Adopting Health Belief Model to Improve Female Employees' Knowledge, Beliefs and Preventive Behaviors regarding Vitamin D Deficiency

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Abstract

Background: Vitamin D deficiency (VDD) is a serious public health issue, particularly among women, due to a lack of knowledge regarding the importance of Vitamin D (VD) and the method of preventing its deficiency. The research aimed to investigate the effect of adopting health belief model to improve female employees' knowledge, beliefs, and preventive behaviors regarding vitamin D deficiency. **Method:** A structured educational intervention based on HBM was implemented using a quasi-experimental study among 300 female employees from 14 faculties affiliated to Mansoura University in Egypt using stratified sampling with a proportional allocation technique. Tools: A self-administered structured questionnaire consisting of five parts was used for data collection before and three months after the intervention. The intervention involved group education, counseling, and follow-up. **Results:** There were statistically significant differences in mean scores of total knowledge, VDD-preventive behaviors, and HBM constructs before and three months after the intervention with $P \leq 0.001$. Three months following the intervention, there was a statistically significant positive connection with ($p \leq 0.001$) between total knowledge, total VDD-preventive behavior, and HBM constructs scores. Also, there were statistically significant differences between participants' knowledge scores regarding VD and VDD with employees' age, occupation, and years of experience in the pre and post-test with $p \leq 0.001$. As well, there were statistically significant differences between participants' VDD-preventive behaviors with their occupation and level of education in the pre- and post-test with $p \leq 0.001$ and $p=0.006$ respectively. Moreover, there were statistically significant differences between participants' health belief scores with their age, working place, occupation, income, years of experience, medical and medications history in the pre- and post-test $p<0.05$. **Conclusions:** Implementing educational intervention based on HBM improves the female employees' knowledge regarding VD and VDD, contributes to the advancement in all constructs of the health belief model, and positively affects their VDD-preventive behaviors. **Recommendations:** Health Belief Model constructs should be an essential part of the existing VDD management program. More research is needed to continue investigating the effectiveness of HBM for a longer period of follow-up time after the intervention.

Keywords: Health Belief Model, Vitamin D deficiency, Female employee

Introduction

In the healthcare field, there has been widespread concern about vitamin D status, because vitamin D (VD) is required for the absorption of dietary calcium and phosphorus from the intestine. Adequate VD levels are required to promote healthy bone growth (Darling, Blackbourn, Ahmadi, & Lanham-New, 2018; Alamoudi et al., 2019). Worldwide, one billion people are thought to be suffering from either vitamin D deficiency (VDD) or insufficiency. Therefore, VDD has become a widespread nutritional condition that has epidemic proportions. (Nowreen & Hameed, 2019). Among adults, VDD is defined as a 25-

hydroxyvitamin D [25(OH) D level below 20 ng/ml (50 nmol/L) and vitamin D insufficiency as a 25(OH) D of 21–29 ng/ml (52.5–72.5 nmol/L) (Alshamsan & Bin-Abbas, 2016).

Vitamin D deficiency (VDD) can cause hypocalcemia, hypophosphatemia, and elevated parathyroid hormone which can result in a number of bone disorders. Children's growth retardation, rickets, and skeletal deformities; adults' osteomalacia, which worsens osteopenia and osteoporosis; muscle weakness; and a higher risk of fractures and falls are just a few of the many complications that VDD can lead to from "in utero to a late stage in life." (Al-Amri, Gad, Al-Habib, & Ibrahim, 2017).

Females are more likely to develop osteoporosis later in life. Dangerously low VD levels have been caused by a variety of reasons including living indoors due to high temperatures, being a woman, multi-parity, having dark skin, wearing conservative clothing, seasonal changes, having a low socioeconomic level, being in an urban area, and knowledge deficit regarding the benefits of VD (Babelghaith et al., 2017).

Outdoor physical activity raises serum VD levels and is associated with endogenous VD synthesis. Women who live in cities and spend the majority of their working hours indoors have a higher prevalence of VDD than women who live in rural regions and spend more time working outside and are exposed to more sun. The little time spent outside in the sun is also directly tied to worries about skin cancer or the aging and darkening of the skin, which necessitates the daily application of sunscreens (Bloukh, Edis, Qassim, & Al-Hariri, 2018).

