5. SUMMARY AND CONCLUSION

Vitamin D deficiency has manifested as an universal health issue andwidespread irrespective of differences in area, gender, race, age and ethnicity. Incidences in India has pointed at a higher prevalence in women up to 70 per cent. The recent discovery of Vitamin D receptors in cells and tissues all over the body has revealed its functions pertaining to immunity, diabetes, cardiovascular diseases, hypertension, cancer, multiple sclerosis and women's health beyond bone health.Vitamin D has been known for its importance in bone health for a long time, The vitamin is majorly obtained through sunlight facilitated production in the skin in the form of Vitamin D_3, a more effective type of Vitamin D compared to Vitamin D_2a plant derivative form of the vitamin.This synthesis was found to be affected by latitude, altitude, duration of sunlight, time of day, seasons pollution, age, the colour of the skin, use of sunscreens and covering the skin. Muslim women around the world follow the Islamic dress code of covering themselves when outdoor as commanded in the Quran. This cultural practice might affect the cutaneous production of Vitamin D. Further, literature has suggested a high prevalence of Vitamin D deficiency among Muslim women.

This background demands a better understanding of the Islamic dress code and other factors contributing to Vitamin D deficiency and postulation of supportive sustainable strategies to overcoming this deficiency and maintaining health. Hence the current study entitled “Impact of Nutrition Intervention and Dress Code on Vitamin DNutriture of Muslim Women”was carried out with primary objectives as follows:

- Elicit information on the demographic profile and lifestyle pattern of Muslim women
- Study their health and nutritional status regarding Vitamin Dnutriture
- Identify the factors influencing Vitamin Dnutriture among Muslim women
- Evaluate the effect of different interventions in improving the KAP and dietary practices among Muslim Women

The present study was conducted in four different phases. In Phase I a baseline survey was conducted to identify factors along with the Islamic dress code that might influence Vitamin D status among the Muslim women living in Coimbatore city. Pothanur,

Athupalam, Karumbukadai, Alameen colony, Sivananda colony, Marakadai and Townhall with dense Muslim population were included in the study.Overall 566 non pregnant and non lactating Muslim women between the age of 20 to 45 years were selected using a combination of purposive and snowball sampling methods. The sample size was determined using Slovin's formula on 2011 census data. a no objection letter was obtained from the Coimbatore Jamath head in charge of the Muslims "Jamath-e-Islamia Hind" and ethical clearance was obtained from the Institutional Human Ethics committee. The baseline data was collected using the door to door strategy of data collection using a systematically designed interview schedule to collect information on the demographic profile, socio-economic background, health status, dietary habits, lifestyle pattern, sunlight exposure, physical activity pattern and knowledge about Vitamin D.

Phase II comprised of two parts. In the first part of the study, nutritional status of 566 Muslim women was assessed using anthropometric measurements such as height, weight, waist circumference and hip circumference using standard procedures. BMI (Body mass index) and waist hip ratio was calculated using these measures. A clinical examination looking for signs and symptoms associated with Calcium and Vitamin D deficiency was conducted and documented in achecklist. The dietary data was collected using a three day 24 hour dietary recall method and using a food frequency questionnaire. Two consecutive weekdays and one weekend pattern were used for the three days 24 hour data collection. The food intake and nutrient intake of the Muslim women were calculated and compared with the RDA suggested by ICMR(2020). In the second part of the study,3ml blood sample was collected from 37 Muslim women and their serum calcium and serum Vitamin D, levels were estimated using Arsenazo III assay and fully automated Chemi Luminescent Immuno Assay respectively and compared with the reference value. As this phase was progressing, the Covid -19 pandemic started and blood sample collection was restricted.

In Phase III a qualitative market research to collect data on the availability and accessibility of Vitamin D fortified foods in the local market of Coimbatore city was conducted. The shops were selected by random sampling methodVitamin D fortified foods were identified from the food labels and details of the product such as shop code, type of shop, product name, product company, amount of Vitamin D fortification, the form of Vitamin D and cost of the product were recorded. Two Vitamin D fortified products, namely

fortified milk and fortified egg available in the local market were selected randomly for calcium and Vitamin D analysis. Calcium was estimated using the titrimetric method and Vitamin D was estimated using the HPLC method. The effect of boiling and refrigeration on nutrient retention was calculated using USDA (2007)true retention formula.

In the Phase IV phase owing to the onset of the Covid 19 pandemic, supplementation of calcium and Vitamin D fortified foods to the women was not possible. Hence, the study was modified to as evaluation of digital health interventional study. Pertaining to this, materials for two different intervention strategies namely digital health intervention and telephonic counselling with dietary modification were developed. Digital health intervention modules developed were YouTube videos, motion graphic videos, memes and recipe idea videos A WhatsApp group as a portal to deliver the digital health interventionand twogoogle forms for evaluation of the impact of knowledge, attitude and practice were developed. The intervention materials that weredeveloped, covered the topics overview of Vitamin D, sources, importance, dietary Vitamin D, its benefits to women and ideas to increase Vitamin D intake. After dropouts, overall 199 Muslim women were present in the three groups, Group I (69) was provided digital health intervention,Group II (67) was provided with telephonic counselling and dietary modification and Group III (63) was the Control Group.The responses before and after intervention on knowledge, practice attitude and dietary intake were collected and compared to evaluate the impact. The t-test of significance, chi-square, correlation and regression were used to study the relationship between variables and impact was assessed using a paired sample t-test. P values 1 per cent and 5 per cent were taken to be significant.

