3. METHODOLOGY

The methodology concerned with the current study entitled, **"Impact of Nutrition Intervention and Dress Code on Vitamin DNutriture of Muslim Women"** comprises of the followingPhases:

3.1.Phase I: Demographic Profile and Lifestyle Pattern of the Muslim Women

3.1.1 Selection of Area

3.1.2 Selection of Participants

3.1.3 Formulation of tools

3.1.4 Ethical authorization and informed consent

3.1.5 Collection of baseline data

3.2. Phase II: Health and Nutritional Status of Muslim Women

3.2.1 Assessment of Nutritional status

3.2.1.1 Anthropometric measurement

3.2.1.2 Clinical examination

3.2.1.3 Diet survey

3.2.2 Estimation of serum Calcium and Vitamin D of selected women

3.3. Phase III: Identification and Evaluation of Fortified Foods

3.3.1 Market survey on Vitamin D fortified foods

3.3.2 Calcium and Vitamin D analysis of selected fortified foods

3. 4. Phase IV: Development and Implementation of Intervention

3.4.1 Development of digital health intervention modules

3.4.1.1 YouTube Videos

3.4.1.2 Motion graphic Videos

3.4.1.3 Memes

3.4.1.4 WhatsApp group

3.4.2 Dietary modification

3.4.3 Implementation of intervention strategies

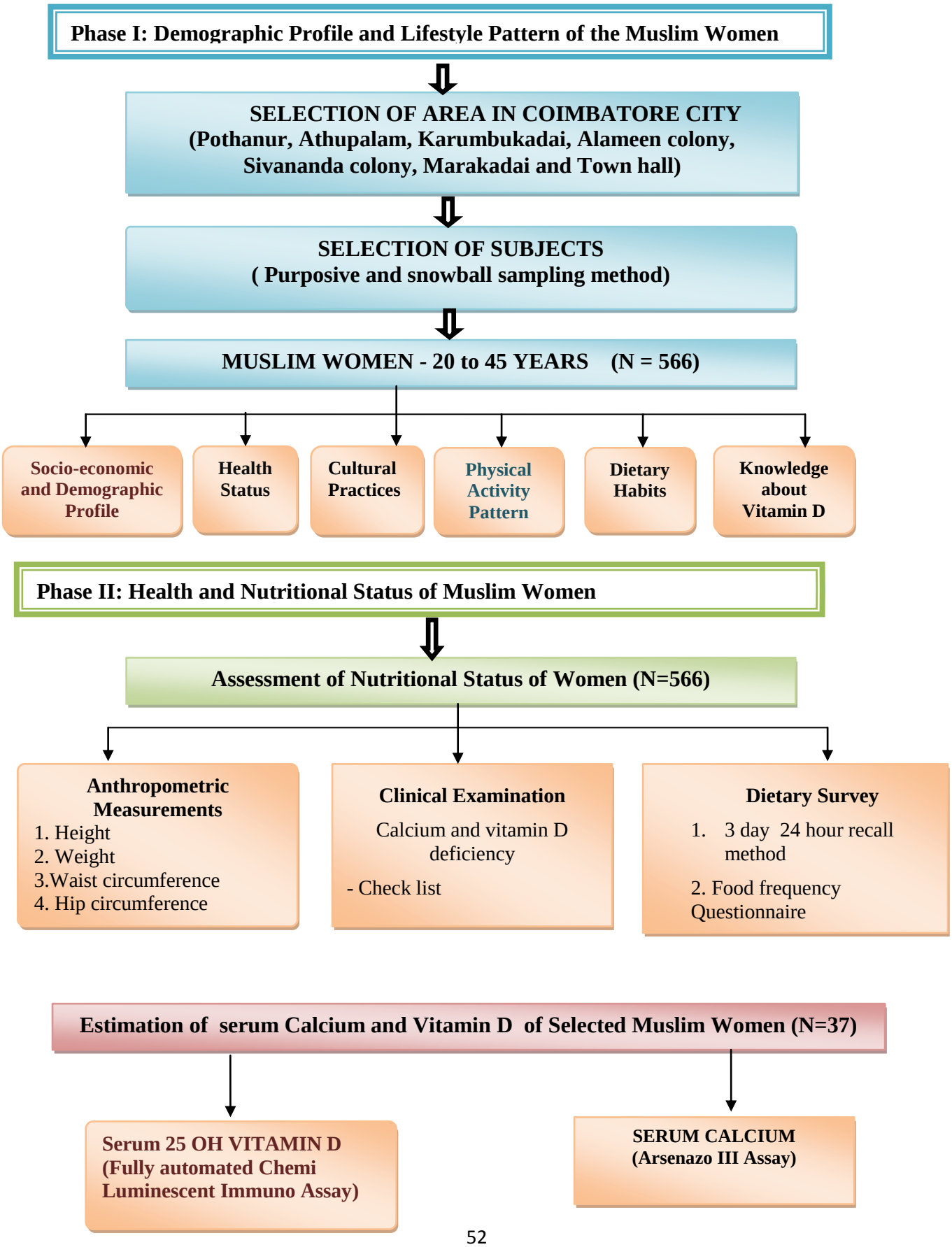
3.5. Phase V: Impact Evaluation

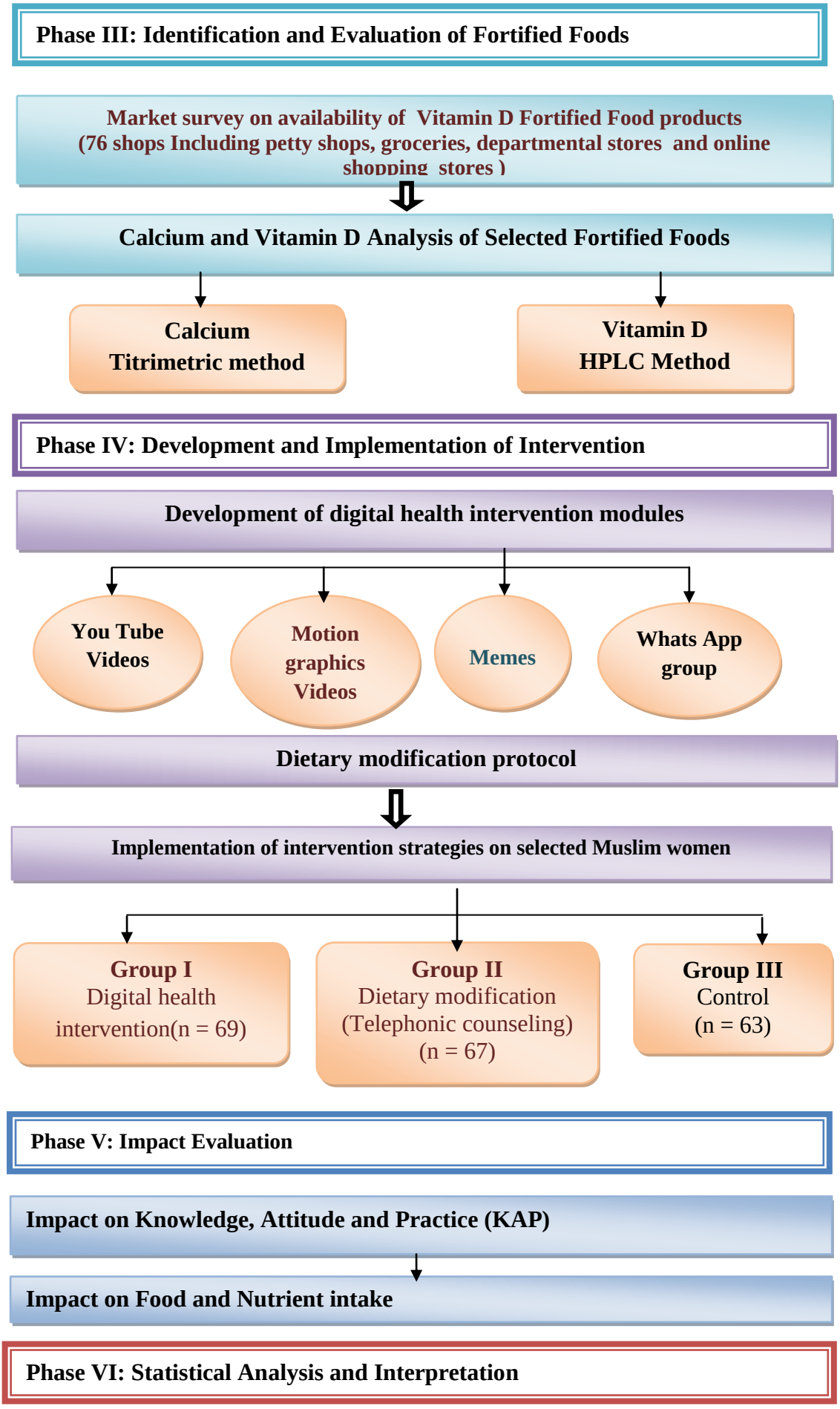
3.5.1 Impact on Knowledge, attitude and practice (KAP)

