufficient Vitamin D intake (Zareef*et al*., 2018).

In Lebanon, the only Vitamin D rich foods consumed were fish and milk supplements and the mean milk intake was half cup daily this was due to the high prevalence of lactose intolerance in the population (Gannagé-Yared*et al*., 2009). Elshafie*et al*., 2012 in Riyadh compared Vitamin D nutriture of couples found a prevalence of 70 per cent among women and 40 per cent among men which coincided with low intake of milk among women when compared to men. Among Pakistani housewives livings in Quetta, 58.9 per cent were Vitamin D deficient and of which 55.1 per cent of them never consumed milk. The study detected that housewife who never consumed milk had 9.72-fold higher odds to develop Vitamin D deficiency compared to those who consumed milk on daily basis (Hussain*et al*., 2021). In the Arab American women with Vitamin D levels as low as 4ng/ml comparative supplementation of Vitamin D pills, milk and fortified orange juice, revealed Vitamin D fortified orange juice consumption had a significant positive effect on 25 (OH)Vitamin D levels followed by milk or vitamin pills (Hobbs *et al*., 2009).

Lack of Awareness

Authentic Knowledge stimulates practices that help in the improvement and maintenance of health. To understand the major cause of the high prevalence of Vitamin D deficiency among Saudi Arabian women a KAP survey was conducted which revealed that the participants had inadequate knowledge about Vitamin D which limited their sun exposure due to intense heat and cultural reasons (Christie and Mason, 2011). Similarly in Jeddah and Makkah in female participants, there was a lack of knowledge about dietary sources of Vitamin D but they were enthusiastic to know and take actions to prevent Vitamin D deficiency (Aljefree*et al*., 2017). In Pakistan despite 52 per cent of females being Vitamin D deficient Knowledge about Vitamin D was limited, only nine per cent could identify foods sources, 33 per cent knew the bone benefits and 36 per cent were aware of sunlight production of Vitamin D (Tariq *et al*., 2020). In a survey conducted in Selangor and Kuala Lumpur shopping malls area, Malaysia, 78 per cent had only limited knowledge about Vitamin D and 70 per cent showed a negative attitude towards sunlight which may influence the Vitamin D levels (Blebil*et al*., 2019). KAP analysis comparing awareness about Vitamin D in Saudi women living in Canada had limited awareness of Vitamin D deficiency (39.3%) and lacked the motivation to use supplements (Lujain*et al*.,2019). Al-Ghraibawi*et al*.(2019) in clinics of Imam Hussein Medical City in Karbala found less than 45 per cent of women had even heard about

Vitamin D, the percentage knowledge was 47 and practice was 51 per cent which was suboptimum indicating the need to increase awareness on Vitamin D. In India among the Muslim women between 18 to 25 yrs in the city of Mumbai 80 per cent were aware of the term Vitamin D but only 46 per cent knew the causes of Vitamin D deficiency (Karthik*et al*., 2017).

Low supplementation:

Supplementation is considered when an individual's Vitamin D levels are too low or in case of lack of access to sunlight or dietary Vitamin D, attitude towards supplements is the main factor affecting the intake of Vitamin D supplements (O'Connor *et al*., 2018). In Lebanon of Middle east were incidences of Vitamin D deficiency are high among osteoporotic women low intake of Vitamin D supplements was observed in Muslim women when compared with Christian women, this supplement intake showed a strong association with the serum Vitamin D levels of the Muslim women (Gannagé-Yared*et al*., 2009) Among Muslim pregnant women in Saudi Arabia the mean Vitamin D levels were as low as 9.9ng/ml though literature recommends Vitamin D supplementation to address the risk of hypovitaminosis D in Muslim pregnant women only 36 per cent of the women took the supplement in Saudi Arabia a Muslim majority country when compared to 80 per cent of pregnant Muslim women on Vitamin D supplementation in Ireland among Muslim minority (Kearney *et al*., 2015).

2.4 Strategies to Combat Vitamin D Deficiency

The main objective in combating Vitamin D deficiency involves raising and maintaining serum 25 (OH) Vitamin D levels above 30 ng/ml. There are five main types of strategies that can be used individually or grouped to combat Vitamin D deficiency; they are dietary diversification, nutrition education, fortification, lifestyle modification and supplementation (Thacher, and Clarke, 2011). An approach to combat severe nutrient deficiency involves supplementation followed by fortification and dietary modification to eliminate the probability of deficiency. Any strategy or combination of strategies should aim for the maintenance of serum Vitamin D levels at 32ng/ml (Pappa*et al*., 2008).