The principal findings of the current study are present as follows

- In PhaseI, among the Muslim families 74 per cent were nuclear families and 26 per cent were joint families. Overall 68 per cent of the families surveyed have four to six members. A pattern of three to four family members was 68 per cent in nuclear families and among joint families, 58 per cent hada five to six member pattern.
- Thirty five per cent were graduates, 17.5 per cent had completed a professional degree and 38 per cent completed high school education. Occupation of the family head showed the presence of businessmen (49%), skilled workers (21.2%) semiskilled workers (10.2%) and professional jobs (9%) and the

- Family income of nearly 27 per cent of the familieswas between Rs.26300 to 53000. Household amenities showed 65.4 per cent of the families had three to five amenities in position. Majority (99%) of the families had a television and two wheelers.
- Majority of the families expended the highest per cent of their income on food (32.7 ± 12.6) followed by 16 ± 21.0 on rent and 9.9 ± 10.44 and 8.3 ± 6.0 on education and transportation. The socio economic status of 45.4 per cent was in the upper middle class range and 40.5 per cent were in the lower middlerange based on Kuppuswamy's classification.
- Among the 566 Muslimwomen, 22 per cent were between 20 to 24 years, 14 per cent were between 25 to 29 years, 21 per cent were between 30 to 34 years, 17 per cent between 35 to 39 years and 26 per cent between 40 to 45 years.Women were categorized as 20 29years, 30-39years and 40-45 years for discussing the results.
- Ninety three per cent among the Muslim women inbetween 40 to 45 years were married, one per cent were divorcees and five per cent were widows. In the 30 to 39 years age group married women were 96.7 per cent and unmarried women were two per cent and in 20 to 29 yearsmarried women were 57.7 per cent and unmarried women were 41.3 per cent respectively.Age at marriage was less than 18 years in 23 per cent between 40 to 45 years, which reduced to 7.3 per cent among women in the age group of 20 -29 years indicating a decrease in the trend of early marriage. Among the age group of 20 to 29 years and 30 to 39 years 29.1 per cent and 40 per cent were married between 18 to 20 years.
- Forty two per cent of Muslim women in 40 to 45 years and 39 per cent in the age group of 30 to 39 years had a first child at or below the age of 20 and 21 to 35 per cent had the first child between 21 to 24 years in all three age groups. The number of children in 56 per cent (30 -39 years) and 58 per cent (40 – 45 years) of the Muslim women was two children, followed by three children in 17.4 per centin 30 to 39 years and 26.5 per cent in 40 to 45 years age group.One child pattern was observed in 24 per cent of the Muslim women in 20 to 29 years age group.Twenty four per cent of miscarriages and 3.3 per cent of stillbirth incidences were reported among the Muslim women in the age group of 30 to 39 years

- Fifty one per cent of the Muslim women between 20 to 29 years were graduates and 22.8 per cent completed higher secondary. In the 30 to 39 years age group,39 per cent completed primary education, 24.4 per cent completed secondary education and 20.2 per cent completed higher secondary education, while only 12.2 per cent were graduated. Fifty six per cent of women in 20 to 29 years, 49 per cent in 30 to 39 years age and 51 per cent in 40 to 45 years preferred women's institutions for education. Among Muslim women between the age of 40 to 45 years and 30 to 39 years 76 per cent and 63.3 per cent were dropouts.
- Majority of the Muslim women studied were homemakers in all three age groups (63 - 87.3%) and the remaining and 29.1 in the age group of 20 to 29 years were students. The remaining worked as businesswomen, caterers, tailors, teachers, sales women, doctors, engineers and maids.
- It was observed that74 to 84 per cent occurrence of acute illness, 67 to 69 per cent common cold incidences and 32 to 36 per cent fever incidences in all three age groupswas evident and the frequency of occurrence was majorly (74 -82%) occasional. Among chronic illnesses, a prevalence of 22.4 per centhypertension, 16.3percent diabetesand 67 to 70 per centrespiratory tract infection was observed.Lifestyle diseases such as hypertension, diabetes, thyroid, cancer and CVD showed an increase in average prevalence with an increase in age, showing an onset after 40 years among the women.
- Muslim women (65% to 68%) in all three age groups exhibited average health while excellent health showed a marginal reduction with age such as 27.7 per cent in 20 to 29 years, 24.4 per cent in 30 to 39 years and 22.4 per cent in 40 to 45 years. Besides, 11.6per cent of Muslim women (40 to 45 years) exhibited poor health.
- Among the 566 Muslim women in all three age groups, 96 to 99 per cent were non vegetarians. Overall 85 to 92 per cent among the Muslim women in all the three age groups consumed three meals per day. Regarding skipping means 47.6 per between the age of 20 to 29 years, 43.7 per cent of women in 30 to 39 years and 36.1per cent of women in the 40 to 45 years age group skipped meals. The meal skippers, the majority of the women skipped breakfast (82– 85%) followed by skipping dinner(9 – 16%). Only 54 to 64 per cent of the women compensated for the skipped meals.