3.5.2 Impact on food and nutrient intake

3.6. Phase VI: Statistical Analysis and Interpretation

Figure 3: Research Design




Phase III: Identification and Evaluation of Fortified Foods
Market survey on availability of Vitamin D Fortified Food products (76 shops Including petty shops, groceries, departmental stores and online shopping stores)
Calcium and Vitamin D Analysis of Selected Fortified Foods
Calcium Titrimetric method
Vitamin D HPLC Method
Phase IV: Development and Implementation of Intervention
Development of digital health intervention modules
You Tube Videos
Motion graphics Videos
Memes
Whats App group
Dietary modification protocol
Implementation of intervention strategies on selected Muslim women
Group I Digital health intervention(n = 69)
Group II Dietary modification (Telephonic counseling) (n = 67)
Group III Control (n = 63)
Phase V: Impact Evaluation
Impact on Knowledge, Attitude and Practice (KAP)
Impact on Food and Nutrient intake
Phase VI: Statistical Analysis and Interpretation

3.1 Phase I: Demographic Profile and Lifestyle Pattern of the Muslim Women

3.1 .1Selection of Area

A longitudinal study was conducted from March 2018 to June 2021 in the city of Coimbatore,Coimbatore district, Tamilnadu, which is the second major city called the Manchester of South(Troshani*et al.*, 2012). The Muslim population in this city is 90,670 (8.63%), among which 44,948 comprised of the female population with a sex ratio of 1000(Census of India, 2011).Pothanur, Athupalam, Karumbukadai, Alameencolony,Sivananda colony, Marakadai and Townhall lying to the south of the city (Figure 4), with adense Muslim population were selected by purposive sampling. Further, ease of access, acquaintance with place and participants were also the reasons to choose this area to conduct this study, which is the first of its kind on Vitamin Dnutriture of Muslim women in Coimbatore city.

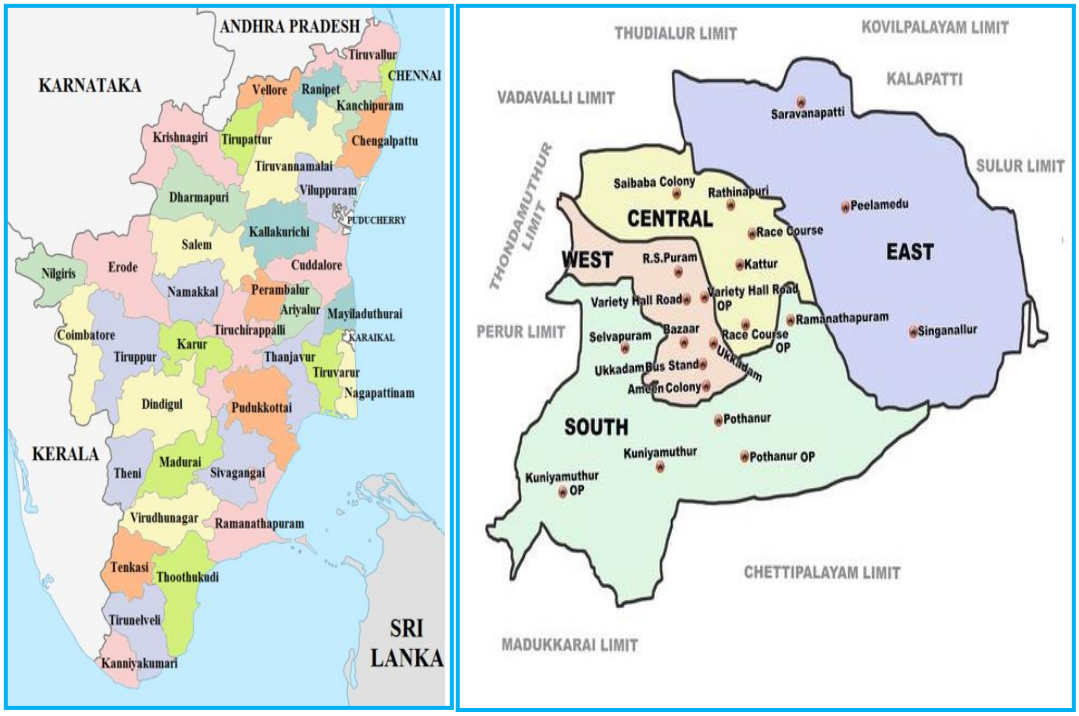


Figure 4: Coimbatore City Map

Source: Jaishink, 2020 andhttps://i.pinimg.com/564x/15/25/7b/15257be97a563ff71f9e5cc97ecdcf18.jpg

3.1.2 Selection of Participants

Research has shown evidence of Vitamin D beyond bone health in the prevention of chronic diseases like obesity, diabetes mellitus, hypertension, cardiovascular diseases

and cancer (Hassan *et al*., 2021). Vitamin D insufficiency has reached an epidemic portion especially among women and is considered an important public health issues (AlFaris, 2019) stressing on the importance of maintaining normal Vitamin D levels in young and middle aged adults to preserve health. Hence, the participants selected for the study were adult Muslim women between 20 to 45 years of age.

Inclusion criteria

Muslim women living in Coimbatore city, in the age group 20-45 years and willing totake part in the surveywere included.