2.4.1 Supplementation

Supplementation is the most widely used strategy to improve Vitamin D levels in a short period. Dietary supplements are defined according to US Drug Supplement

Health and Education Act as a product containing dietary ingredients such as vitamins, a mineral, a herb or other botanical, an amino acid, any other substance used to enrich the diet by increasing total dietary intake (Baran, 2014). According to the Endocrine society suggestions, 1500 to 2000IU/day of supplemental Vitamin D will be required to raise the serum 25 (OH) Vitamin D levels to 30ng/ml in adults, pregnant and lactating women (Holick*et al*., 2011). Vitamin D supplementation studies disclosed Vitamin D supplementation doses and serum 25-hydroxyVitamin D levels did not cause a high elevation in levels up to 250mcg (10000 IU) Vitamin D per day, to obtain concentrations above 40 ng/ml Vitamin D up to 4000 IU per day is required, no symptoms of toxicity have been observed till serum concentrations <56 ng/ml, which can be reached with Vitamin D supplementation of 10000 IU per day this shows that the limits suggested for toxicity of 2000 IU per day is low up to 5-fold (Garland *et al*., 2011; Nausheen*et al*., 2021). Hallida*yet al*. (2011), opines that 25(OH) Vitamin D concentrations significantly increased with the intake of multivitamin supplements in winter. During winter there is a lack of sunlight decreasing the production of Vitamin D and serum, 25(OH)Vitamin D has a circulating half-life of 15 days this increases the risk of Vitamin D deficiency where supplementation can help to prevent the deficiency. Supplements contain Vitamin D in two forms Vitamin D_2 and Vitamin D_3 studies have suggested 25 (OH) Vitamin D_3 be more potent than the other forms of Vitamin D in supplements (Quesada-Gomezand Bouillon, 2018). Garand *et al*., 2021 studies the changes in the blood transcriptome and the potential mechanisms associated with Vitamin D_3 supplementation among 100 Middle East Vitamin D deficient women who were given 50000 IU of Vitamin D for three months. Vitamin D_3 supplementation strongly modulated expression in 54 genes. Vitamin D_3 showed a strong effect on the immune system, G-coupled protein receptor signalling, and the ubiquitin system highlighting the major molecular changes and biological processes induction by Vitamin D_3 supplementation Randomized clinical trials on pregnant women supplemented with different concentrations of Vitamin D revealed that 4000 IU/day supplementation in pregnant women was safe and effective in achieving normal Vitamin D levels in women regardless of race, but the average requirement not sufficient to achieving adequate 25(OH) Vitamin D levels (Hollis *et al*., 2011). A comparison between control and intervention groups receiving 5000 IU, 10000 IU and 15000 IU according to the severity of Vitamin D deficiency between identical groups showed that the blood 25(OH) Vitamin D level increased significantly in the intervention group, from 14.30±4.30 ng/ml to 33.62±6.99 ng/ml in contrast to control group (Lu *et*

al., 2018). Supplementation of 2000IU per day in 90 healthy monozygotic twins found a 65 per cent increase in serum 25 hydroxy Vitamin D, levels above 50nmol/L stimulated the expression of VDR receptors yielding associated health benefits, increasing lean mass and decreasing body fat respectively (Medeiros *et al*., 2020).

Marwaha*et al*., 2019 found 2000IU/day of Vitamin D_3 supplementation increased serum Vitamin D levels considerably without causing hypercalcaemia when compared with recommendations 400IU/day by the Indian Council of Medical Research and 600IU/day by the Institute of medicine for preventing deficiency. Clinical and laboratoryevidence from double-blind randomized controlled trials pointing at the potential relationship between low levels of 25-hydroxy Vitamin D and a variety of chronic pain states and the effectiveness of Vitamin D supplementation in treating pain conditions (Shipton and Shipton, 2015). A comparative study on supplementation of 500000 IU single loading dose, loading dose plus 50,000 IU per month and 50,000 IU per month without loading disclosed a rapid increase in Vitamin D levels by 58 n mol/L from the base in loading dose and loading dose plus group within a month which then plateau between 69 to 91 n mol/L. In the monthly group levels plateau at 80 n mol/L in a period of 3 to 5 months opinions that large doses of Vitamin D supplements can be used to normalize the Vitamin D levels safely within a short period compared with small regular doses (Bacon *et al*., 2009). Hata*et al*., 2014 conducted a placebo control trial illustrating that darker skin types and elevated BMI were important risk factors for Vitamin D deficiency in subjects with serum 25(OH) Vitamin D below 20 ng/mL, after 21 days of oral supplementation mean serum 25 OH Vitamin D increased considerably, A pooled analysis on the impact of Vitamin D supplementation found a high prevalence of hypovitaminosis D (19.5ng/ml) among fracture cases and that Vitamin D supplementation at a range of doses safely helped in increasing serum 25(OH) Vitamin D levels (Sprague *et al*., 2016). Armin 2018 observed from a Meta analysis the small beneficial effects of Vitamin D on parameters of CVD risk, such as arterial stiffness, with Vitamin D supplementation at doses of 1,000-5,333 IU per day. Based on the documentation in studies on animals and humans lack of Vitamin D has been identified as a risk factor in the development and control of all types of diabetes. Observational case control studies have shown Vitamin D supplementation to reduce the risk of incidence of GDM and type 1diabetes among pregnant women and children (Pittas and Dawson-Hughes, 2010). According to PanPan*et al.*(2019) observed between the control

group receiving regular Vitamin D_3 supplement doses and the observation group receiving supplements based on Vitamin D levels, after 6 months of intervention, the serum levels of 25(OH)D, osteocalcin, BMD of the lumbar spine and hip, grip strength, simple physical ability tests score, fall risk assessment tests, station starting line test, daily pace test, stand up the test in the observation group were significantly higher than those in the control group indicating that Vitamin D stratified supplementation can improve bone health, bone mineral density, limb function, and reduce falls risk and increase the quality of life. Eight weeks of cholecalciferol supplementation up to 40000 units per week increased mean baseline Vitamin D levels from 34 to 111 n mol/L also the supplementation was also reduced intestinal inflammation in patients with ulcerative colitis (Garg*et al*., 2018). Meta analysis of twenty five clinical trials suggested methodical intake of 2000IU of Vitamin D per day to be protective against acute respiratory tract infection in Vitamin D deficient population. Thus it is reasonable to provide prophylactic supplementation of Vitamin D to boost immunity and reduce the risk of developing COVID-19 infection (Khemka*et al*., 2020)