- The habit of consuming outside foods was observed in 80 to 90 per cent of Muslim women in all three age groups. Of which, 32 per cent of Muslim women between 20 to 29 years consumed outside food on weekly basis. Occasional consumption and restaurants were preferable among the Muslim women in all three age groups.
- Seventy six per cent among the Muslim women between the age of 20 to 29 years, 68 per cent in 30 to 39 years and 50 per cent in 50 to 45 years read food labels. Among the facts read on a food label majority (92 to 100%) read the expiry dates. The practice of reading about ingredients and nutrient content was low among Muslim women.
- Purchasing behaviour showed grocery shop purchase to be 50 percent in women between 30 to 39 years of age and 59 per cent in women between 40 to 45 years of age, while purchase from departmental stores was higher up to 46 per cent (20 -29 years) among young Muslim women. Petty shop purchase was in the range of 28 to 33 per cent among women of all three age groups. Online purchase was 12 per cent in women between 20 -29 years of age which was higher than other age groups. These low to moderate levels of purchase from online stores and departmental stores may limit the access to Vitamin D dietary sources exclusively available at these outlets.
- Known consumption of Vitamin D fortified foods was among 12 per cent in Muslim women between 20 – 29 years of age; this was better when compared to 7.5 per cent known consumption in women between 30 – 45 years of age. The main reason for not consuming was specified as lack of Knowledge in 83 to 91 per cent of Muslim women.
- Regarding the Islamic dress code practice, 95 per cent of the women between 20 to 39 years wore Islamic dress. Jilbab, hijab, niqab and burqa were the different Islamic dress codes identified. Among which the use of Jilbab was 62.0 per cent in the age group of 30 to 39 years and 57.8 per cent in the 40 to 45 years.while in the age group of 20 to 29 years 34.5 per cent wore niqab, 31.6 per cent wore jilbab, 18.4 per cent wore hijab and 10.2 per cent wore a burqa. More preference for niqab and burqa, the two fully covered dresses among women between 20 to 29 years compared to women in other age groups suggested a recent increase in practice

among the younger generation (20 to 29 years) and the colour selected for Islamic dress was black in the majority of the women irrespective of age (73 - 83%).

- Majority of (>87%) of Muslim women in the age group of 20 to 39 years started wearing Islamic dress on or below the age of 20 years. Muslim women wearing Islamic dress for a longer durationbetween 30 to 39 years of age showed that 37.6 per cent wore Islamic dress for 16 to 20 years and 27.7 per cent wore the dress for 11 to 15 years. . The materials used for the Islamic dress were synthetic (50.5%), cotton (29%), viscose (6%), velvet and crepe were minimal.
- The practice of fewer than twenty minutes of sunlight exposure was 57 per cent in Muslim Women between 20 to 29 years and 59 per cent in women between 30 to 39 years. Among Muslim women between 40 to 45 years, 20 to 30 minutes exposure was 37 per cent followed by less than 20 minutes in 35 per cent, greater than 60 minutes habits was observed in 14 per cent of these women. Duration of sunlight exposure showed that nearly three per cent of women were completely devoid of sunlight and positivelyamong the Muslim women in all three age groups42 to 53 per cent of them were exposed to sunlight between 11 am to 3 pm which would support Vitamin D production. The remaining women were either exposed to sunlight before 11 am or after 3 pm.
- The use of parasols such as umbrellas and sunscreen creams was low, showing 10 to 12 per cent umbrella users in all three age groups and 11.7 per cent between the age of 20 to 29 years used sunscreen creams.
- Majority (94 – 95%) of the Muslim women between 20 to 39 years covered with Islamic dress for religious reasons, while in the age group of 40 to 45 years 85 per cent covered for religious reasons.87 per cent of women of 40 to 45 years, 79 per cent of women in 30 to 39 years and 66 per cent from 20 - 29 years did not avoid sunlight intentionally. Nearly 23 per cent of Muslim womenavoided sunlight to maintain complexion in 20 to 29 years age group.
- Regarding the extent of covering while going out in the sunlight, 66 to 77 per cent in all three age groups cover their head, exposing face, hands and feet and 24 per cent among the Muslim women betweenthe age of 20 to 29 years covered entire body.

Hand covering with gloves (4.4%) and feet covering with socks (1.9 %) was higher in the age group of 20 to 29 years.

- Concerning physical activity, an exercise routine was followed only by 19.9 per cent among the Muslim women in between the age of 20 to 29years, 18.8 per cent in the age group of 30 to 39years and 16.3 per cent in the age group of 40 to 45 years, of which 70 per cent and 62.5 per cent in 30 to 39 years and 40 to 45 years of age exercised regularly. Indoor exercising pattern was between 55 – 66 per cent among the exercising Muslim women irrespective of age. Duration of exercises was predominantly 20 minutes in 46 per cent between the age of 20 to 29 years, 33 per cent in the age group of 30 to 39 years and 54 per cent in the age group of 40 to 45 years.
- Knowledge of Vitamin D was very low among Muslim women. Only 56.3 per cent (20 - 29 years), 33.8 per cent (30 to 39 years) and 35.4 per cent (40 to 45 years) had heard the term Vitamin D. Three to five per cent among the Muslim women irrespective of age had tested Vitamin D and were aware of its normal levels. Sixty five per cent between the age of 20 to 29 years and 84 per cent between 30 to 45 years were not aware of the benefits of Vitamin D.
- Twenty three per cent between the age of 20 – 29 years were aware of the dietary source of Vitamin D, while only 10 per cent between the age of 30 to 45 years were aware.Twelve per cent of them were aware of fortified foods and five per cent were ware aware of the government's role in fortification between the age of 20 to 29 years. Attitude towards intake of Vitamin D fortified foods was good in Muslim women in all three age groups.
- Knowledge scores showed that 51.94 per cent, 62.91 per cent and 59.86 per cent in

knowledge on Vitamin D

- The demographic and lifestyle variables such as marital status, education occupation, duration of exposure to sunlight, the extent of covering in outdoors and physical activity showed an association with Islamic dress indicating that the Islamic dress code affected these factors. Muslim women purusing higher education was better

among the women following Islamic dress compared to Muslim women of regular dressing habits. Islamic dress practice was observed to be less among working women. , the duration of sunlight exposure was found to be comparatively greater among Muslim women not practising Islamic dress, which was highly significant ($p<0.01$). A statistically significant difference in the extent of covering while outdoor in sunlight was evidentbetweenthe women wearingIslamic dress and women of regular dressing habit, also a very weak difference in the physical activity practices between the two groups showing better physical activity among Muslim women wearing regular clothing was observed. Also, nosignificant association of health scores and knowledge scores with Islamic dress practice were noticeable.