Exclusion criteria

Women from other communities, Muslim women below 20 years and above 45 years of age, pregnant and lactating women and women not willing to take part in the study were excluded.The first participant selected was by purposive sampling and the subsequent samples were selected bysnowball sampling strategy. According to Ruel*et al*, 2015 in a snowball sampling the participants introduced the investigator to the other participants and correspondingly, this strategy facilitated the acquisition of confident active participation when suggested by the neighbours.

Slovin's formula was applied to determine the sample size at 95 per cent confidence level applied on Muslim women population size 44, 948 (Census of India, 2011) to get 381 as sample size

$$n = \frac{N}{1 + N(e)^2}$$ **(Bishop, 2019)**

Where n = sample size, N = population size and e = level of precision

Making allowance for an increase in population between the last census in 2011 and the study conducted in 2018 an additional 185 participants were included. Hence, 566 Muslim women between 20 to 45 years of age were selected asthe study participants.

3.1.3Formulation of Tools

A research tool is a developed, evaluable discussion guide that determines the base to be explored by the investigator with the agreement of the participants (Bradley, 2007). An interview schedule was selected as a tool for data collection considering the type of research and participants involved. A structured interview schedule was designed with objectives and interview techniques in view. Questions on family and socio economic

status, health status, dietary pattern and dietary intake were taken from a previously validated questionnaire. Questions on lifestyle patterns, knowledge of Vitamin D and assessments framed in view of the literature review and purpose of the study. The interview schedule was validated by a medical and nutrition expert followed by reliability testing by test-retest method on 20 participants with an interval of one month. The suggested changes were incorporated before data collection. A proforma designed for anthropometric data recording, a checklist for clinical examination and a standard food frequency questionnaire along with three day 24 hour recall questionnaire alsoformed part of the research tool(Appendix I).

3.1.4 Ethical Authorization and Informed Consent

The importance, methods involved, tools used for data collection,way of approach, informed consent procedure, sample collection and analysis, risks, maintaining integrity and confidentiality of data and participants were presented to the human ethical committee members to secureapproval for conduction of the study. A no objection letter was procured from the Coimbatore Jamath head in charge of the Muslims. "Jamath-e-Islamia Hind" as directed by the chairperson, Institutional Human ethical committee. Ethical clearance was obtained from the Institutional Human Ethics committee of Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore (certificate no.: AUW/IHEC-18-19/FSN/FHP-08) (Appendix II).

3.1.6 CollectionofBaseline Data

Written informed consent was acquired after a clear explanation of the process, need, benefits, risks and assuring confidentiality with the help of a written consent form before collection of data and sample. According to Hillier *et al*. (2014) door to door interview facilitates spending time, observing and building rapport with the community, a key to the success of any community research. This interview method was found valuable andrelevant in the present study. The first participant for data collection was selected by the purposive sampling method by the investigator followed by the snowball sampling method for identification of the other participants in a particular area. Before data collection, a positive relationship was developed with the participants to explain the scope of the study. A total of 566 Muslim women were surveyed, door to door interview strategy of data collectionusing the developed interview schedule was employed to collect the baseline dataunder the sections– demographic profile, socio economic

background, health status, lifestyle and dietary pattern, sunlight exposure, physical activity pattern and knowledge about Vitamin D. Socio-economic status determine the educational level, diet and lifestyle of an individual (Alkerwi, 2015), these may affect their Vitamin D status. Family size, type, education, income and expenditure, education, occupation, age at marriage and number of children were some of the demographic and socioeconomicvariables studied. Vitamin Dpreserves health and reduces mortality risk in an individual (Nair and Maseeh, 2012) which reflects on their health status. Hence, the health status covered data on acute and chronic illness, medication and treatment preferences. Among the lifestyle variables data on the Islamic dress practice, sunlight exposure and physical activities were studies. Sunlight facilitated the production of Vitamin D in the skin was found to be the major source of this Vitamin D (Holick *et al*. 2011) taking into account the time and duration of sunlight exposure, sunscreen usage, the reason for less exposure and extent of covering were recorded. Data on physical activity pattern concerning exercise pattern and knowledge of the basics, sources and importance of Vitamin Dwas collected and recorded(Plate1).

Plate 1: Collection of Baseline Data

3.2. Phase II: Health and Nutritional Status of the Muslim Women

3.2.1 Assessment of Nutritional Status

Nutritional assessment is a process of systematic gathering and interpreting of data to determine the nature and root cause of an issue affecting a person (British Dietetic Association, 2012), Nutritional assessment includes an anthropometric, clinical and dietary and biochemical study (Bhattacharya*et al*., 2019). In this study, the nutritional status of 566 Muslim women was ascertained using anthropometric measurements, clinical examination and dietary survey.

3.2.1.1 Anthropometric measurements

Anthropometric measurements are quantitative and non-invasive measurements to assess body composition reflecting on an individual's nutritional status used as a baseline measure (Casadei and Kiel, 2021). The anthropometric measurements such as height, weight, waist circumference and hip circumference of all the Muslim women(n = 566) was measured. Obesity has been identified as a factor causing lowVitamin D levels, while the vice versa of the same has also been reported (Vimaleswaran*et al.*, 2013) Hence, from the measured values Body Mass Index and Waist hip ratio was calculated to detect whole body obesity and abdominal obesity among the women. The measures were recorded in a proforma developed as a part of the interview schedule.

(i) Height

To measure the height a tape was fixed to the wall, the subjects were asked to stand erect without slippers with heels joined and toe separated forming an approximate angle 60^{o} and back touching the wall. The head was aligned in frankfort horizontal plane. A ruler was placed overhead of the participant, a slight pressure on hair to make contact with the top of the head. (NHANES, 2013) Measurements were recorded twice to 0.5 cm accuracy (Plate 2).

Plate 2: Measurement of Height

(ii) Weight

Bodyweight is a simple, sensitive,reproducibleandcurrentmeasurement of the nutritional status (Bamji, 2009). The body weight of all the participants was measured using a portable digital weighing balance placed on a flat surface, the instrument was calibrated with known weight and adjusted to zero before taking the measurement. The equipment was checked periodically (every day) to maintain accuracy. The participants were made to stand in the centre of the balance with their hands in the side and looking straight facing the investigator. (NHANES, 2013) with minimal clothes andbasal condition (NIN, 2011) (Plate 3). Measurement was taken twice with an accuracy of 50 – 100 g (Bamji, 2009).

Plate 3: Measurement of Weight

(iii) Body Mass Index (BMI)

Body Mass Index a ratio of body weight in Kilogram to the square of stature (height) in meter square is used in population studies to assess obesity as a major risk factor in the onset of chronic diseases like diabetes, hypertension, and cardiovascular diseases, thus BMI can be used as a predictor of morbidity (Nuttall, 2015). The BMI of the participants was calculated by applying measured height and weight based on the formula :

Body Mass index = Weight (kilogram)/Height (metre)^2

The Body Mass Index computed figures were then classified according to WHO South Asian criteria (2004) cut off for adults into underweight, normal, overweight, Obese type I, type II and type III as shown in Table I. This criterion was found to be

more appropriate for Asian women compared to the WHO standard criteria (Misra, 2015).