A systematic review looked into the connections between occupancy, VDD, and VD levels. Compared to those who worked outdoors, indoor workers had significantly lower levels of [25(OH)D] and were more likely to develop VDD (Sowah, Fan, Dennett, Hagtvedt, & Straube, 2017). With more time spent indoors for work and entertainment across almost all age groups, the modern lifestyle has generally demonstrated a significant negative impact on the production of cutaneous VD and overall health (Edis & Bloukh, 2016).

Health education is the best and most efficient way to provide people with the health care they need, according to the World Health Organization (WHO), both in terms of human resources and the high cost of medical care (Mallekmahmoodi et al., 2020). The term "health education" refers to a group of educational strategies that empower individuals to choose and practice healthy lifestyles on their own. Booklets, pamphlets, and educational sessions are frequently disseminated as educational strategies or tools to encourage behavioral and attitude changes (Linton et al., 2020).

The importance of applying a theoretical foundation for VDD prevention programs is emphasized in order to promote preventive behavior. The Health Belief Model (HBM) was created to explain the preventive health behaviors rather than illness-related behaviors. The goal of this model is to change people's perceptions regarding health threat and to direct their behavior toward health (Kalkım & Dağhan, 2017). According to the HBM, six structures affect health behaviors including perceived sensitivity, belief in one's perception of being in a particular situation, perceived severity: the perception of how serious these conditions are, perceived benefits; a person's opinion about the efficacy of suggested activities to reduce the risk of the expected effect, perceived barriers; belief about the potential negative aspects of particular health behaviors, cues to action; accelerating forces that elicit a person's need for action and self-efficacy; a person's belief in her ability to carry out a behavior (Said & Aly, 2019).

Significance of the study

Vitamin D deficiency (VDD) is very prevalent across all age categories in the Middle East and North Africa with a rate of 81%. VDD is prevalent in Egypt, despite the fact that there is plenty of sunlight throughout the year. VDD levels in Egyptian healthy females of all ages have been found to be alarming. VDD was shown to be prevalent in the nursing group (72.6%), pregnant group (54%), childbearing age group (72%), elderly group (39.5%), and geriatric group (77.2%) (Botros et al., 2015).

Through health education, community health nurses contribute significantly to the prevention of VDD. VD, its significance to health and welfare, the effects of its insufficiency, and methods to prevent VDD can all be brought up in health education (Ferri, 2016). HBM has been extensively used to study a variety of health behavior interventions because it is a comprehensive pattern that shows how beliefs and behaviors are related (Ahn & Oh 2021).

To our knowledge, despite VDD's significant prevalence across different age groups in the country and its negative impact on their health, a lack of studies has been done on educational interventions based on HBM. As a result, this study was carried out to evaluate the effect of an educational intervention based on HBM on knowledge, beliefs, and VDD-preventive behaviors of female employees.

Aim of the study

The study's aim was to assess the effects of adopting health belief model to improve female employees' knowledge, beliefs, and preventive behaviors regarding Vitamin D deficiency.

Study Hypothesis

1.Female employees received HBM-based education will exhibit improved mean knowledge score after intervention compared to their mean score pre-intervention.

2.Female employees received HBM-based education will exhibit improved mean health beliefs score after intervention compared to their mean score pre-intervention.

3.Female employees received HBM-based education will exhibit improved mean VDD-preventive behavior scores after intervention compared to their mean score pre-intervention.

Method

Study design

A quasi-experimental design (pre- and post-test) was employed to perform the current study.

Study setting

The study was carried out at 14 faculties affiliated to Mansoura University, Egypt. The study included Faculties of (Nursing, Law, Commerce, Sciences, Medicine, Engineering, Agriculture, Computing and Information, Veterinary Medicine, Education, Pharmacy, Physical Education, Dental, and Arts).

Participants

Female employees working in the previously mentioned settings were selected based on the following inclusion criteria: working indoors, reading, and writing proficiency, not having participated in educational program on VDD in the preceding year, and willingness to participate.

Sample size calculation

Sample size was calculated using openepi.com using sample size calculator software, the sample size at 5% alpha error (95.0% significance) and 20.0% β error (80.0% power of the study), assuming that the average score of perceived behavioral control is 11.02 ± 3.32 (before intervention) become 11.82 ± 3.33 (after intervention) (Alami et al, 2019). The calculated sample size is 272 female employees; we can add 10% to compensate for possible dropout. The final sample size reaches 300 subjects.