- The scores showed variance with marital status, education, occupation, socioeconomic status, Islamic dress type, the extent of covering, physical activity and consumption of Vitamin D fortified foods. The variance in the case of marital status, education, occupation was contributed by higher scores observed in students who were unmarried and of better educational qualification. Knowledge scores were higher among the Muslim women belonging to the upper middle class (3.45 ± 1.68), followed by upper class (3.12 ± 2.03).
- A very weak association between duration of sunlight exposureand knowledge score indicated that even with sufficient knowledge Muslim women did not expose to sunlight significantly, also Muslim women wearing burqa (3.82 ± 1.75) and hijab (3.45 ± 1.64) showed marginally higher knowledge score compared to women wearing the niqab, jilbab. Physical activity was comparatively better among Muslim women with higher knowledge scores (3.62 ± 1.98). A strong association between knowledge score (5.33 ± 1.62) and known intake of Vitamin D fortified foods among Muslim women was observed. Therefore, Vitamin D fortified food intake, physical activity practices and duration of sunlight exposure among Muslim women can be improved with better knowledge.
- Height of 51.5 per cent of the Muslim women in the age group of 20 to 29 years, 62 per cent in the age group of 30 to 39 years and 54.4 per cent in the age group of 40 to 45 years was in the range of 150.1 -160 cm. the height of 20.9 per cent (20 to 29 years), 18.3 per cent (30 to 39 years) and 16.3 per cent (40 to 45 years) was in the

range of 160.1 to 170 cm. The mean height was 155.2 ± 6.9, 155.4 ± 6.2 and 153.8 ± 6.2, in the age group of 20 to 29 years, 30 to 39 years and 40 to 45 years, which was 6.8, 6.58 and 8.23 cm deficit compared to ICMR the standard for height. This differencebetween mean height and ICMR standards was statistically significant.

- Thirty eight per cent, 31 per cent and 27.2 per cent in the age group of 40 to 45 years, 30 to 35 years and 20 to 29 years weighed between 60.1 to 70 kg. while34.5 per cent and 18 per cent in the age group of 20 to 29 yearsweighed between 50.1 to 60 kg and 40.1 to 50 kg. . The mean weight of 58.3 ± 11.8, 68.9 ± 12.1 and 67.2 ± 11.03 among Muslim women in the age group of 20 to 29 years, 30 to 39 years and 40 to 45 years was higher than the ICMRstandard for weight.This differencebetween mean weight and ICMR standards was highly significant.
- Body Mass Index of the Muslim women, when compared with WHO South Asian criteria, revealed that 11 per cent and 31.5 per cent of the Muslim women in the age group of 20 to 29 years were underweight (17.16 ± 0.92) and normal weight (20.8 ± 1.36) and 40 per cent and 34 per cent of the women in the age group of 40 to 45 years and 20 to 29 years were overweight. Prevalence of type I and type II obesity was 37.6 per cent(30.07 ± 1.42) and 16.5 per cent(34.59 ± 1.36) in the age group of 30 to 39 years and 33.3 per cent (29.76± 1.4) and 16.3 per cent (34.35± 1.12) in the age group of 40 to 45 years. Type III obesity was observed in 2 to 3 per cent of the Muslim women in all three age groups, the mean BMI was 38.79 ± 4.64, 40.76 ± 2.63 and45.64± 9.13 respectively.
- The average waist circumference was 77.9 ± 12.2, 90.4 ± 12.4 and 92.2 ± 10.6 in the age group of 20 to 29 years, 30 to 39 years and 40 to 45 years and hip circumference were 89.4 ± 12.9, 102.0 ±12.44 and 103.8 ± 10.5 in 20 to 29 years, 30 to 39 years and 40 to 45 years respectively. The mean waist hip ratio was 0.87 ± .05, 0.89 ± .05 and 0.89 ± 0.04 in the 20 to 29 years, 30 to 39 years and 40 to 45 years age group among the Muslim women. When compared with WHO standard for waist- hip ratio 64 to 80 per cent of the Muslim women in all three groups were in a high risk category.
- Clinical signs and symptoms revealed 7.8 per cent (20 – 29 years)falling ill frequently fatigue 13.1 per cent in 20 to 29 years, 17.4 per cent in 30 to 39 years and

23.1 per cent 40 to 45 years age group.). Leg pain was present in 33.5 per cent (20 - 29 years),44.1 per cent (30 - 39 years) and 63.3 per cent (40 - 45 years) and back pain were present 20.4 per cent (20 - 29 years), 33.8 per cent (30 - 39 years) and 40.1 per cent (40 - 45 years) among the Muslim women. seven per cent in the age group of 20 to 29 years exhibited calf muscle tenderness, Body pain was 19.5 per cent among Muslim women in the age of 40 to 45 years, while in the other two age groups the occurrence was 15.5 per cent. Depression was present in 29.1 per cent of the Muslim women between 20 to 29 years and 26.5 per cent between the age of 40 to 45 years.