Table I

BMI Cut-Off based on WHO South Asian Criteria Values

Nutritional Status BMI cut-off	BMI cut- off
Underweight (low)	<18.5
Normal	18.5-22.9
Overweight	2`3 – 27.49
Obese I	27.5 – 32.49
Obese Type II	32.5 – 37.49
Obese Type III	≥ 37.5

Source:WHO(2004)

(iv) Waist circumference

Waist circumference can measure the central adiposity. Waist circumference was obtained by measuring the smallest area between the low rib and iliac crest by winding a fibreglass tape without squeezing the soft tissue (Ma*et al*.,2013) .The participant was made to stand straight with feet together to evenly balance weight, reading was taken over minimal clothing twice to an accuracy of 1cm (Plate 4). According to the World health organization (2011), a measure of above 80 cm for women is suggested as cut off for the Asian population

(v) Hip circumference

Hip circumference was measured with a fibreglass tape passing over maximum protuberance on buttocks without compressing and tape parallel to the ground with the participants standing with weight equally balanced and minimal clothing (WHO, 2011)measured twice to 1 cm accuracy (Plate 4).

Plate 4: Measurement of waist and hip Circumference

(vi) Waist- Hip Ratio

Waist- Hip Ratio is a widely used adiposity index to indicate that individuals with greater fat deposits in the trunk to be at health risk. Android obesity, deposits of fat in abdomen poses greater risk compared togynoid obesity with fat deposits in the hips and thighs (Watson, 2014). The Wasit-Hip Ratio (WHR) was calculated by applying the measured waist circumference and Hip circumference to the formula

$$\text{Waist - Hip Ratio} = \frac{\text{Waist circumference(cm)}}{\text{Hip circumference(cm)}}$$

The ratio is the indicator of abdominal adiposity. Asian women showing waist-hip ratios of greater than or equal to 0.80 are considered to have central obesity (WHO, 2011). Hence the calculated values were compared with the WHR value of 0.80.

3.2.1.2 Clinical examination

Clinical examination involves checking from signs and symptoms related to deficiency, that have been widely used as a non invasive, first-line diagnostic tool for any nutrient deficiency. Signs and symptoms can be similar in more than one deficiency, also manifest after long term nutrient deprivation. It can be used as an indicator to decide the requirement of laboratory assessment (Charney and Melone, 2009).Training for detection of clinical signs and symptoms was obtained from a medical expert. All the

participants (n = 566) were screened for signs and symptoms pertaining toVitamin D and calcium deficiency such asfalling sick often, fatigue, depression, leg pain, back pain, fracture incidence, muscle weakness, hair loss and PMS symptoms by the investigator with the help of a checklist developed as a part of the interview schedule.

3.2.1.3 Diet survey

A dietary survey collects data on food intake, nutrient intake and eating habits among the people of interest which reflects on their nutritional status (Kearney, 2010). The frequency of use of different food items in the dietaries of the respondents will indicate the quantity of the food item consumed by them. Dietary survey data was collected by direct assessment using a Food Frequency Questionnaire and three day 24 hour recall method of food consumption. A standard Food Frequency Questionnaire consists of selected food items under each of the basic food groups and frequency they are consumed in such as daily, weekly, rarely and never with reference to FAO(2018) to know the pattern of consumption over a period of time. The frequency of processed foods and Vitamin D fortified foods intake was also assessed.Healthy dietary intake helps to prevent malnutrition, as well as protect from chronic diseases. Three day 24 hour recall method was employed to learn the consumption pattern of the participants. Twonon consecutive weekdays and one weekend day pattern were employed. Standard spoons and cups were used to quantify the cooked food intake from which the raw food consumption was calculated (Plate 5). The data for intake was recorded in a standard three days 24 hour recall questionnaire (FAO, 2018). The nutrient intake was calculated using the Indian Food Composition Table(Longvah*et al*., 2017) and compared with recommended dietary allowances suggested by ICMR(2020).

Plate 5: Diet Survey

3.2.2 Estimation of SerumCalcium and Vitamin D of Selected Women

Biochemical assessment is an objective, sensitive set of investigations to detect changes in nutrient concentration of blood as an indicator of nutritional status (Hickson and Smith, 2018). Since biochemical parameters are performed on a sub sample, 37Muslim Women who were willing to give a blood sample, were selected for sample collection. It was during this phase of the study, the Covid – 19 pandemic started and blood sample collection was not permissible owingtothe transmission of infection while handling body fluids. The blood sample was collected from only 37 selected women to understand the calcium and Vitamin D status of the Muslim women. Three millilitres of blood was collected with the help of a lab technician who visited the house of the women following the SOP of Covid-19 (Plate 6). Calcium and Vitamin D were combined for estimation due to the interrelationship shared by the two nutrients (Del Valle*et al*., 2011). Serum Calcium was estimated using Arsenazo III assay (Bourguignon *et al*., 2014) and serum 25 hydroxyVitamin D was estimated using fully automatedChemi Luminescent ImmunoAssay.Analysis of 25 OH Vitamin Dis a reliable indicator of the Vitamin D status of an individual (Holick, 2009). The estimated values were compared with reference cut offs for 25 hydroxyVitamin D is given in Table II.

Table II

Reference for 25-OH Vitamin D Levels

25-OH Vitamin D	Reference Range*
Deficient	<20ng/ml
Insufficiency	20-30ng/ml
Sufficiency	30-100ng/ml
Toxicity	100ng/ml

*Vitamin D Standardization Program (VDSP, 2010)

Calcium estimated values were compared with the cut off value shown in Table 3.

Table III

Reference for Serum Calcium Levels

Calcium	Reference range*
Low	<8.5 mg/dl
Normal	8.5-10.5 mg/dl
High	>10.5 mg/dl

*Krueger *et al.* (2003)

Plate 6: Collection of Blood Sample for Calcium and Vitamin D Estimation

3.3. Phase III: Identification and Evaluation of Fortified foods

3.3.1 Market Survey onVitamin D Fortified Foods

Market research is a process of meticulous collection and assessment of the market environment for a particular target (Xu, 2020). The WHO and FAO of United States recommend food fortification as an effective technique to combat micronutrient deficiencies and one such global deficiency is Vitamin D deficiency. Commonly, fortification of Vitamin A, Vitamin D, Vitamin B, iron and iodine are in practice. (Mannar and Hurrell, 2018) In the present study, 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 method and were categorised based on classification of retailers in India into Kirana shop (petty shop), speciality stores (grocery stores), departmental stores (supermarkets) (Panagariya and Bhagwati, 2013) and online stores. Before the survey, required permission was obtained from the owners. The food labels were used to identify theVitamin D fortified foods(Plate 7) 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 in a designed list item form (Appendix III). As the owners of the shop were not willing to disclose the shop names a code was provided for each shop. The survey was carried on until the products identified repeated and no new products were identified in the last five shops surveyed. A total of 76 shops including 25 petty

shops, 29 grocery stores, 15 supermarkets and seven online stores were included in the survey.

