INTRODUCTION

Nutrition is an important aspect of health, it can promote health in infancy, childhood and maternity by improving immunity, preventing non – communicable diseases and thereby decreasing mortality, while malnutrition can cause serious health consequences. (Heidari-Beni, 2019). Nutrients are essential components of food that determine the nutrition one obtains and the major nutrients are carbohydrates, proteins, fats, vitamins and minerals. The term micronutrients cover all the vitamins and minerals required in very small quantity but are of vital importance for the wellness of our body (McMahon, 2017). The hidden hunger of micronutrient deficiency has affected more than 2 billion individuals worldwide including both the developing and developed world (Biesalski and Black, 2016) and has a detrimental effect, especially on pregnant women and children. Thus it is important to maintain the micronutrient levels in women of reproductive age group to prevent these effects. One such global pandemic is Vitamin D deficiency.

Vitamin D belongs to the group of fat-soluble vitamins, it exists in several forms but the predominant forms of existence is the Vitamin D_2 and Vitamin D_3 form. Vitamin D_2 is a plant derivative of Vitamin D formed from a sterol in plants named ergosterol which is converted into ergocalciferol, while Vitamin D_3 is an animal derived form produced from 7 dehydro cholesterol which is converted into cholecalciferol in the presence of UVB rays. Research has suggested that Vitamin D_3 was a more bioavailable form of Vitamin D in comparison with Vitamin D_2 (Shieh*et al.*, 2016). In contrast to other essential vitamins, Vitamin D is not only supplied through diet but can also be synthesised in the skin like pro-hormones. This vitamin can be obtained from diet, medicine or through epidermal synthesis, of which the synthesis in the epidermis of skin on exposure to UVB rays of sunlight was considered as the major source of Vitamin D followed by diet (Mendes *et al.*, 2018). There are three different types of UV rays namely UVA rays, UVB rays and UVC rays. The UVA and UVB rays reach the earth due to their high wavelength, UVB rays of wavelength 290 nm penetrate the outermost layer of the epidermis of the skin (https://www.fda.gov/radiation-emitting-products/tanning/*ultraviolet*-uv-radiation) and through a process similar to photosynthesis, the 7 dehydrocholesterol is converted into pre Vitamin D_3 which then undergoes isomerisation to form Cholicalciferol or pro Vitamin D_3.

Whole body exposure to UVB radiation for 15 to 20 minutes produces 250 micrograms of the Vitamin, which is much higher compared to the daily requirement of 15 micrograms signifying sunlight exposure as a primary source of Vitamin D (Fedotova, 2020). Factors such as latitude, altitude, season, time of the day, pollution including the extent of covering, use of sunlight repellents and skin complexion affect this production of Vitamin D_3 in the skin (Wacker and Holick, 2013). The dietary Vitamin D sources include fortified foods and food sources of Vitamin D, only a handful of foods like egg, oily fish, cod liver oil, beef liver and milk are the richest sources of Vitamin D. Vitamin D fortification is a programme to overcome the deficiency, among the fortified foods such as cereals, milk, orange juices etc. fortification following FDA regulations is mandatory in developed countries like USA and Canada while In India the regulations for Vitamin D fortification are still uncertain. Even with set regulations in USA and Canada Vitamin D deficiency prevails (Gupta, 2014). Medicinal and dietary supplements such as containing 10 IU to 10000 IU for daily intake and up to 60,000 IU for weekly intake are available and taken as prescribed by a medical practitioner (Lhamo*et al*., 2016). All these Vitamin D produced as well as consumed are not in the active form hence it should undergo hydroxylation in two positions to be activated. The Vitamin D produced in the skin is transported through Vitamin D binding protein first to the liver to form 25 OH Vitamin D by enzyme Vitamin D 25 hydroxylase and then to the kidney to form 1, 25 OH Vitamin D by enzyme 25 hydroxyVitamin D1 alpha hydroxylase. This activated form of Vitamin D takes various functions in the body (Botelho*et al*., 2020).

1.1 Importance of Vitamin D

The traditionally known function of Vitamin D is its contribution to bone health via maintenance of calcium concentration in blood and regulation of mineralisation in bones. This dates back to 525 BC where Herodotus found on the battlefield the skulls of Egyptians were strong as they did not cover their heads while the Persians who were habitual to wearing turbans had very fragile skulls this was the first allusion to the effect of sunlight on bone health (Anon,2011). Recently, the discovery of Vitamin D receptors(VDR) and understanding of genomic regulation facilitated by Vitamin D has broadened our perception on the role of the Vitamin beyond skeletal functions in integral processes such as regulator in proliferation and differentiation of cells, glycemic control immune regulation, and anti inflammation (Umar *et al*.,2018).