2.4.2 Dietary modification

Beck and Health, 2013 described dietary modification as changes proposed in terms of preparation, processing and consumption to improve the bioavailability of nutrients thereby decreasing the incidence of deficiency in a population or community, for incidence simultaneous consumption of fat and Vitamin D is found to facilitate the absorption of Vitamin D by the body (Deluca, 2012) Vitamin D absorption through the enterocyte brush border membrane experimented using radiolabelled Vitamin D and clinical trials studying the effect of a single dose of Vitamin D suggests Vitamin D absorption to not a simple diffusion. Vitamin D absorption was better when consumed a meal containing fat and also factors influencing cholesterol absorption affected Vitamin D absorption (Silva and Furlanetto, 2018) A comparison of serum 25 OH Vitamin D after consumption of high and low fat meals with 1.25mg of Vitamin D over a period of 7 to 14 days proclaimed a significant difference in 25 OH Vitamin D levels to 42.7 ± 19.0 nmol/L in individuals consuming a high fat meal which was higher when compared with low fat meal consumers (36.4 ± 19.0 nmol/L) as observed by Raimundo*et al*. (2011) similarly in 2013 Dawson –Hughes *et al*. examined the effect of fat content of meal on Vitamin D absorption found low fat diet to increase Vitamin D_3 levels to 241.1 nmol/L in 24 hours compared to high fat diet (207.4 nmol/L) and test

without a meal (200.9 nmol/L) denoting limited fat content in meals to be sufficient for increasing Vitamin D bioavailability. Concerning the effectiveness of Vitamin D absorption based on the type of fat among monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA) and saturated fatty acids (SFA). Meals rich in MUFA increased the absorption of Vitamin D_3, while meals rich in PUFA and SFA impaired the effectiveness of absorption of Vitamin D_3 in healthy adults (Dawson–Hughes and Harris, 2011; McLarnon, 2011). This affinity between fat and Vitamin D in the body leads to the volumetric dilution and deposition of Vitamin D in the adipose tissues of obese individuals with high BMI rendering the vitamin unavailable and increasing the requirement of Vitamin D for maintaining normal serum levels in distinction with lean individuals (Lenders *et al*., 2009) Among obese individuals an examination of the combined effect of Vitamin D intake and BMI indicated that obese and overweight individuals exhibited Vitamin D levels 19.8 nmol/L and 8.0 nmol/L lower than individuals with normal BMI recommending 2 to 3 times higher intake of Vitamin D in obese and 1.5 times higher intake among overweight individuals which was in par with Vitamin D recommendations by the Institute of Medicine and the Endocrine Society two to three times more Vitamin D for obese to prevent Vitamin D deficiency (Ekwaru*et al* 2014). Another pharmacokinetics of three different doses of Vitamin D 25-hydroxyVitamin D in a group of obese subjects for 21 weeks found a steady increase which was directly related to dosage and body fat approximately 2.5 IU/kg required for unit increase in 25(OH) Vitamin D levels denoting an increase in demand with increase in BMI (Drincic*et al*., 2013). Weight reduction serves as a single solution to two problems affecting both Vitamin D deficiency and obesity, among obese individuals the mobilisation of Vitamin D from the fat stores improves the availability and levels of the vitamin to the body, also this loss of visceral fat improved obesity related metabolic dysfunctions such as insulin resistance, adverse lipid profiles, arterial hypertension and thereby metabolic syndrome (Vranić*et al*., 2019). Further sufficient levels of Vitamin D protected against high fat diet induced weight gain through relative inhibition of lipogenesis and the promotion of Fatty acid oxidation in the liver signalling on capacity of Vitamin D in maintaining weight revealing an inverse relationship between the two (Yin *et al*., 2012) studies have perceived Improvements of circulating 25(OH) Vitamin D levels with reduction of BMI through lifestyle changes, including randomized controlled trials stressing at maintaining of healthy BMI to be key to combat the burden of Vitamin D deficiency (Gangloff*et al*., 2016). Studies following