Plate 7:Conduct of Market Survey

3.3.2 Calcium and Vitamin D Analysis of Selected Fortified Foods

Two Vitamin D fortified products, namely fortified milk and fortified egg available in the local market were randomly selected for calcium and Vitamin D analysis. Jetty Jakobsen and Knuthsen (2014) found household cooking methods to have a deteriorating effect on the Vitamin D content of the egg. Hence, the current study was conducted to detect the effect of household boiling and refrigeration on Vitamin D fortified milk and egg. A hundred millilitre of the milk was boiled to a temperature of 100^{o}C cooled and used for analysis. The egg was kept in cold water and brought boiled to 100^{o}C then simmered for 15 minutes and immediately cooled in cold water (Puckett, 2012). The refrigeration sample was prepared by keeping egg and milk products in the refrigerator at normal temperature 4^{o}C for twenty four hours. All three variants of the product namely raw product as such, product after boiling and product after 24 hours of refrigerationwere tested for their Calcium and Vitamin D content(Plate 8). Calcium content of all the three variants was estimated by the titrimetry in which calcium oxalate was precipitated from the ash solution, then dissolved in sulphuric acid and titrated against the dye potassium permanganate, each sample analysis was done in triplets with reference to the procedure recommended by National Institute of Nutrition

(Raghuramunu et al. 2003) and the Vitamin D content of all three variants was determined by the HPLC method (https://www.shimadzu.com/an/sites/shimadzu.com.an/files/pim/pim_document_file/applications/application_note/10986/jpl214031.pdf). (Plate 9)The percentage of true retention was calculated using the formula

$$\% \text{ TR} = \frac{\text{(nutrient content per g of cooked food) X (g of food after cooking)}}{\text{(nutrient content per g of raw food X g of food before cooking)}} \text{ X 100}$$

(USDA,2007)

Note: Vitamin D analysis of boiled egg and milk was performed for supplementationto detect the composition and effectiveness of fortification in improving Vitamin D levels. Due to the onset of Covid –19 followed by an uncertain course of events diminishing the possibilityof supplementation the study had to be redesigned into evaluation of digital health interventional model to enhance Knowledge on Vitamin D as the baseline survey revealed very low knowledge on Vitamin D among the Muslim women.

Boiling **Refrigeration**

Plate 8: Methods of cooking and storing

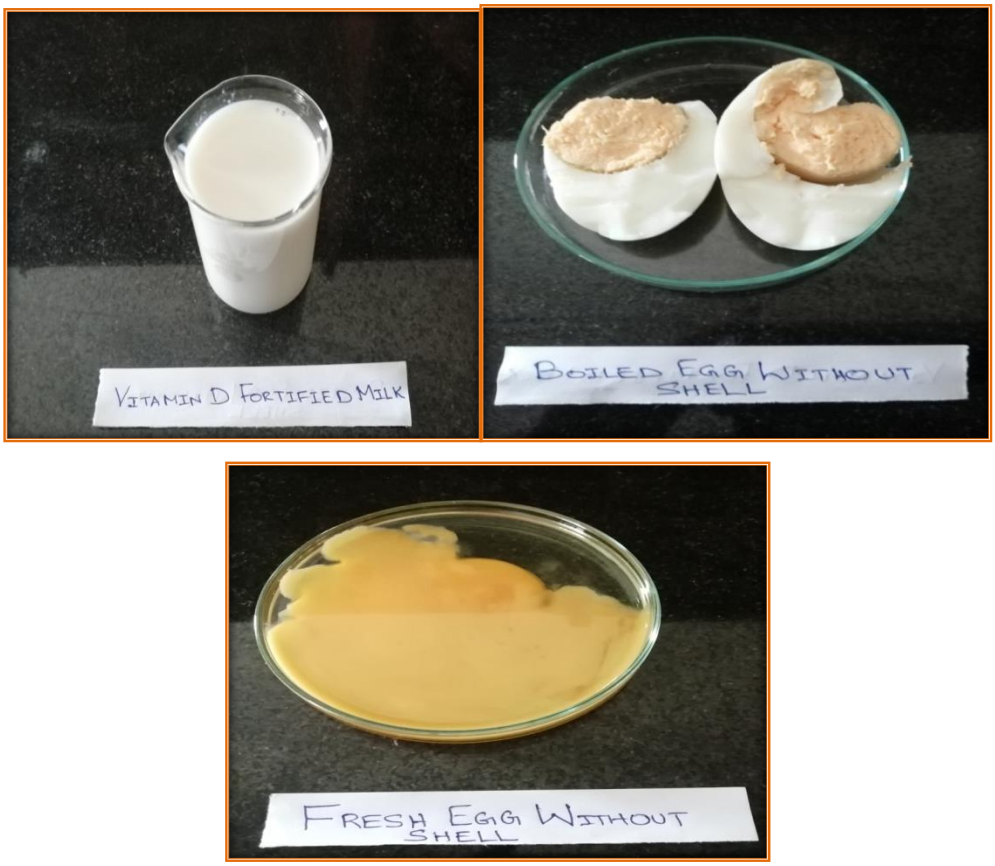


Plate 9: Estimation of Calcium and Vitamin D

3.4. Phase IV: Development and Implementation of Intervention

3.4.1 Development of digital health intervention modules

With the onset of the Covid – 19 pandemic there had been a change in the education system shifting to online learning, with time the children, as well as the parents, became well acquainted with the usage of digital mode of education and use of mobile applications. (Dhawan, 2020) further, the cheap availability of the internet with high bandwidth on cell phones has opened the doors for digital learning to reach inaccessible sectors of the population in the developing world. (Milakovich and Wise, 2019).Nutrition education is a process of conveying the scientific findings of benefit to a particular community using methods of education to promote better feeding habits and behaviour to enhance their standard of living(Contento, 2010). Hence, in the present study to know the effectiveness of a different form of educationalinterventionappropriate modules and portals were selected.Since, Muslim Women followed concealed clothing while outdoors and a solution without disturbing the dress code of the community was required sunlight exposure in the private area of homes was promoted in the content of the educational materials. Materials for two different intervention strategies namely digital health intervention and dietary modification using telephonic counseling were developed. The materials were assorted acrossdigital health interventionmodules such as YouTube Videos, Motion graphic videos and nine memes to avoid monotony.

3.4.1.1 YouTube videos

. The YouTube platform has gained importance in recent years an increase in usage of this platform from 48 per cent in 2016 to 68 per cent in 2021 has been apparent with every 2 out of 3 adults and also less age gap among users compared to other social media platforms displaying its potential to be used as an educational tool (https://www.marketingcharts.com/digital/video-106574)In the present studyYouTubevideos developed were in the form of lectures for 10 – 15 minutes(Plate 10). The content of which was gathered from book references and a literature review. These lectures were recorded using a mobile phone and edited professionally before implementation. The videos developed were as follows:

- The first Video on the topic “Vitamin D an overview” includedthe aspects on basics, history, benefits andconsequences of Vitamin D deficiency.
- The second video on the topic “Sunlight and Vitamin D”projected on sunlight as the major source of Vitamin D, production of Vitamin D in the skin, UV rays, their types, guidelines on effective sunlight exposure and a special emphasis was

made on strengthening the practice of sunlight exposure in private areas of homes.

- The third video “Diet” focused on Vitamin D_2 and Vitamin D_3, their vegetarian and non vegetarian sources, the basics of fortified foods and reading nutrients on a food label.
- In the fourth video“Vitamin D for health", special attention was provided to women’s health comprehending on importance of Vitamin D in pregnancy, lactation, fertility, prevention of other chronic health problems and consequences of Vitamin D deficiency in women as per the latest research substantiation.