Sampling technique and procedure

The female employees were recruited for this study using stratified sampling with proportional allocation technique. Initially, the academic faculties affiliated to Mansoura University were classified as medical, theoretical, and practical stratum. Number of female employees in each faculty within each stratum were counted, and proportional numbers were calculated to obtain the required sample. Then in each faculty, the female employees were selected by using systematic random sampling. Accordingly, the sample of the female employees comprised 114 out of (n=905) from practical faculties, 112 out of (n=907) from medical faculties, and 74 out of (n=596) from theoretical faculties (Table 1).

Table 1. Distribution of Recruited Female Employees from Existed Number at the Selected Faculties

Stratum	Name of the faculty	Total	Recruited
Medical	Medical	263	33
	Dental	190	24
	Pharmacy	173	21
	Nursing	164	20
	Veterinary Medicine	117	14
Practical	Engineering	302	38
	Science	290	36
	Agriculture	176	22
	Physical Education	91	11
	Computer and Information Technology	46	7
Theoretical	Arts	190	24
	Education	177	22
	Commerce	122	15
	Law	107	13
Total		**2408**	**300**

Study tools

After analyzing the pertinent literature, the researchers constructed a structured self-administered questionnaire. They were translated into Arabic language by a translator specializing in medical texts and the researchers. Then, the Arabic version was translated back into English for specification and the translation was then checked against the original text by the same team. By group consensus, minor discrepancies between the original and the back-translated version were corrected (Beaton, Bombardier, Guillemin, & Ferraz, 2000). The study tool consisted of five parts as the following:

Part I. Participants Socio-demographic and work-related data.

It included questions about age, residence, workplace, years of experience, job title, educational level, marital status, family number, monthly income, weight, and height.

Part II. Participants Medical and medications history.

This part included questions about the relevant present and past medical health history including cardiovascular, metabolic, and autoimmune diseases. In addition, information about current medications used, including weight-loss medications, anti-cholesterol, anti-coagulants, and/or corticosteroids.

Part III. Participants level of knowledge regarding VD and VDD.

This tool was adapted from Abdel Nabi et al., (2020), Babelghaith et al. (2017), and Mohamed, Al Qerem, Gassar, and Hailat (2021); Mostafa, (2020); O'Connor, Glatt, White, and Revuelta Iniesta (2018). It entailed two knowledge categories. The first category consisted of questions focused on assessing participants level of knowledge related to the nature, function, sources, recommended daily intake of VD, and duration of sun exposure. The second category consisted of questions focused on assessing knowledge related to the definition, causes, high-risk groups, signs, symptoms, complications, diagnostic measures, prevention, and treatment of VDD.

Each knowledge question was graded with a (1) for the right response and a (0) for the wrong response, or don't know. The total score for knowledge was added to determine the overall knowledge score. The total potential score was 0 to 60 points. Greater understanding of VD and VDD prevention is reflected in the better scores, and vice versa.

Part IV. Participant's VDD-preventive behaviors.

This tool was adapted from AlFaris et al., (2019), Faid, et al., (2018), Głąbska et al., (2016), Jamil et al., (2019), Kuwabara et al., (2019), and Watkins, Freeborn & Mushtaq (2021). It entailed items related to the female employees' **self-reported VDD-preventive behaviors**, focusing on three main categories including dietary intake of VD (12-items) based on a seven-point Likert scale ranging from never with one mark to one per day with seven marks. **VD supplementation and fortification intake** (4-items) based on a four-point Likert

scale ranging from never with one mark to always with four marks. Sunlight exposure behavior (12-items) calculated as "1" score for done, while "0" for not done. Maximum VDD-preventive behaviors score ranged from 0 to 112 points. A higher score indicated a greater level of VDD-preventive behaviors and vice versa.

Part V. Participant's Health Belief regarding VDD.

This tool was adapted from Evenson & Sanders (2015), Sahib (2018), Sayed-Hassan & Bashour (2013), and Xiang et al., (2020). It was based on six HBM constructs and involved 46 questions used for measuring the following:

Perceived susceptibility. The female employees' opinion about chances of getting VDD (6 items with a scoring range of 6 to 30 marks)

Perceived severity. Seriousness of VDD (5 items with a scoring range of 5 to 25 marks).

Perceived benefits. The benefits of sun exposure and dietary supplement intake (8 items with a score range of 8–40 marks).

Perceived barriers. Barriers to sunlight exposure and consumption of foods high in VD (13 items with a score range of 13–65 marks).

Health motivation/ internal cues to action. The fear of suffering from complications of VDD and a sense of the inner peace following preventive behaviors (seven items with a score range of 7–35 marks).

Perceived self‑efficacy. The ability for sunlight exposure, dietary intake, and supplementation of VD (seven items with a score range of 7-35 marks).