the discovery of Vitamin D. Nelson and Smith, observed while irradiation of rats there was photochemical activation of residual foods and non irradiated rats on ingestion of this irradiated food showed changes identical to the irradiated rats. Similarly, Steenbock and Black detected food low in antirachitic factors when irradiated and fed to rachitic rats promoted growth and calcium assimilation leading to the discovery and patent of irradiated foods. This discovery was considered as a jewel in crown to overcome the burden of rickets (Rajakumar*et al*., 2007) shiitake mushrooms (*Lentinulaedodes)* on subjection tosupercritical fluid extraction and irradiation with UV rays at wavelength of 254 nm was more effective in enriching the extract with Vitamin D_2 compared to 365nm elucidating 10 am to 3 pm (290 nm) to be effective time for irradiation similar to dermal synthesis of Vitamin D (Morales *et al*., 2017) Teichmann*et al*., 2007 on comparison of different varieties of mushroom ascertained higher ergosterol content in cultivated varieties (4 to 5 mg/g) compared with wild varieties(1.7 to 3.5 mg/g) which on irradiation at 254 nm produced 9 fold higher content of Vitamin D 2 in wild mushrooms and 14 folds higher content in cultivated mushrooms uncovering the cultivated mushroom varieties such as oyster mushrooms, white and brown button mushrooms, portabella mushrooms and shiitake mushrooms to be better irradiated sources of Vitamin D_2. Analysis of 35 species of commercially dried mushrooms with an average of 1.98 mg/g of ergosterol and 16.88 µg/g of Vitamin D_2 and mushrooms sun drying for 10, 30 and 60 minutes showed a significant increase in Vitamin D_2 content (229.7 and 67.0 µg/g) on comparison with the fresh mushrooms. UVB exposure of the mushroom enriched Vitamin D_2 content to 45mcg/g when compared with sundried mushrooms containing 36 to 39 mcg/g Although UVB light increased D_2 synthesis considerably, solar drying method due to its ease of preparation, cost effectiveness and natural formation of ergocalciferol, it serves as an excellent approach to improve bioavailability from foods sources. (Huang *et al*., 2016; Nölle*et al*., 2017). Urbain*et al*. (2011) conducted a placebo controlled trial demonstrating the difference in effect on intake of 700mcg irradiated Vitamin D_2 with 700mcg supplementation of D_2 and placebo highlighting on the bioavailability of Vitamin D_2 from irradiated button mushrooms using UV B rays was in par with Vitamin D_2 supplementation which was much effective showing an increase of 3.9 to 4.7 nmol/L per week in Vitamin D levels of human participants. A similar study on rats fed with bread prepared using enriched yeast showed better bioavailability of Vitamin D significantly improving trabecular BMC, BMD, bone volume and connectivity density in rats in comparison with Vitamin D deficient rats.

This features the effectiveness of UV irradiation of foods in increasing serum Vitamin D levels. (Hohman*et al*., 2011).Calcium is another vital nutrient for bone, muscle, heart and nerve health and shares a close relationship with serum 25(OH) Vitamin D levels. A long term diet with insufficient quantities of calcium and Vitamin D is said to harm the stature growth, formation of the skeleton and the process related to growth and development. Calcium availability from the diet or supplements is directly influenced by Vitamin D; consequently for routine execution of functions pertaining to calcium, maintenance of Vitamin D levels is critical. In the gut,normal serum 25 (OH) Vitamin D levels support 30% absorption of dietary calcium in adults and more than 60-80% during the high demand growth period, seen in children (Bueno and Czepielewski,2008). Christopher *et al*., 2012 while studying the effect of increasing doses of Vitamin D_3 on calcium absorption detected an increase in 25 (OH) Vitamin D levels from 15.6ng/ml to 46.5ng/ml when subjected to high doses, calcium absorption was related to Vitamin D levels than doses of intake besides the relationship was stronger at low serum Vitamin D levels (10ng/ml). Conversely, A diet high in calcium increases the half life of 25(OH) Vitamin D, this half life decreased with hyperparathyroidism where half life of 25(OH) D is shorter,whereas a low calcium intake increases the production of the active metabolite of Vitamin D this has also been reported in a rat study indicating that a high calcium intake may regulate the levels of Vitamin D.Meta-analyses on Vitamin D for fracture prevention suggested a combination of Vitamin D and calcium to be more appropriate than Vitamin D alone. This result suggested a converse relationship to exist between the two nutrients. Clinical trials with Vitamin D and calcium to decrease fracture incidence generally have shown that trials with Vitamin D and calcium had better results than calcium or Vitamin D alone (Lips, 2012). A diet high in calcium intake has a Vitamin D-sparing effect because it increases the half-life of 25(OH) Vitamin D (Lips *et al*., 2014)The role of Vitamin D in nutritional rickets has been known for long very recently involvement of calcium has been brought to light evidence of higher risk of rickets in individuals with a dietary calcium intake of <300mg/day was observed which further worsened Vitamin D status stimulating activation of Vitamin D resulting in elevated levels of 1, 25 (OH) Vitamin D. Thus global consensus recommendations for management and treatment recommend both calcium and Vitamin D intake in accordance with age (Thandrayen and Pettifor, 2018). In food sources,Vitamin D exists in D_2 and D_3 forms in which the D3 form is found to be more bioavailable, most dietary sources are low in Vitamin D with very few Vitamin D rich