Coutinho*et al*., (2019) observed a reduction in the risk of cancer among fishermen who were exposed to sunlight between 21 to 28 hours every week for 15 years. Similarly the anti fibrotic and anti proliferative property of Vitamin D has been found beneficial in decreasing the severity of Non alcoholic fatty liver disease (Milic*et al*., 2015). Vitamin D supplementation in type I diabetic children has shown higher fasting C-peptide(FCP) a marker of pancreatic beta cell function suggesting its role in the preservation of insulin secretion by pacifying beta cells through calcium regulation to prevent diabetes mellitus (Nakashima *et al*.,2016).

Hypertension is a chronic health issue that can contribute to cardiovascular problems and increase mortality rate literature suggests an indirect modulation of Blood pressure by Vitamin D levels via rennin angio tension mechanism (Mehta and Agarwal, 2017). In the cardiovascular system, 25 OH Vitamin D plays an important role in regularising cell shape and preventing adhesion, further presence of VDR on major cardiovascular cells denotes its importance in decreasing the likeliness of Cardiovascular Diseases (Norman and Powell, 2014). A converse relationship linkedVitamin D status with adiposity, in accordance with literature an estimation of cholecalciferol content in adipose tissue showed a negative correlation with serum 25OHVitamin D concentrations in obese individuals, where adiposity had a confounding effect on activatedVitamin Dlevel, while optimal activated Vitamin Dlevel facilitate mobilisation of fatty acids from adipose tissue exhibiting protective effect against future weight gain controlling the rate of obesity (Pourshahidi, 2015; Hengist*et al*., 2019). Correspondingly its role in the prevention of multiple sclerosis, tuberculosis, autoimmune diseases, rheumatoid arthritis, psoriasis and depression have been exposed to view with the presence of Vitamin D receptors on the cells and tissues involved in these health issues (Rejnmark*et al*., 2017). In women's health, apart from the above mentioned general health maintenance, Vitamin D is also required during vital functions of life such as pregnancy, fertility, lactation and menopause. Pregnancy is the most vulnerable time in a women's life that affects not only her but also the foetus she carries. Maintenance of healthyVitamin D levels in a mother is critical for the growth and healthy skeletal and tooth development in the infants, it also prevents complications related to pregnancy such as low birth weight, cranio tabs and rickets in the foetus and preterm labour, pre eclampsia and need for cesarean section (Fiscaletti*et al*., 2017) necessitating the requirement of supplementation, Vitamin D

dosage as high as 4000 IU per day improved the birth outcomes and did not cause toxicity in pregnant women (Khadilkar, 2013).

A recent increase in the infertility rate has led to consideration for various treatment options unfolding its momentousness effect in improving conception rate, a meta analysis revealed a positive relationship of Vitamin D status with conception in women on fertility treatment similarly a seasonal variation in the pregnancy rate with high rate during summer was noted in northern countries (Pilz*et al*., 2018). PCOD and endometriosis the two main causes of infertility may be influenced by Vitamin D through regulation of symptoms such as immune modulation, ovarian dysfunction, insulin resistance and inflammation (Muscogiuri*et al*., 2017). During lactation sufficient Vitamin D helps to maintain bone health by preventing losses in bone mass, very interestingly it has been found that high Vitamin D intake of up to 4000 IU per day results in secretion up to 400 IU in the milk, where 400 IU is equivalent to the daily recommendation for infants thus benefiting both the infant and their mothers (Hollis *et al.*, 2015). In menopausal women, Vitamin D helped maintain skeletal health thereby preventing fracture, osteoporosis and incidence of falls (Hill and Aspray, 2017) Very recently the immune boosting role of Vitamin D has also been used in the treatment and prevention of Covid 19 via supplementation (Shakoor*et al*, 2021) additionally sufficient levels of Vitamin Dreduces blood pressure, improves glycemic control, immunity and symptoms such as depression, insomnia, anxiety and pain improving the quality of life (Mathews et al., 2021).

1.2. Prevalence of Vitamin DDeficiency

Despite the inexhaustible significance of Vitamin D, its deficiency has manifested as a global pandemic widespread in over one billion people of all races, ages, gender, region and dietary habits. High levels of this deficiency were observed in healthy individuals worldwide with concentrated cases in India, the Middle East, South Africa and China. (Shah and Gupta, 2015). This deficiency may be attributed to decreased sunlight exposure due to covering, use of sunscreen, pollution, pigmentation, indoor lifestyle, inadequate intake through diet, low absorption due to related conditions, liver or kidney diseases affecting activation of Vitamin D, medicine induced increased catabolism in liver and organ resistance (Sizar*et al*., 2021) Vitamin D status is majorly assessed using serum 25 OH Vitamin D levels. The severances of deficiency was

classified based on the serum 25 OH Vitamin D levels as deficiencyless than 20ng/ml, insufficiency between 21 to 29ng/ml and sufficiency below 30ng/ml (Maghbooli, 2020).