- Rice was consumed daily by 99 per cent, wheat was consumed weekly 60 to 68 per cent among Muslim women of all three age groups. The consumption of pulses was weekly three or four. Red gram dhal, black gram, green gram, Bengal gram, peas and chickpea were among the pulses consumed weekly in all three age groups. Among the roots and tubers onion was consumed every day (100%), while other roots and tubers, like potato, carrots, beetroot and yam were consumed once or twice a week followed by an occasional consumption pattern in all three age groups.
- Green leafy vegetable consumption was low revealing amaranth and palak were consumed once a week and sometimes occasionally. Beet greens and manathakkali were not preferred by 51 to 61 per cent of the women. Other vegetables such as brinjal, beans and ladies fingers were consumed once or twice a week by above 70 per cent of Muslim women in all three age groups. Mushroom consumption was as low as 14 to 18 per cent consuming weekly and 45.6 per cent in 20 to 29 years, 32.9 per cent in 30 to 39 years and 42.9 per cent in 40 to 45 years consuming occasionally. Among the fruits, banana consumption was daily in near 30 per cent in the age group between 20 to 39 years in 40 to 45 years 40 per cent daily consumption was observed. Other fruits such as apple, pomegranate, guava and papaya were consumed once or twice a week.
- Refined oil was preferred for cooking by 53.4 per cent (20 - 29 years), 63.4 per cent (30 to 39 years) and 60.5 per cent (40 to 45 years) among the Muslims.Consumption of flesh foods like chicken, mutton, beef and fish was weekly twice or thrice in most Muslim women irrespective of age.Forty per cent in between 20 to 29 years and 40

to 45 years age group did not consume beef while 45.5 per cent in the age group of 30 to 39 years consumed beef weekly. organ meat consumption was found to below. Weekly consumption of fish was among Muslim women was 70.4 per cent, 65.3 per cent and 70.7 per cent in the age group of 20 – 29 years, 30 to 39 years and 40 to 45 years respectively. But the consumption of mackerel, tuna and salmon containing more Vitamin D was considerably low.The milk consumption among the Muslim women was, 86.9 per cent, 88.7 per cent and 91.8 per cent in the age group of 20 to 29 years, 30 to 39 years and 40 to 45 years consumed milk. Forty to forty six per cent of the Muslim women consumed curd daily followed by weekly consumption in 24 to 32 per among all the three age groups.

- A pattern of weekly and occasional consumption of processed foods and daily consumption of tea was evident in all three age groups among Muslim women. Tea consumption was 2 to 3 times among most of the Muslim women above the age of 30 years, and 4 to 5 times a day.
- Vitamin D fortified foods daily consumption of Vitamin D fortified oil by 52.9 per cent (20-29years), 63.4 per cent (30-39 years) and 58.5 percent (40-45 years) of Muslim women was observed. The women barely consumed fortified foods such as Vitamin D fortified cereals, milk, biscuits and supplements and the main reason for not consuming was lack of awareness about the products.
- Mean food intake among the Muslim women showed that the intake of all the foods except cereals, fruits and animal foods was deficit compared to the recommended dietary allowance of ICMR in all the three age groups. There was Excess consumption of cereals which increased with age. pulse intake was deficit by25.5 per cent in 20 to 29 years, 24.3 per cent in 30 to 39 years and 16.7 per cent in 40 to 45 years of age. The green leafy vegetable and other vegetable consumption were as low as 82 to 84 per cent and 87 to 89 per cent below recommendation among the Muslim women in all three age groups. The intake of roots and tubers were deficit by 43 per cent in all age groups.
- Animal food consumption was excess by 30.2 per cent in Muslim women in the age group of 30 to 39 years followed by 29.5 per cent in 40 to 45 years and 16.5 per cent in 20 to 29 years and consumption of fruits was marginally above the RDA among

Muslim women. Milk and milk product intake was deficit by 34 per cent in 20 to 29 years, 25.8 per cent in 30 to 39 years and 16.7 per cent in 40 to 45 years age group among the Muslim women. In all the age groups the consumption of fats oils and sugars was deficit.

- Nutrient intake of the Muslim women showed the mean energy intake was higher than the recommended dietary allowances of ICMR (2020) by +15.9 per cent (20 - 29 years), +24.9 per cent (30 – 39 years) and +31.1 per cent (40 – 45 years) among the Muslim women. Protein intake was in excess in the range of 100 to 133 per cent and the fat consumption was excess by 139 to 164 per cent in all three age groups. Fibre intake of the Muslim women was deficit in the range of 62 to 64 per cent in all the age groups.
- Concerningiron intakea deficit by 43.5 per cent, 40.7 per cent and 40.5 per cent and calcium intake was deficit by 25.1 per cent, 21.14 per cent and 18.2 per cent in Muslim women in the age group of 20 to 29 years, 30 to 39 years and 40 to 45years. Vitamin C intake was moderately excess in the range of 13 to 17 per cent among all the age groups The consumption of Vitamin D_2 was higher than the other two forms of the Vitamin among Muslim women, mean intake was40.78 ± 17.12 (20–29 years), 39.20 ± 13.3 (30 – 39 years) and 41.52 ± 15.8 (40 – 45 years respectively. This might be due to more amount of Vitamin D_2in cereals, pulses and spices that form a major portion of the Indian diet.
- Body Mass Index and energy intake among the Muslim women in the age group of 20 to 29 years30 to 39 years and 40 to 45 years showed a positive correlation with one percentage significance at ‘r’ value 0.207, 0.217 and 0.214 respectively.
- Serum Vitamin D of the selected Muslim women (n = 37) revealed that 35 Muslim women (94.6 %) were deficient showing levels below 20 ng/ml and the remaining two Muslim women were insufficient (20 – 30ng/ml).
- Serum calcium levels of the selected Muslim women (n = 37) revealed thatmajority (91.9%) of the selected Muslim women had serum calcium levels within normal range. Nearly eight per cent of the selected Muslim women had low levels of calcium below 8.5mg/dl. None of the women had high levels of calcium.