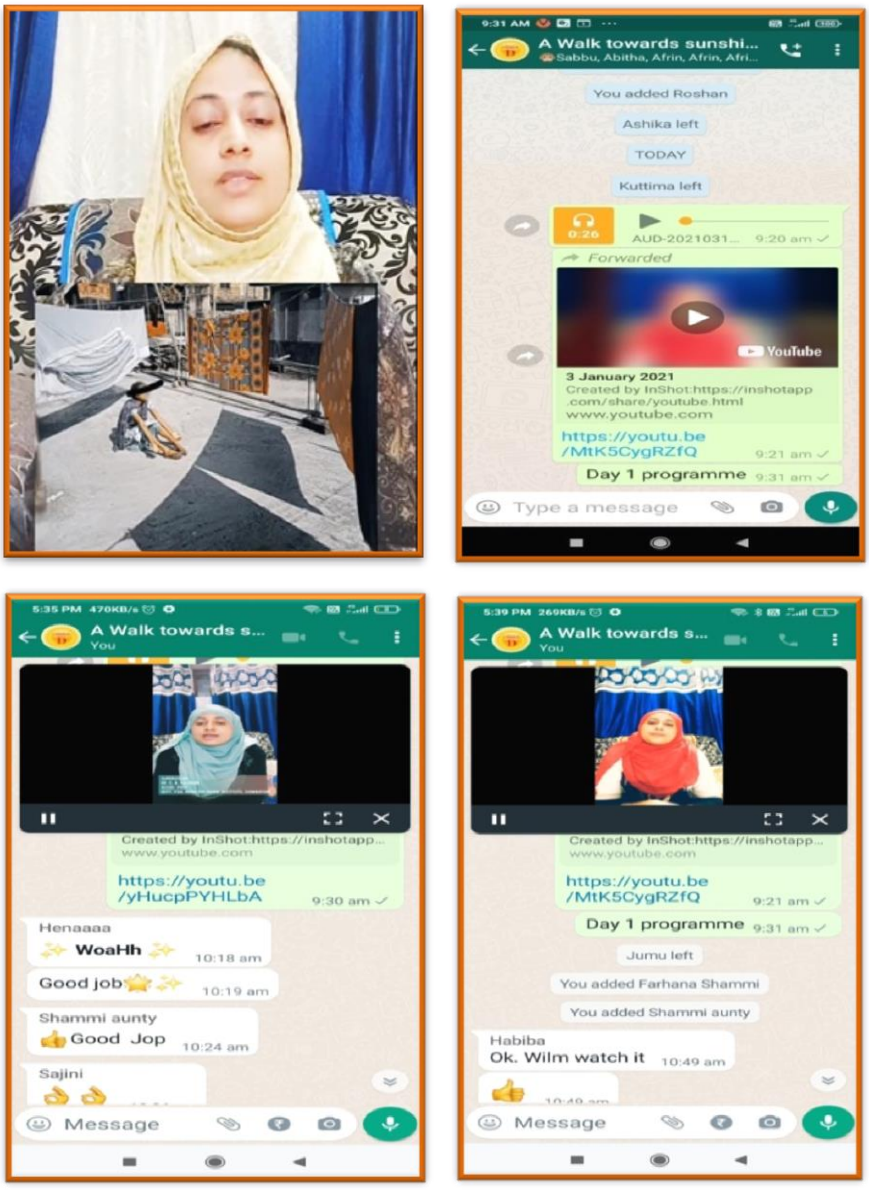


Plate 10: Development of YouTube Videos

3.4.1.2 Motion graphic videos

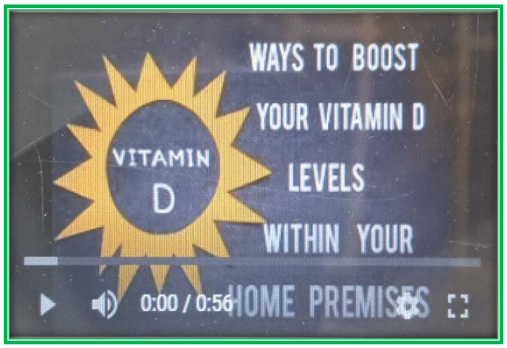
The main importance of motion graphic videos lies in their ability to quickly communicate information to users its short display time makes it viewer friendly increasing its preference (Karl, 2018). The motion graphic videos developed in the study were self explanatory videos of 2 to 3 minutes duration (Plate 11). These Motion graphic videos were prepared and edited using the In short app. A total of seven videos were developed,

i. The first video depicted the ways to boost Vitamin Din house premises in which recommendation on body partsand different private areas at home for exposure to sunlight was provided with the help of illustrative pictures in the video.

ii. The second video provided tips to enhance Vitamin D during cooking through irradiation of foodsand methods to enhance nutrient retention was covered with the help of details from the Indian food composition table (Longvah*et al*., 2017) and pictures for the video were surfed from the internet to improve perseverance.

iii. The third video on Vitamin D fortified foods available in the local market exhibited the images of fortified foods and dietary supplements which were identified during the market surveyalong with their labels and Vitamin D composition per 100g of the productand

iv. The remaining four videos wererecipes to include Vitamin D rich foods in daily diet. An alteration was made to the standard recipes for instance, in masala dosathe potato was replaced with cheese and mushroom and soya flour was added in a 1:5 ratio to the batter to increase the Vitamin D content of the recipe similarly to a standard fish biriyani prepared with broken wheat will increase its Vitamin D content,ragi and tofu two Vitamin D_2 rich foods combined in a meal of ragi roti with tofu bhurjiand curd, milk and papaya which are rich in Vitamin D and calcium in a snack recipe papaya lassi were demonstrated as models to useinclude a combination of Vitamin D rich foods in daily diet.