Vitamin D deficiency in India, is present in an epidemic amount showing a prevalence rate of 70 to 100 per cent in the overall population. This deficiency even with the availability of ample amount of sunlight may be attributed to the factors such as darker skin tone among the Indians in comparison with people in the west, less body surface area exposed to sunlight due to modestly covered dressing habits in public among both the genders, avoiding sunlight for the desire of maintaining complexion and residing in crowded urban structures not supporting sunlight exposure, where the face and arm exposure to sunlight along with outdoor activity for 45 minutes was found to be beneficial in maintaining healthy Vitamin Dlevel(Ritu and Gupta, 2014).

The prevalence of Vitamin D deficiency among Indian women was 64.06 per cent (<20ng/ml), 98.75 per cent (<30ng/ml), 70 per cent in housewives and 29.92 per cent in illiterates (Garg*et al*., 2018). Literature also suggested manifestation of Vitamin D deficiency among the female population in India (20 to 60 years) when compared with the male counterparts and also a higher prevalence was observed in the urban population in comparison to the rural population which can be due to the lifestyle, diet and occupation (Bachhel*et al*., 2015, Misra*et al*., 2017, Dik and Kaur, 2020). Similarly, in a study conducted in Kanchipuram district of Tamilnadu, a mean 25 OH Vitamin D level was 20.5ng/ml among males (21.8ng/ml) and the mean value was higher than females (19.7ng/ml) also 59 per cent were found to show very low values of Vitamin D (<12ng/ml) (Mechenro*et al*., 2018).

In a study conducted on 1500 individuals in urban Chennai the overall deficiency was 55 per cent and women showed 1.6 times higher risk than men and further this deficiency was high in diabetics and pre diabetic individuals when compared to those with normal glucose levels (Jayashri*et al*., 2020). When left untreated this chronic deficiency can cause consequences like osteoporosis, osteomalacia, rickets, depression, Parkinson's disease, psychiatric issues, increased infectious diseases, autoimmune diseases, cancer, heart disease, diabetes mellitus and obesity, the discovery of these complications is just one dimension with thousands of Vitamin D receptors in cells and tissues of the body this deficiency could cause a greater burden on the health and development of a population (Aparna*et al*., 2018).

1.3 Background of the Problem

Lifestyle is the behaviour of an individual determined by place, economy, culture, time and religion influencing their occupation, activities and diet. Lately, the effect of lifestyle on health is gaining importance as 60 percentage of correlation was absorbed between lifestyle practices and health as reported by WHO. Lifestyle can be healthy or unhealthy, A healthy lifestyle helps to improve the quantity of life which results in increased life expectancy, whereas an unhealthy life can lead to a high risk of chronic diseases, deterioration and even death (Farhud, 2015). Islam is the second largest religion in the world with a 1.8 billion global population and its followers are called Muslims. Around the world, Muslims follow a unique lifestyle as commanded in the Quran (Holy scripture of Islam) and Hadith (life of Prophet Muhammad). According to Islam men and women are equal and are expected to fulfil the same duties of worship, fasting, moral, faith etc. but recognizing that they are not identical in terms of psychology and physiology, the sharia (Islamic laws) recommended some lifestyle practices specially assigned to women based on their contribution for a healthy family and society (https://www.history.com/topics/religion/islam), This lifestyle comprising of unique dressing habits, indoor living and distinguished diet may affect the Vitamin D status of the Muslims, yet there is a lack of understanding about other related factors influencing the Vitamin D status of these women, research on the prevalence of Vitamin D deficiency has indicated a high rate of insufficiency among the Muslim women.