- Correlation and regression analysis suggested a negative effect of age, education, type of Islamic dress, duration of practising Islamic dress, physical activity on Vitamin D levels and a positive effect of duration of exposure tosunlight and occupation. Overall 30.8 per cent of changes in serum Vitamin D levels were found to be due to these factors altogether. Based on the regression coefficient a 0.051 ng/ml decrease in Vitamin D levels for every increase in age (in years), a 1.161 ng/ml decrease in Vitamin D levels with an increase in educational qualification, 1.208 ng/ml decrease in Vitamin D levels with an increase in cover, 0.069 ng/ml decrease in Vitamin D levels with an increase in the duration of following Islamic dress and 1.078 ng/ml increase in Vitamin D levelswith an increase in sunlight exposure was observed.
- Duration of sunlight exposure and the type of Islamic dress have more effect on Vitamin D levels. Considering the influence of Islamic dress on other factors, it is evident that Islamic dress is the major determinant of Vitamin D levels among Muslim women thereby having an impact on Vitamin D status.
- Correlation of all the body measures and symptoms was negative with serum Vitamin D levels. BMI and weight showed a very weak relationship between Serum Vitamin D levels. An increase in BMI and weight leading to a decrease in Serum Vitamin D levels was evident. Among the symptoms only back pain showed a significant negative correlation with Vitamin D levels, indicating an increase in incidences of back pain with a decrease in serum Vitamin D levels.
- Concerning Nutrient intake, the correlation was not significant for all the nutrients except Vitamin D_2 and total Vitamin D was significant.
- In Phase III during the market survey among the 76 shops and stores surveyed, 33 per cent (25) were petty shops, 38 per cent (29) were grocery stores, 20 per cent (15) were departmental stores and 9 per cent (6) were online stores.
- Around 108 products were identified during the survey, which was categorized into foods, baby foods formula and health drinks. The products under the foods category were further grouped into milk and milk products (10.2%), cereals (3.7%), cooking

oils (16.7%), biscuits (10.2%), glucose powder (2.7%) and egg (0.9%). The milk and milk products identified included packed milk, milk powder and flavoured milk.

- Among the cereals, only four products were found to be fortified with Vitamin D,all the Vitamin D fortified cooking oils identified were packed refined sunflower oil,Eleven different biscuits showing Vitamin D fortification at various levels were identified. Glucon D and glucoside were fortified with Vitamin D. One product under eggs was identified among the Vitamin D fortified products. Apart from the foods,16 baby foods and 10 baby formulas were fortified with Vitamin D.Six products for toddlers, 21 products for consumption for adults and seven disease specific health drinks for diabetes and renal conditions were also identified.
- The mean availability of Vitamin D fortified products in different shops and storesshowed availability of all the products was high in online stores compared to other shops and stores.Availability of Vitamin D fortified products also showed a decrease with a reduction in the size of the stores and shops, departmental stores sold more Vitamin D fortified products followed by grocery stores and then petty shops. Among the Vitamin D fortified products available in petty shops biscuits and adult Health drinks were 48 per cent and 34 per cent.
- In grocery stores, availability of cooking oil (51%), biscuits (65%), toddler Health drinks (42%) and regular Health drinks (51%) was greater than petty shops. Vitamin D fortified cooking oils, biscuits, milk and milk products, infant formulas, baby foods, eggs, glucose powder, Health drinks for toddlers, adults and specific for diseases were available more in departmental stores compared with grocery stores and petty shops. Disease specific supplement availability was comparatively greater up to 40 per cent in online stores. Overall the availability in departmental stores and online stores was higher, emphasizing the importance of purchase behaviour from these stores for better access to Vitamin D fortified foods.
- The products identified were in different forms, 57 per cent of the products were in the powder form, four per cent were cerealin pellet forms, 17 per cent in liquid form 10 per cent were oils and one product was present in the form of a tablet.