sources. The Vitamin D content of dietary sources are determined using HPLC or liquid chromatography-linear mass spectrometry (LC-MS) or liquid chromatography-tandem mass spectrometry (LC-MS/MS) methods Best sources of Vitamin D are fish (especially fatty fish), egg yolk, liver, meat, mushrooms and milk, majority of them being non vegetarian sources containing Vitamin D_3 are regarded as potential sources.(Schmid and Walther, 2013). Among these food sources, oily fish are considered to be one of the best sources. Studies analysing different species of oily and non-oily fish for their Vitamin D content revealed 24 farmed salmon (249 ± 40 IU) had about approximately 25 per cent of the Vitamin D content compared with 20 wild salmon (981± 89 IU) Farmed trout, bluefish, swordfish and Mahi had about half of the Vitamin D content compared to the wild varieties of salmon. Cod, grey sole, haddock, squid and clams had less than 10 per cent of Vitamin D content compared to the wild caught salmon. Cooking with microwave or baking did not decrease the Vitamin D content significantly in salmon where in fried salmons only half of the Vitamin D was retained (Chen *et al*., 2007).In another research analysing the effect of fish intake on Vitamin D, the consumption of fish increased the Vitamin D levels by 4.4nmol/L in comparison with control (Lehmann *et al*., 2015). High fibre intake with its low affinity for fats affecting the release of lipophilic nutrients from food, emulsification, micelles formation and rapid clearance from gut reduces with Vitamin D bioavailability In a study examining the effect of high fibre diet and normal diet on radiolabelled Vitamin D among healthy individuals resulted in mean serum increase of 27.5 ± 2.1 per day with normal diet intake 19.2 ± 1.7 per day with high fibre intake. (Meza-Meza *et al*, 2020;Maurya and Aggarwal, 2017). Since the fat soluble vitamins share the same pathway for absorption a competition with Vitamin D absorption is observed for incidence a study on $CaCO_2$ cell line confirmed impairment of Vitamin D absorption by 15 per cent at a medium concentration of vitamin E and 17% at high concentration of vitamin E in the intestine (Goncalves*et al*., 2015). A global review had provided evidence that Vitamin D intake from the diet was very low to sustain healthy levels of circulating levels of 25 (OH) Vitamin D accordingly a combination of other strategies with diet such as supplementation or fortification may prove beneficial in preventing Vitamin D deficiency.

2.4.3 Fortified foods with Vitamin D

Fortification is the deliberate enrichment of foods with specific micronutrients that are deficient in the diet to improve the nutritional status of the population thereby preventing and overcoming deficiency and improving the health of the population. The best outcomes of fortification depend on the food selected for fortification such food should be a staple, inexpensive, easily available and within a safe set fortification rate (Olson *et al*., 2021) The fortified marked largely consists of iodised salt, iron and calcium fortified biscuits and vitamin A fortified milk and oils besides scientific literature has also uncovered strong evidence confirming the impact of fortification in reduction of micronutrient deficiencies such as vitamin A deficiency, iodine deficiency, anaemia and iron deficiency (Keats *et al*, 2019) therefore fortification can be used as a potential strategy even in combating Vitamin D deficiency. WHO and FAO guidelines recommended Vitamin D fortification of milk and margarine to be useful strategies for increasing intakes up to 200IU/day through the addition of fortified foods (Lindsay*et al*., 2006). Vitamin D fortification strategy has already been implemented in countries like the USA, Canada, India and Finland, In USA and Canada, an estimated 60 per cent of the intake of Vitamin D is contributed by fortified foods (Calvo and Whiting, 2013). In Finland, an investigation to examine the effect of fortification of milk and fat spread between 2000 to 2011 disclose among fortified milk consumers a 6 nmol/L higher serum levels compared to the non consumer also an overall 91 per cent consuming fortified milk, fat spread and following Finnish recommendation exhibited better Vitamin D levels (>50nmol/L) in 2011(Jääskeläinen*et al*., 2017) Bromage*et al*., (2018) projecting effectiveness of mandatory industrial fortification of wheat flour, milk, and edible oil with multiple nutrients among Mongolian adults alluding fortification of flour, oil and milk in accordance with the international guidelines would increase Vitamin D intake considerably, with the greater benefit from flour fortification and smaller benefits from fortified oil and milk. In European Union,Vitamin D fortification practices showed an improvement in intake and status of Vitamin D and do not contribute to adverse effects (Hennessy *et al*., 2013). Among Danish and Pakistani women a 12 weeks placebo control intervention during winter providing 20 mcg Vitamin D_3 per day through fortified yoghurt, cheese, eggs and crispbreadshowed an increase in serum 25 (OH) Vitamin D levels from 49.6 to 77.8nmol/L among Danish women and 46.6 to 54.7nmol/L among the Pakistani women this indicated that fortification with a low dose can be effectively used to combat the Vitamin D deficiency (Grønborg*et al*., 2020). Keller *et al*. (2018) found that women who were prenatally exposed to the extra Vitamin

D from fortification tended to have a lower risk of subsequently developing GDM compared with women unexposed to Vitamin D from fortification. Further, the Vitamin D fortification programs in USA, Finland and Canada provide a solid basis to introduce and modify Vitamin D food fortification to improve public health with this likewise cost-effective approach (Pilz*et al*., 2018).