Studies on the Gulf Cooperation Council countries where dense Muslim population lived, revealed low levels of Vitamin D (<20ng/ml) despite the availability of sunlight signifying the contribution of other factors in determining Vitamin D status. Among 415 Muslim women in Morocco 91 per cent showed a moderate deficiency of the vitamin (Allali*et al*., 2008; Singh *et al*., 2019). As low awareness may also influence the Vitamin D status, supporting studies among Muslim women in Jeddah and Mumbai has also disclosed very low awareness in existence (Agha *et al*., 2016). According to WHO nutrition education programs help to step up and control the gravity of specific deficiency, there are many forms of nutrition education such as demonstrations, digital education, telephonic counselling etc. but their effectiveness is determined by the type of nutrition education and population under study (Lopes *et al*., 2021) Further, limited data is available on the Vitamin D status of Muslim women in India, India being a country with diverse culture and population the factors contributing to the deficiency might differ

due to regional, cultural and social influence. Considering the importance of Vitamin D in health and cultural influence, it is essential to understand the major factors which might determine the Vitamin Dnutriture of a specific population and provide sustainable norms within their cultural lifestyle using appropriate educational tools to effectively overcome Vitamin D deficiency.

1.4 Scope and Significance

To our knowledge, this study is the first of the kind to be conducted in Coimbatore city in the state of Tamilnadu. The city lies between 11°North Latitude, 77°East Longitude and 1225.18 km north of the equator, receiving ample amount of sunlight around the year with minimal difference observed during winter favouring the production of Vitamin D. The city hasan estimated population of 8.6 per cent from the census of India (2011) and comprised the total population of Muslims of which 44,984 were women. Unlike the lifestyle of the Muslim women from the Middle East, the lifestyle of women in Coimbatore is influenced by region as well as culture. Most of the previous studies focus only on the effect of concealed clothing, while the present study along with the Islamic way of dressing, also considered knowledge about Vitamin D and influence of other factors, such as the practice of diet, education, occupation, socio economic status, knowledge, attitude, practice etc. that may contributing to the Vitamin Dnutriture among the Muslim women. The identification of these factors can help to provide objective resolution for the problem of Vitamin D deficiency among the Muslim women living in this area. Previous intervention studies have focused on improvement in Vitamin D levels with supplementation, emphasis to improve knowledge and promote healthy practices have not been considered. Hence, the present study examined the effectiveness of different interventions using digital technology and telephonic counselling for dietary modification in improving knowledge, attitude, practice, food and nutrient intake related to Vitamin D. Considering the practice of covered dressing habits and indoor lifestyle among the women the concept of sunlight exposure in private areas of the home was promoted. Also, with the outburst of the Covid- 19 pandemic, there was an increase in the use of digital technology in the field of education, increasing awareness and usage among the women that facilitated use of digital technology for providing intervention (Dhawan, 2020). The findings of this study will benefit Muslim women in improving practices to maintain healthy levels of Vitamin D and suggest an

effective mode for intervention in these women. A significant improvement in lifestyle practices favouring access to Vitamin D may enable women to lead a healthy life.

1.5 Operational Definitions

Vitamin D 25 hydroxylase - An enzyme present in the liver which facilitates hydroxylation in 25th position of cholecalciferol to form 25 OH Cholecalciferol

25 hydroxyVitamin D1 alpha hydroxylase - An enzyme in the kidney which facilitates hydroxylation in 1st position of 25 OH Cholecalciferol to form 1, 25 OH cholecalciferol

Vitamin D receptors – Site on the target organs where the Vitamin D attaches to carry out different functions

Fasting C-peptide - It is the compound formed as a response to endogenous insulin production

Hypertension – It is a condition of high blood pressure

Cardiovascular cells - The vascular smooth muscle cells, endothelial cells, lymphatic cells and cardiomyocytes that plays an important role in circulation and supportive cardiac activities.

Gestational diabetes – It is the increase in blood glucose level during pregnancy

Adiposity – a condition characterized by being overweight

PCOD – Poly Cystic Ovarian disease, a condition characterized by the release of immature eggs that changes into a cyst

Endometriosis – a condition in which the tissues lining inside the uterus overgrows outside the uterus

Pre eclampsia - a condition during pregnancy reporting high blood pressure and damage to organ systems like the liver and kidneys.

Organ resistance – organs like the liver and kidneys become resistant to activation of Vitamin D.

1.6 Objectives of the Present Study

Primary objectives

- Elicit information on the demographic profile and lifestyle pattern of Muslim women
- Study their health and nutritional status with reference to Vitamin D nutriture
- Identify the factors influencing Vitamin Dnutriture among Muslim women
- Evaluate the effect of digital health interventions and dietary modification in improving the KAP and dietary intake among Muslim Women

Secondary objectives

- Determine Vitamin D intake of the Muslim women
- Study the availability of Vitamin D fortified foods in the market
- Analyse the calcium and Vitamin D content of selected fortified foods
- Assess KAP on Vitamin D among Muslim Women
- Develop digital health intervention modules and implement on selected Muslim Women.
- Implement dietary modification through telephonic counselling