- Vitamin D fortified foods inVitamin D fortification was present in 69.4 per cent of the products, Vitamin D_2 form was present in 27 per cent of the products, Three per cent of the products were fortified with Vitamin D_3 and nearly one per cent of the products were fortified with both Vitamin D_2 and Vitamin D_3. Due to the unavailability of the type of Vitamin D used for fortification in the specification of nearly 70 per cent of the products.
- Calcium and Vitamin D content of fortified food products as specified by the labels showed the mean calcium per 100g/ml among the Vitamin D fortified foods was more up to 366.8 ± 66.5 in the identified cereals, followed by 220.7 ± 266.9 in milk and milk products. In the baby foods and infant formula, the mean content was 471.3 ± 122.9 and 415.9 ± 43.7. The mean Vitamin D content per 100g/ml was 15mcg in egg, 13.5 ± 5.2 in glucose powder, followed by cooking oil (9.35 ± 3.2) and health drinks for toddlers (7.73 ± 3.04) and adults (680.1 ± 328.2). The levels of Vitamin D fortification in milk identified during the survey was 200IU per litre. Thirteen out of 18 oils identified were fortified with 11.25 mcg/100ml of Vitamin D.
- Vitamin D content of fortified product when compared with RDA (ICMR,2020) wasper hundred gram of Cooking oil (68.4%), glucose powder(90%), infant formulas (68.8%), baby foods (51.3%) and health drinks (33 – 52%) were fortified with more amount of Vitamin D. However, the likelihood of consumption of these products is mostly within 30 g due to their portion size and hence, cannot be used an effective source of Vitamin D. Eggs, cereals, infant formulas and baby foods providing 100, 31.5, 68.8 and 51.3 per cent of the daily Vitamin D requirement may prove more effective fortified food sources. The cost of the Vitamin D fortified product and Vitamin D content showed a positive correlation, which was significant in the food, infant formula and baby foods groups.
- Calcium and Vitamin D content of fortified egg revealed that the ash content (g) of the raw Vitamin D fortified egg was 0.85 ± 0.02, moisture and calcium content(g) were 76.7 ± 0.15 and 48.31 ± 0.35 respectively. On boiling, there was a 4.5g increase in the raw weight of the egg, further the mean moisture content increased to 80.03 ± 0.09 (%) and ash content (g)was marginally higher (0.94 ± 0.07) in comparison with the raw egg. The calcium content (g) of the egg decreased to 41.83 ± 1.07 on

boiling. This may be due to the hard boiling of the egg andVitamin D levels were not detected.

- On refrigeration of the eggs for 24 hours,ash content (0.85 ±0.01 g) was similar to the raw egg, whereas the moisture and calcium content of the refrigerated eggs showed a difference of 0.04 and 0.8, which may have been lost during storage. Vitamin D levels were not detected.
- Calcium and Vitamin D content of a randomly selected sample of fortified milk revealed that the moisture and ash content of raw milk was 90.29 ±1.19 and 0.51 ± 0.03 respectively, This moisture content decreased to 84.17 ± 0.568 in the boiled milk, this change may be attributed to vapourization during the process of boiling. A 0.01g/100ml increase in ash content and 4.26mg/100ml increase in the calcium content of boiled milk compared to raw milk was observed The contents of refrigerated milk did not exhibit much variation in comparison with raw milk. Similar to eggs the Vitamin D content of Vitamin D fortified milk was also not detected.
- The true retention values of the nutrients calcium, ash and moisture in Vitamin D fortified eggs boiled and refrigerated and Vitamin D fortified milk both boiled and refrigerated showed the retention of the nutrients was above 90 per cent for all four samples. As Vitamin D content was not detected, true retention could not be calculated.
- This part of the study was carried out in view of supplementation to determine the effectiveness of consumption of Vitamin D fortified foods on Vitamin D levels of the Muslim women in the following phase. The onset of the Covid pandemic lowered the possibility of conducting a supplementation study. Hence the study was redesigned to a digital health intervention study.
- In Phase IV the evaluation of Knowledge, attitude and practice among the 199 selected Muslim women for intervention showed it is evident that the mean knowledge score among the selected women was between 0.57 to 1.35 out of 9 with the better score in the Muslim women of 20 to 29 years showing a reduction of knowledge scores with age. This difference was significant at 5 per cent.

- Attitude towards sunlight exposure, fortified foods and Vitamin D supplements was higher (>80%) in Muslim women in the age group of 30 to 39 years and 40 to 45years. These women expressed an approving outlook towards healthy practices.
- Concerning the practices related to enhancing Vitamin D levels, the overall scores point at better practices among the Muslim women between the age of 40 to 45 years, preceded by womenbetween the age of 30 to 39 years. However, these scores were very low in the range of 4.04 to 4.81 out of 14. The scores provided for the extent of exposure to sunlight based on the amount of skin exposed was between 1.6 to 1.42 out of 3, which may be due to the Islamic concealing dress practices among these women. Overall practice scores showed a significant difference with age.
- Impact of the digital health intervention and telephonic counselling on knowledge score showed a statistically significant ($p<0.01$) increase in knowledge after providing intervention among the Muslim women in all three age groups. The difference in mean overall knowledge score increase in Group I(digital health intervention) was 7.00 (20 – 29years), 7.71(30 – 30 years) and 8.11 (40 -45 years) and in Group II(telephonic counselling) it was 4.42 (20 – 29years), 5.22(30 –30 years) and 5.28 (40 -45 years). In Group III (control), a difference of 0.20 (20 – 29years), 0.14 (30 – 30 years) and 0.24 (40 -45 years) were apparent. Signifying that digital intervention was more effective in increasing the knowledge compared to telephonic counselling.
- When examining the improvement in different areas of knowledge, the increase in knowledge about fortified foods was more in Group I compared to Group II. This may be due to better understanding through audio visual aids of digital health intervention.
- Concerning attitude, there was a significant increase in overall attitude towards sunlight, fortified foods and supplements among Muslim women between 20 to 29 years of age in both the intervention groups. There was no significant difference in attitude scores after intervention among Muslim women between 40 to 45 years of age and 30 to 35 years of age, except in overall scores among Muslim women in Group II. This may be because the majority (>80%) of the Muslim women in this age group (30 -45 years) had a positive attitude towards Vitamin D even before the

intervention. compared to the two groups changes in attitude among the Muslim women in Group III was not significant.