2.4.4 Nutrition education

Nutrition education can be defined "as any set of learning experiences designed to facilitate the voluntary adoption of eating and other nutrition-related behaviours conducive to health and well-being", nutrition education helps to address the numerous personal and environmental influences on food choices and assist individuals in practising healthy behaviours, besides literature proposes eating patterns to be responsible for 4 out of 10 deaths (Contento, 2010) Lua and Elena, 2012 evaluating the impact of nutrition education delivered using web-based education, lectures, and supplementation showed an improvement in measures such as consumption of food, nutrition knowledge, dietary habits, physical activity, and quality of life. In accordance with Alshamsan and Bin-Abbas, (2016) it was evident that individuals with knowledge on importance and health risks associated with Vitamin Dperfected themselves with precautionary solutions. Thus, nutrition education on Vitamin D and risk of deficiency may increase concern on maintenance of healthy Vitamin D levels among individuals which could stimulate habits that can potentially prevent Vitamin D deficiency. In an osteoporosis prevention education program aiming at increasing knowledge on osteoporosis, increasing health beliefs and increasing frequency of osteoporosis preventing behaviours, evaluation of changes in knowledge and behaviour sported highly significant levels of knowledge among all the groups after completing the programs (Abuelmaaty*et al*., 2021) when examined the knowledge about Vitamin D among pregnant women of Irish, Asian, Sub-Saharan African and Middle Eastern and North African (MENA) origin 71 per cent reported insufficient knowledge which correlated with 88 per cent and 68 per cent risk of deficiency among MENA women andSub-Saharan African pregnant women, highlight the urgent need to establish practice guidelines for improving Vitamin D status among pregnant women (Toher*et al*., 2014). Nutrition education among Chinese-American women on the Theory of Planned Behavior about calcium and Vitamin D through six weekly interactive lessons design an improvement in all measures including an increase in calcium and Vitamin D intake was

observed in the intervention group when compared to control suggesting the effectiveness of nutrition education on theory-based behaviour in increasing the dietary calcium and Vitamin D intake (Nan and Brown, 2011). Park *et al*. (2017)concluded that intervention via an individualised educational program after education regarding the percentage of calcium and Vitamin D intake below recommended cut-offs, inadequate dietary calcium (89.4 % to 84.4%) and Vitamin D (79.9% to 65.8%) intake were decreased, improvement in parameters including osteoporosis knowledge, osteoporosis self-efficacy and reduction of falls was observed. Among polish women, the higher the education level of the women higher the frequency of supplementation was observed. In addition, women's awareness of functions and sources of Vitamin D was significantly associated with intake of Vitamin D supplements stressing the importance and effectiveness of increasing awareness via nutrition education in combating Vitamin D (Zadka*et al*., 2018).

2.4.5 Lifestyle diversification

Sunlight exposure and physical activity are two important lifestyle behaviours that influence the Vitamin D status of an individual which was demonstrated by Othman *et al*. in 2012 who found individuals on daily sun exposure and practising moderate physical activity had higher levels of Vitamin D (22.7 ± 1.5 nmol/L) on comparison with physically inactive individuals (17.7 ± 1.6 nmol/L), emphasizing on the importance of both sun exposure and physical activity in the prevention of Vitamin D deficiency (Othman *et al*., 2012). It is well recognized that physical activity has a positive effect on health. It is believed that 20 to 30 minutes of physical activity outdoors can increase Vitamin D levels and that two to three times of sun exposure in a week is enough to achieve healthy Vitamin D levels in the summer (Lanteri*et al*., 2013) According to Lee *et al*., 2020 effect of sunlight exposure of 20 to 30 per cent of body surface for 30 to 60 minutes per day for three days in a week among Vitamin D deficient subjects showed an increase in Vitamin D levels. In the elderly group who were encouraged to go outside for 20–30 minutes between 11 a.m. and 3 p.m. every day for two months during the summer, 25(OH)D levels increased significantly, also reported better self-perceived mental health and low need of supplements among the population (Samefors*et al*., 2020).Dawodu*et al*., 2011 studies the outcome of 15 minutes per day sunlight exposure of face, arms and hands twice a week for four weeks among high risk Arab women though Vitamin D levels remained sub-optimal, median serum 25(OH)D

levels were significantly higher post-intervention (23.0 nmol/L) than pre-intervention (17.6 nmol/L). Physical is muscle activity resulting in energy expenditure where exercises are planned physical activity carried out with the aim of a healthy lifestyle (Carter and Micheli, 2012).The marginal Vitamin D deficiency observed among Vietnamese and Australians living in Australia were predicted to be due to low intake and lack of physical activities. Hence increased physical activities may prevent the occurrence of Vitamin D deficiency (Brock *et al*., 2007). Medical analysis of literature assessing the influence of outdoor and indoor physical activity on Vitamin D levels pointed out that exercising outdoors would have both the benefits of physical activity and sunlight exposure for Vitamin D. However, according to the studies analyzed, increased plasma concentration ofVitamin D occurred with physical activity both indoors and outdoors (Marcos and Junior, 2017). In accordance with a review study by Espinoza *et al*., 2020 the correlation between physical activity and Vitamin D levels was strongly recommended for an increase in physical activity to raise serum 25-hydroxyVitamin D levels. There was a greater impact for Vitamin D_2 and Vitamin D_3 in individuals taking part in sports rather than spending time watching TV or video games. in another attempt, using the three ranges for the time spent on video games per week with Low: 0-75 minutes, Moderate: 80-360 minutes, and High: 420-3,360 minutes against levels of Vitamin D_2 and Vitamin D_3 divided into Low: 13.90-35.30 nmol/L, Moderate: 35.50-67.00 nmol/L, and High: 67.20-140.00 nmol/L, the Chi-square test provides a statistically significant association between time spent playing on video games and levels of Vitamin D_2 and Vitamin D_3. Physical activity also reduced body fat leading to liberation and utilization of Vitamin D in the fat stores resulting in a raise and better maintenance of Vitamin D levels a key to combat Vitamin D deficiency (Vranić*et al*., 2019).