All statements are based on a five-point Likert scale ranging from strongly disagree to strongly agree (one to five marks). For the SPSS barrier subscale, the statements were given a reversed score: (1) was given to strongly agreeing, (2) for agreeing, (3) for neutral, (4) for disagreeing, and (5) for strongly disagreeing. Higher scores indicating extremely healthy beliefs and lower scores indicate more negative health beliefs.

Validity and reliability.

The questionnaire was developed by the researchers following a thorough assessment of the literature for validity issues. Then, it was revised by five academic experts in nursing and medical fields, including three professors in community health nursing and two in public health and preventive medicine for testing content validity. According to the expert panel's recommendations regarding the appropriateness of the material and the clarity of the phrases, the self-administered questionnaire received minor changes.

The reliability analysis was done by Cronbach's Alpha coefficient test which revealed that the overall reliability of the knowledge instrument was 0.929 pre intervention and 0.874 post intervention. For behavior instrument, Cronbach's alpha was 0.844 pre intervention and 0.839 post intervention. The total HBM scale was 0.859 pre intervention and 0.948 post intervention.

Pilot study

The pilot study was conducted on a sample of (30) female employees, or 10% of the total sample size. The aim of the pilot study was to determine whether the study instruments were clear, applicable, and relevant, as well as to estimate the time needed to fill in the study tools and predict the timing of data collection. After making the necessary adjustments to the data collection tools and rephrasing some questions and sentences in light of the piloting, the final fieldwork plan was created. Accordingly, 15- 20 minutes was the average time needed to finish the structured questionnaire. Because some changes were made, the data from the participants in the pilot study were not used in the final analysis.

Ethical consideration

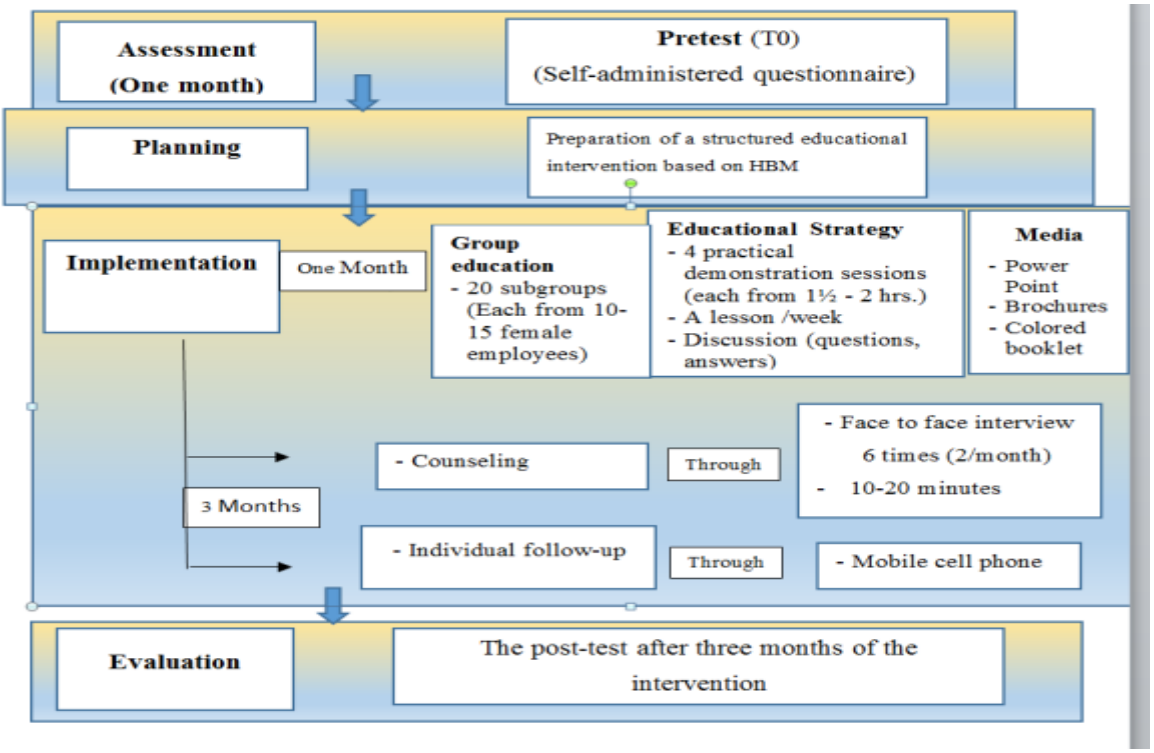
The research ethics committee of the faculty of nursing, Mansoura University provided its approval before the study was carried out (Reference No.P.0265). In order to determine the number of female employees working in each faculty at Mansoura University, a written letter was obtained from the Dean of the Faculty of Nursing and given to the head of