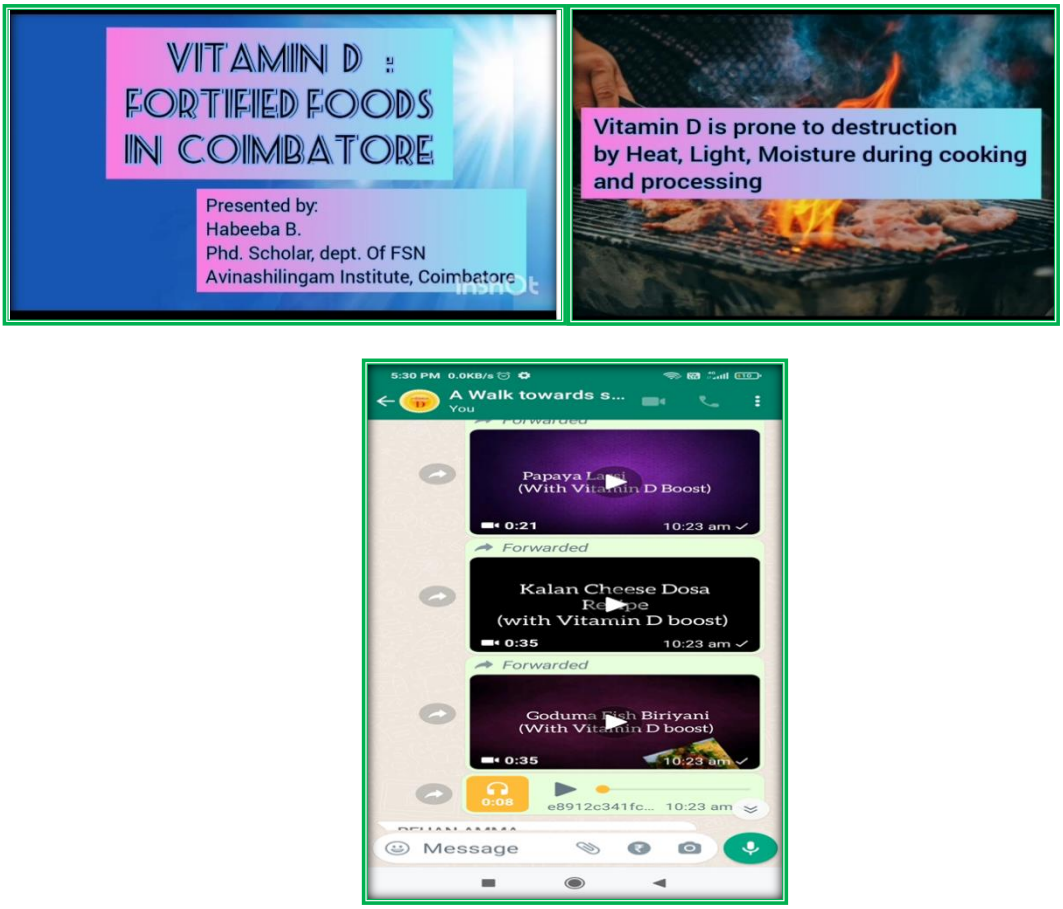


Plate 11: Development of Motion Graphic Videos

3.4.1.3 Memes

Memes are unspoken means of communication using pictorial representation surfed through the internet, that can be used to improve knowledge on many different topics and leave a lasting effect on participants (https://en.wikipedia.org/wiki/Internet_meme). Overall, nine memes were developed on sources and importance of Vitamin D,of which two memes were on sources and the remaining six were on the importance of Vitamin D. the memes were based on the topics Vitamin D richest sources, vegetable and fruit sources of Vitamin D, benefits of Vitamin D during pregnant women andits role in preventing osteoporosis, CVD, Diabetes, low immunity and obesity. The images used in the memes were collected from the internet, the data to be communicated was obtained from recent literature and food composition table and the memes were designed using Microsoft Powerpoint(Plate 12).

Plate 12: Development of Memes

3.4.1.4 WhatsApp group

A WhatsApp group was developed with the name "A Walk Towards Sunshine" as a portal to deliver the intervention modules and a schedule for the different topics was set to facilitate consistency in delivering thedevelopedmodules(Plate 13). The content and topics delivered in telephonic counselling were the same as digital health intervention. A protocol for covering the topics during counselling and dietary modification was established. A list of 22 questions containing six questions on knowledge, 13 on practice and three on attitude towards Vitamin D were included

(Appendix IV). The questions on knowledge were on basics, tests, sources, benefits of the vitamin, questions on practice were related to sunlight exposure, use of sunscreens, outdoor physical activities, the inclusion of Vitamin D rich foods and fortified foods. Two Google forms were prepared as a tool with the above questions for evaluation (Plate 14).