2.5 Digital Health Intervention

Recently the convergence of science and digital technologies, such as the Internet and mobile phones, are potential and scalable means of educating and stimulating practices for the promotion of healthy behaviour, known as ‘digital health interventions’ (Faust*et al*., 2020). World Health Organization is harnessing the power of digital technologies and health innovation for the attainment of global health and well-being intending to translate the latest research and evidence into action, enhancing knowledge through scientific communities and systematically linking needs with the supply of

innovations. WHO's vision for digital health is to support and provide universal access to achieve healthy living for all (WHO, 2011).

From time immemorial technology has been used to improve the reach and effectiveness of interventions. The digital intervention was the brainchild of an experimental electronic duo formed by British electroacoustic composer and sound engineer artist Paul Kendall and French-born British composer, Olivia Louvel (https://en.wikipedia.org/wiki/Digital_health#cite_note-ehj-4). Which has improved tremendously in the 80's and 90's denoted as the golden time for digital health when many professional associations around the world encouraged healthcare delivery through digital communication. In the 21st century, a hardware and software revolution in this field commences, in the case of hardware the internet usage, increase in mobile phone or smartphone usage and the software front enormousamount of health information, open access clinical studies and guidelines were becoming widely available. This lead to the coining of new terms such mHealth (mobile health), eHealth(electronic health), and Personalized Health. From 2010 till date with the launch of a digital health unit by the FDA in 2017 the digital health has gained more significance, developed and distributed globally (Meskó*et al*., 2017; Lorena, 2015; FDA, 2019; Meister *et al*., 2016). The onset of the Covid -19 pandemic has widened the space for digitalisation in many fields leading to the enormous growth of digital technology among the middle and low income groups (Williamson *et al*., 2020).

This digital health intervention has also been introduced in the field of health education for creating awareness via mobile technology, social media and online learning, for improvement in terms of effectiveness, accessibility, efficiency, flexibility and safety at the convenience of the home (Ansari and Khan, 2020). Forincidence, a Gedanken experiment for increasing health awareness used wearable computer technology that unobtrusively senses and ambient present wellness information in intuitive and holistic ways, The novelty of this experiment lies in providing a plug-and-play wearable technology customised towards health education and empowerment through a "you build it" approach (Ananthanarayan and Siek, 2010). Some of the technology used for such interventions are smartphones and tablets applications, websites, social media tools such as YouTube Videos, Whatsapp, Facebook, Twitter etc., games, messages and memes, which when used individually or in combination appropriately can help in creating awareness and promoting healthy behaviour such as

improving physical activity, inculcating healthy eating habits, improve outcomes in individuals with long term health issues etc. (Murray *et al*., 2016).

2.5.1 Importance of digital health intervention

The field of digital health is growing rapidly when we consider the future possibilities its is just the tip of the iceberg. This technology is preferred for its cost effectiveness, a study comparing mobile learning initiatives with traditional education generalized on the cost effectiveness of the mobile intervention, similarly, text messages with their very low cost can be used effectively in health intervention (Moore*et al*., 2014). Digital health initiatives help to gather data from a large portion of the population as in global and regional data collection by government organizations, the data can also be made viewable, enumerable and calculable in terms of numbers and visualizations, thus making it possible to pinpoint and trace individuals through their data trails (Barnes and Wilson, 2014; Williamson, 2016). As people are preferring awareness and self care to an increased extent digital health interventions have been designed for self management and support, through being connected to health and care providers at the convenience of their homes (Georgsson*et al*., 2016). Research indicates that social isolation and loneliness have a negative effect on the health and wellbeing of an individual, various types of technologies and their effectiveness in dealing with social isolation identified were general ICT, video games, robotics, personal reminder information and social management system, asynchronous peer support chat room, social network sites, Telecare and 3D virtual environment as effective technologies to promote social communication (Khosravi*et al*., 2016) also implementation and feasibility of digital technology in enhancing social connectivity studied for 3 months among old adults including semi structured interviews, psychometric scales, field observations, and usability tests found the technology to be a feasible requiring an adoption period for implementation, Sense of well-being and confidence were also enhanced with technology (Barbosa*et al.*, 2019).

2.5.2 Usage of Digital health technology

After processing the importance of technology it is essential to move forward and understand its technology and usage in different fields for improving awareness and thereby health. Some of the digital technology to establish a more definitive relationship with technology is discussed below.