- The impact on practices thedifference in duration of sunlight exposure and extent of exposure, before and after the intervention was statistically significant in both the intervention groups in the age group of 20 to 29 years and 30 to 39 years brought about through suggestion of sunlight exposure in home premises. Regarding the physical activity among Muslim women between 20-29 years, a statistically significant improvement in physical activity was observed in Group II. Among Muslim women in the age group of 30 to 39 years, there was a significant increase in physical activity in both the intervention group.The intake of Vitamin D rich foods and fortified foods had increased significantly after intervention in both the intervention groups irrespective of age.
- The difference in overall practice scores of Group I was 3.81 (20–29 years), 4.17 (30–39 years) and 3.56 (40–45 years) respectively, While the difference in Group II was 3.65 among Muslim women in the age group of 20 to 29 years, 3.26 in 30 to 39 years and 1.94 in the age group of 40 to 45 years. This indicates an increase in overall practice among all three age groups in Group I followed by Group II, exhibiting minor differences except among the Muslim women between the age of 40 to 45 years present in Group II. These findings suggest an average improvement in the practice
- Impact ofdigital health intervention and dietary modification on food revealed among women between the 20 to 29 years, In Group II, there was a highly significant reduction in cereal consumption,a significant increase in the green leafy vegetable and other vegetable consumption compared to Group I and Group III.
- In 30 to 39 years age group, also there was a significant increase in the green leafy vegetable and other vegetable consumption among Muslim women in Group II compared to other groups. A moderate increase in fleshy foods and pulses intake was noticeable. The increase in pulses consumption 61.3± 126.7after intervention met the daily pulse requirement of 60 g suggested by ICMR.

- In the age group of 40 to 45 years in Group I, a significant reduction in cereal intake and milk and milk products was observed. This might be due to weight reduction and a decrease in the consumption of coffee and tea suggested during the intervention. In Group II, there was an increase in green leafy vegetable, milk and milk products and other vegetable intakes detectable from the difference in consumption before and after the intervention compared to the other two groups.
- Impact ofdigital health intervention and dietary modification on nutrients revealed in the age group of 20 to 29 years there was an increase in Vitamin D_3 and iron intake in Group I while no significant difference in consumption of other nutrients was observed in Group II and Group II. In 30 to 39 years and 40 to 45years age group, there was a significant increase in Vitamin D_2 and total Vitamin Dintake in Group II compared to the other two groups.
- As a whole, the dietary modification was able to bring the difference in Vitamin D intake among Muslim women in the age group of 30 to 45 years. The increase in food intake notices in green leafy vegetables and other vegetables were significant but lower than the actual recommendations of ICMR.

Serum Vitamin D levels were not estimated due to the Covid – 19 protocols. From the feedback, the digital health intervention modules and telephonic counseling were appreciated and found useful and informative by the Muslim women.

These findings conclude that Vitamin D deficiency is a major health issue among Muslim women residing in Coimbatore city.Islamic dress practices, low duration of sunlight exposure, low physical activity, lack of knowledge about Vitamin D, indoor lifestyle among the majority of homemakers, low consumption of Vitamin D fortified foods, high BMI, abdominal obesity, low consumption of Vitamin D_3 and calcium rich foods were the distinct factors identified to contribute to Vitamin D deficiency among the Muslim women. The influence of the Islamic dress code practice on the identified factors signifies its impact on the lifestyle of the Muslim women and thereby their Vitamin D nutriture. Further, the high rate of Vitamin D deficiency even with the intake of Vitamin D_2 exceeding RDA indicates inadequacy of the suggested RDA for Muslim women and the low potential of Vitamin D_2 as a source of Vitamin D. The low availability of Vitamin D fortified foods and uncertainty of the label specifications add

to the burden. Digital health intervention showed a significant impact on Knowledge and an average improvement in attitude and practices there was a difference in nutrient intake in both the groups but it was much more significant in Group II (moderate increase) suggesting one to one dietary modification to have better effect in improving the intake. Thus, a holistic approach to digital health education and dietary modification may be an effective strategy to improve the KAP and dietary intake. Therefore, from the findings of this study, strategies such as increasing awareness and practices on sunlight exposure on home premises and increased intake of dietary Vitamin D, encouraging lifestyle changes to maintain a healthy weight and Vitamin D levels, increasing RDA and improving fortification are urgent needs to be addressed to combat the manifestation of Vitamin D deficiency among the covered Muslim women understudy. Hence the findings of the study may be recommended to the government policy makers and program planned to target programmes and regulations focusing on improving awareness and practices, promoting healthy lifestyle practices, mandating fortification of staple foods, maintaining quality and quantity of fortification, revising RDA and considering supplementation in vulnerable groups to prevent a future epidemic in the target population. Sustainability of these should help in the eradication of Vitamin D deficiency among Muslim women in the future.

Limitations

The study could suggest strategies to overcome Vitamin D deficiency among the Muslim women in Coimbatore city through improvement in knowledge and bringing about a difference in attitude, practices and intake.

- Owing to Covid - 19 pandemic conditions biochemical estimations or measures of bone health were not feasible during the study.
- The study was restricted to Coimbatore city.
- The data was obtained from participants during the baseline, KAP and dietary intake, which may be subjected to social desirability bias.

Recommendations

- Policy changes and regulations to be implemented on exclusive RDA for the Muslim women.

- Organize long term, large scale intervention studies to determine the effectiveness of enhanced practices on Vitamin D status.
- Prevalence of Vitamin D deficiency among Muslim women may be assessed in a larger population.
- The study may be extrapolated to other districts of Tamilnadu.
- Supplementation of calcium and Vitamin D rich foods among Muslim women may be studied
- Bioavailability of Vitamin D fortified foods may be studied.
- Calcium and Vitamin D rich ready to eat and ready to serve food products may be developed.