personnel affairs in the university administration. A second written formal letter was given to the general secretaries of each faculty asking for their agreement to conduct the study. Each female employee was given written informed consent to participate in the study after explaining of its purpose and methodology. They received assurances that they posed no physical, social, or psychological risks by participating in the study, and they were allowed to leave at any time while data was being collected without penalty. Additionally, by giving each participant a code number for use alone in analysis, participant confidentiality and anonymity were ensured. The participants in the study were not given any incentives or rewards for completing the questionnaire.

Fieldwork

A structured educational intervention was carried out through four phases to carry out the study including assessment, planning, implementation, and evaluation. These phases were completed from the beginning of November 2022 until the end of June 2023. The researchers visited the previously indicated faculties on Sunday, Tuesday, and Thursday from 9 am to 3 pm in order to gather data from the female employees. Details of the educational intervention is shown in Figure 1.

Figure 1. The educational intervention design



Assessment phase.

At the beginning, the self-administered questionnaire was given to female employees as a pre-test to identify their general characteristics, awareness of VD and VDD, health beliefs, VDD-preventive behaviors, and educational needs. To establish the effect of the intervention, the data collected in this period was the baseline for later comparisons.

Planning phase.

According to the pre-test assessment findings, the educational intervention for the target group using the HBM was prepared. The HBM-based intervention's main goals were to encourage female employees to adopt risk-reducing behaviors and to support early detection of risk factors in order to lead a healthy life. The intervention's objectives included raising female employees' awareness about their own

risk of illness, emphasizing how serious the illness is, and lowering perceived obstacles to behavior change. The Merck Manuals in the US and Canada offered the educational recommendations used in this study, which contained information related to the VDD's definition, risk factors, symptoms, side effects, and preventive measures (Johnson, 2021).

Implementation phase.

- **Group Education Program.**

Details of the group education program can be seen in Table 2. To ensure that knowledge would continue to be useful after the event ended, a colorful brochure with basic Arabic text was developed. Two experts panel composed of community health nursing and public health specialists with doctorate degrees assessed the booklet to evaluate its content validity. This booklet was sent back to the expert panel for another evaluation after the research team made the necessary adjustments and applied them. The qualitative content validity of the booklet was then confirmed.

- **Monitoring and Counseling program.**

They were executed following the completion of the educational program. The researcher addressed and listened to the female's concerns about changing her behavior. They were urged to begin and maintain their behavioral change. Supporting and motivating people, in accordance with the HBM, increases their perceived sensitivity and fosters the development of positive, healthy behavior by lowering perceived barriers.

Evaluation phase.

The same pre-test questionnaire was used post-intervention to evaluate the effect of the intervention. To give the participants the chance to alter their behavior and beliefs, the post-test was carried out three months after the intervention had been ended.

Table 2. Group Education Program.

Week	Topics for the program
1st	An orientation and introduction phase took place during the first session. Following a presentation on the research's goals and methodology. After that, a lecture and discussion were held because the majority of the female employees lacked the information, so the discussion was held to familiarize the female employees with the definition, risk factors, and high-risk group for developing VDD.
2nd	The second session's emphasis was on perceived susceptibility and severity among the female employees. This was touched by presenting the incidence and prevalence rate of VDD globally and in Egypt, as well as its signs and symptoms, vulnerability, and the serious consequences brought on by improper VD consumption.
3rd	Perceived benefits, barriers, and cues to action were the main focus of the discussion in the third session. The materials of this session emphasized on the benefits resulting from sufficient exposure to sunlight, consumption of VD rich foods, and dietary supplementation. Identifying and removing perceived barriers against performing VDD preventive behaviors such as unawareness, feeling bored, embarrassment, or fatigue through reassurance, correction of misinformation, and assistance The role of internal and external cues to action or triggers affecting VDD preventive behaviors, such as motivations and inner peace resulting from engaging in VDD preventive behaviors, physicians, family members, television, books, and magazines in health centers, has also been identified.
4th	Perceived self-efficacy and performance of VDD preventive behaviors were the main topics of discussion in the fourth session. The self-efficacy construct was emphasized by giving the female employees the tools they needed to promote their VD status, including educational visuals presented on PowerPoint slides, packages of various foods and beverages rich in VD, booklets, and leaflets. Along with showing them how to prevent VDD and any potential complications, encouraging screening for VDD through group discussions and question-and-answer sessions.