Smart Phone and tablets application

Smartphones with their portability and features have become comparable to computers helping in new developments in the field of health. A review on health applications found applications pertaining to calorie count, food diary, reminders for people with food allergies, suggest exercises with measurement of sports statistics, lifestyles suggestions and tips and positive experiences for elderly for intervention in the population (Bert *et al*., 2014). A population based study revealed 61 per cent to be smartphone users, among health app users were younger, more likely to work full-time, mostly had a university degree, engaged in physical activity, consume low fat diet and possess higher health literacy (Ernsting*et al*., 2017). Glynn *et al*. (2014) in an eight week randomised controlled trial in rural west Ireland, android smartphone users provided with similar physical activity goals and information on the benefits of exercise a difference of daily step count increased from week 1 to week 8 up to steps per day, favouring the intervention. Improvements in physical activity in the intervention group were sustained until the end of the trial. Meta analysis of randomised control trials showed that therapist guided digital health intervention (internet based mobile intervention) had a high potential for prevention and treatment of health disorders across various indications, settings, and populations. Emphasizing the need for digital health intervention into routine care as both adjunct and alternative to face-to-face treatment for its high desirability (Ebert*et al*., 2019). Correspondingly, a tab based intervention among the tribal youth communities in Kerala to prevent addiction to alcohol, tobacco and drugs provided through an integrated program training 1000 indigenous youth, in digital literacy and health awareness using tablet technology in the local language designed for low-literate learners benefited the community (Pillai*et al*., 2018).

Websites

A clinical trial of interventions such as websites, smartphone apps and text messages aiming to improve diet, physical activity or BMI found the digital platforms supported improvement in diet and physical activity and sometimes in body weight or BMI (Lappan*et al*., 2015). Stress Gym an evidence-based, self-help website intervention developed to manage stress and depression among U.S. military members was effective and rated for its interactivity, self-pacing, and pleasing aesthetics. Which supported the management of stress (Williams *et al*., 2011).A website on health behaviour change models, adult education, and website construction. Developed to guide old adults in an experiment control evaluation there was significantly higher ratings of usability and

learning to the new site in the experimental group they also reported that participation was likely to improve future searches (Fink and Beck, 2015). Grimes *et al*. (2018) while determining the efficacy of a Web-based salt reduction program on knowledge, attitudes, and behaviours, self-efficacy, and intake of salt observed a significant improvement among individuals who took up a weekly online interactive website based programme for five weeks. A study analysing different classes of websites using approval criteria for web information namely the JAMA score has determined that the commercial websites scored lower in comparison with health based websites reporting better trustworthiness of health based websites (Mubashar and Pietro, 2015).

Text messages and memes

Text messages are the major form of communication among the adolescent population usage of them has increased drastically by 2012 compared with any other method of communication. With an increase in incidences of obesity among the age groups,text messages have been effective in managing BMI as an obesity treatment among adolescents (Keating and McCurry, 2015).Webb *et al*., 2010 while assessing the effectiveness of the internet as a medium for the delivery of interventions designed to promote healthy behavioural change conducted a meta analysis of 85 studies involving 43,236 participants and found that the effectiveness of Internet based interventions was enhanced by the use of digital technology such as short message service (SMS), or text, messages, besides Interventions providing more information on behavioural change techniques tended to have larger effects compared to interventions providing fewer techniques signifying the higher effectiveness using digital technology. Memes are thought provoking captions or information which can be transmitted between humans and have some influence on the behaviour and attitude of the participants. The findings of an intervention using memes in social media to boost health campaign reach and engagement revealed that influencers message sources generated more campaign branded and sharable content, volume and reach per day. Indicating the importance of introducing content creators (influencers) and messages (memes) to social media, as a promising strategy for improving health campaign interest and engagement (Kostygina*et al*., 2020).Akram*et al*.(2020) explored the effect of internet memes on depression. The results indicated perception of humour, reliability, shareability and mood improving the potential of the internet memes to have a positive effect on an individual's adaptive emotion regulation.

Games

Gamification of intervention for increasing health awareness and physical fitness to live independently for longer and will thereby reduce the costs in the health care system among the elderly. Investigating the gamer types, personality factors and technical expertise on the performance and changes in the attitude towards individual health after the game. Surprisingly, gamer type had a better effect on performance besides a positive effect on the perseverance of pain was detected after the Exergame intervention (Brauner*et al*., 2013) Gamification is also being used progressively in campaigns aiming at creating awareness and bringing about behavioural change, especially among the Gen Z (Generation between 1995 to 2010) the emerging gamification approach was found beneficial for a health awareness campaign to defeat the COVID-19 pandemic (Zain*et al*., 2021).

YouTube Videos

YouTube is an online video sharing website, with an increasing need for health educators to adopt new technology to engage the web 2.0 generation. This technology can be used to provide a more motivating, productive and enriched health intervention. Utilisation and perception among faculties on YouTube Videos in health education classroom indicated an overall acceptance of the effectiveness of among both users and non users YouTube videos suggesting them to be a viable and innovative resource for use in health education and other disciplines (Burke *et al*., 2009). Research on using YouTube Videos on medical education reported high popularity and awareness about YouTube (98%), of which 92 per cent strongly recommended the channel for education. The results also revealed the use of these videos to be an effective tool to enhance instruction if the videos were scrutinized, diversified, and aimed toward course objectives (Jaffar, 2012). Some studies have also reported that though YouTube videos were frequently viewed but were found to be a poor source of accurate health care information, on the development of high quality videos. A YouTube channel has a clear opportunity to enhance the value of educational material (Gonzalez-Estrada*et al*., 2015).