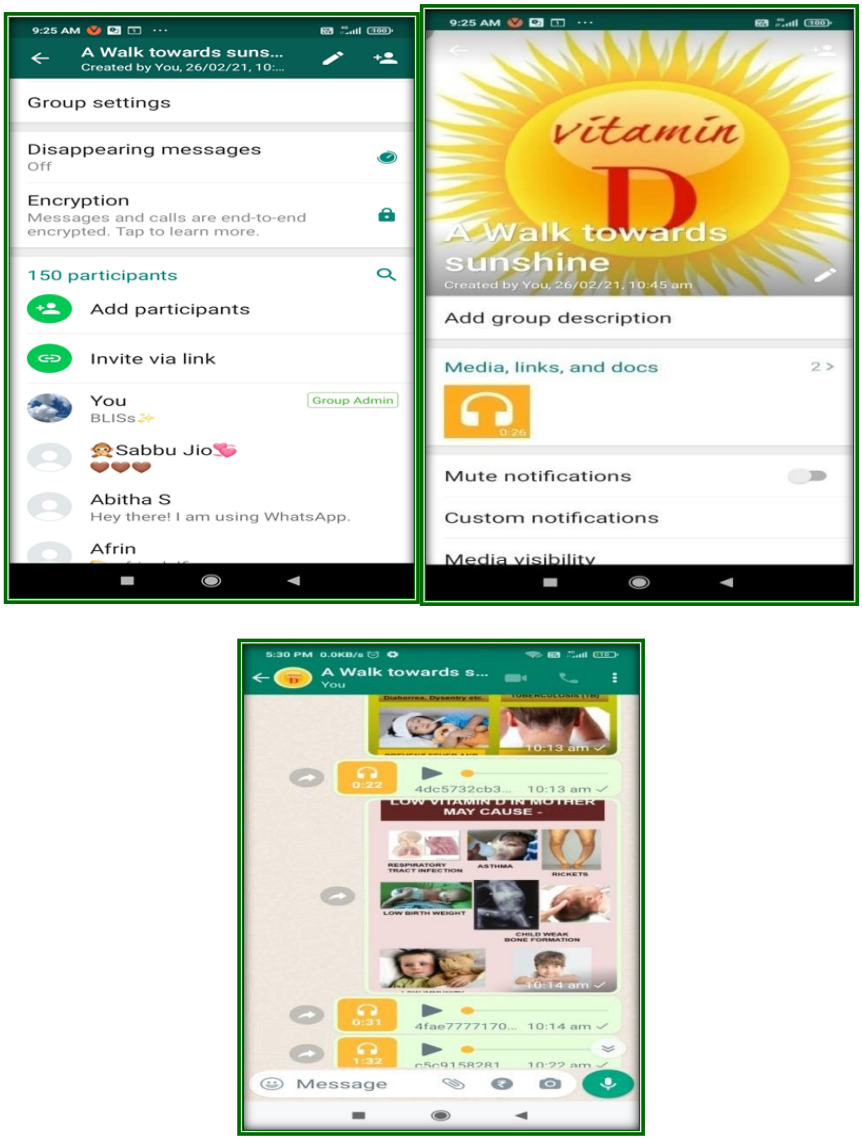


Plate 13: WhatsApp Group for Digital Health Intervention

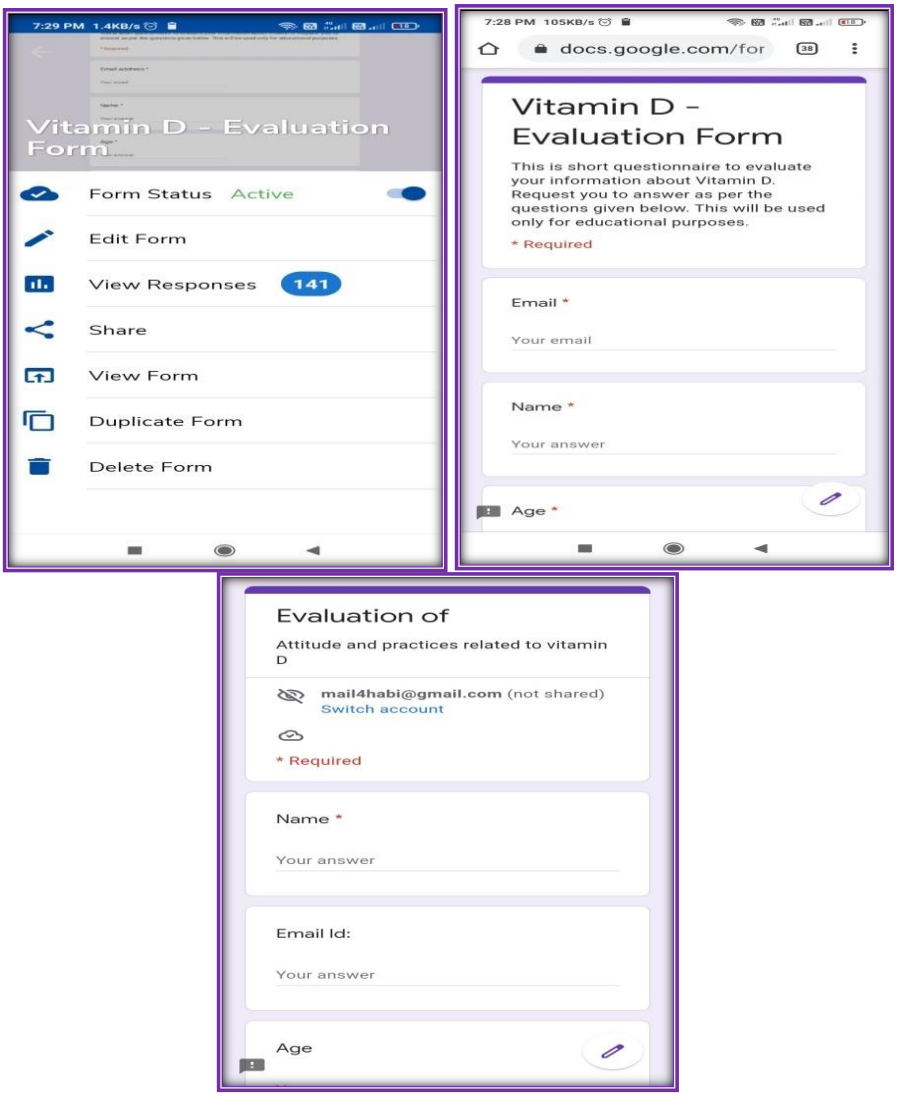


Plate 14:Google Form for Evaluation

3.4.2 Dietary modification

Dietary modification was suggested regarding modifications in calories for weight management as in obese individuals Vitamin D accumulates in the adipose tissue rendering the vitamin unavailable for body functions (Thani*et al*., 2019) calcium and Vitamin D rich food sources including fortified foods was suggested due to the association between the two nutrients in skeletal and muscular health(Khazai*et al*., 2008). Since the vitamin is fat soluble importance of adding a limited quantity of Mono Unsaturatedfatty acids, irradiation of foods, sources and benefits of intake along with breakfast for better absorption and utilization of Vitamin Dwere also suggested(Dawson-Hughes, 2015). A 3 day 24hourrecall questionnaire developed for the dietary survey was used to evaluate pre and post dietary modification changes and the data was collected through telephonic interview.

3.4.3 Implementation of intervention strategies

As Vitamin D deficiency existed in above 90 per cent of the tested women, a population of 10 per cent of the sub sample was selected for intervention considering dropouts an additional 13 participants were included for each group. A total of 210 participants were divided into three groups with 70 participants in each group.Vitamin D knowledge of the participants was assessed using the 22 questions selected for the evaluation through telephonic interviews. Group I was provided with digital health intervention (n = 70), Group II was provided with dietary modification using one to one telephonic counseling (n = 70), Group III was considered the control group (n = 70).For the digital health intervention group, 70 participants were added to theWhatsApp group "A walk towards sunshine" and the developed modules were delivered through this portal for 8 days. For dietary modification, nutritioncounselling was provided through telephone calls on different topics related to Vitamin D and also dietary changes such as balanced diet along with an emphasis on increasing calcium and Vitamin D intake was suggested after hearing the regular intake of the participants for 8 days period. Control group were not provided with any of the interventionalmodules during the study period but post data collection digital health intervention modules or telephonic counselling was provided according to the feasibility of the participants to benefit the control group (Plate 15).

Plate 15: Telephonic Counselling for Dietary Modification

3.5. Phase V: Impact Evaluation

The impact can be denoted as change or an effect of a particular service of an initiative on a person or a group (Streatfield, 2009). Hence, in the present study a measure of impact was used to identify and evaluate the changes in knowledge, attitude and practice and dietary intake of the participant.

3.5.1 Impact on Knowledge, Attitude and practice (KAP)

The impact on KAP was evaluated with the help of the developed Google form. The data on changes in knowledge and attitude was collected just after the interventionand data on changes in practice were collected after two months of intervention in all three intervention groups to assess the effectiveness. There were 63 participants in the control group, 67 participants in dietary modification through telephonic counseling group and 69 participants in the digital health intervention group, While11 dropouts were there in the final phase of the study. The responses before and after intervention on knowledge, practice and attitude were scored with 1 or 2 accordingly and compared to understand the impact of digital health intervention.

3.5.2 Impact on Food and Nutrient intake

The impact on food and nutrient intake was assessed using three days 24 hour recall method and compared with dietary intake before and after the intervention. The dietary intake of 199 participants was collectedusing a three day 24 hour recall questionnaire over the telephone. The participants were asked to express the intake of cooked food in terms of standard bowls and spoons used previously in the assessment of nutritional status. This cooked weight was converted to raw weight from which food and nutrient intake was calculated using the nutrient IFCT(Longvah*et al*., 2017) table and compared with Recommended dietary allowances suggested by ICMR(2020). The effectiveness of digital health intervention and dietary modification was evaluated by comparing food and nutrient intake before and after intervention between the three groups.

3.6. Phase VI: Statistical Analysis and Interpretation

The data collected from the different surveys were recorded in the respective tool constructed for collection, which was then consolidated and subjected to analysis and interpretation. Research statistics are an important tool in designing, analysing and drawing a conclusion from the collected data (Kothari,2013). The statistical analysis was carried out using Sigma Plot 14.5 and Systat 13.2 statistical analysis softwares. Descriptive statistics including measures of central tendency and measures of dispersion such as frequency, mean, median, range, the standard deviationwas used for elucidation and tabulation of the baseline data. Inferential statistics including measures of relationship such as Pearson's Chi square test, ANOVA and t-test of significance were applied toassociatethe influencing factors. Correlation and regression were applied to find the relationshipbetween Vitamin D status and influencing factors. A one sample t-test was used to understand variance compared to standards and recommendations and before and after the intervention data was compared using paired samplet-test.