Statistical analysis

Data were analyzed using the Statistical Package of Social Science (SPSS) program for Windows (Standard version 26). The normality of data was first tested with one-sample Kolmogorov-Smirnov test. Continuous variables were presented as mean ± SD (standard deviation). The two groups were compared with independent t test while paired groups (pre and post intervention) were compared by paired t test. ANOVA test was used to compare more than two groups. Pearson correlation was used to correlate continuous variables. The threshold of significance is fixed at 5% level (p-value). The results were considered significant when the probability value is less than 5% ($p \leq 0.05$). The smaller the p-value obtained, the more significant are the result.

Results

Table 3 clarifies that 61.3% of the female employees were more than 30 years old, with the mean age and SD for them 33.21(9.57) years. Regarding the workplace, 38% of them working at practical faculties, with 40.3% and 33% of them working in technician and administrative roles, respectively, with a median year of experience ranging from zero to 34 years. It was found that 70.7%, 46.3%, and 67.3% of them were from rural areas, had higher education and/or postgraduate degrees, and were married, respectively. According to their income, 51.7% of them did not have enough income, with a median family size of four members. Participants were mostly overweight, with a mean body mass index (BMI) among them 29.90±8.87kg/m2. It was obvious that 50.7% of them reported suffering from health conditions, and the most reported medical problems were bone diseases 19.3%. Regarding medications, 69.3% of them did not take any medications.

Figure 2 Illustrates that the main source of female employees' knowledge regarding VD & VDD was colleagues and friends that constituted 37.3% followed by 34% from the media.

As shown in Table 4, there were statistically significant variations in mean scores of knowledges, VDD-preventive behaviors and HBM constructs before and 3 months after the educational intervention implementation with $P \leq 0.001$. According to the results of the paired t-test, the mean knowledge scores significantly increased from 21.97, 34.01 before the intervention to 49.49, 53.15 after three months post the intervention respectively. In addition, it was noted that the mean score of the VDD-preventive behaviors was significantly improved from 34.01±14.49 before the intervention to 53.15±10.06 after three months post the intervention. Furthermore, the table shows a statistically significant increase in the mean score of all items of the health belief model constructs (total perceived susceptibility, total perceived severity, total perceived benefits, total perceived barriers, total self-efficacy, and cues to action) post the intervention with $P \leq 0.001$.

Table 5 reveals that, three months after implementing the educational intervention, there was a positive statistically significant correlation between the total knowledge score, the total VDD-preventive behavior score, and the HBM constructs score with $P \leq 0.001$.

Table 6 signifies that there were statistically significant differences between female employees' total knowledge score regarding VDD with their age, occupation, and years of experience in the pre- and post-test with $p \leq 0.001$. Moreover, there were statistically significant differences with female employees' levels of education, marital status, and history of using medications in the pre-test only, with $p \leq 0.001$, $p=0.023$, and $p \leq 0.001$, respectively. On the other hand, there weren't statistically significant differences with female employees' residence, family size, and medical history in the pre- and post-test with $p \geq 0.05$.

Table 6 also signifies that there were statistically significant differences between female employees' total VDD-preventive behaviors score with their occupation and level of education in the pre- and post-test with $p \leq 0.001$ and $p \leq 0.006$, respectively. Moreover, there were statistically significant differences between female employees' working place, history of VDD, and medical history in the post-test only, with $p = 0.007$, $p = 0.02$, and $p = 0.015$, respectively.

Table 7 indicates that there were statistically significant differences between female employees' HBM construct scores with their age, working place, occupation, income, years of experience, medical history, and medications history in the pre- and post-test with $p<0.05$.

Table 3. Demographic and Clinical Characteristics of the Female Employees (N=300)

Variables	n (%)
Age (Years)	
$\bar{x}$ (SD)	33.21(9.57)
Min-Max	19-60
Age categories	
<30 y	116 (38.7)
≥30 y	184 (61.3)
Workplace	
Practical faculties	114 (38.0)
Medical faculties	112 (37.3)
Theoretical faculties	74 (24.7)
Occupation	
Administrative	99 (33.0)
Secretariat	43 (14.3)
Technician	121 (40.3)
Workers	37 (12.3)
Duration of work (Years)	
Median (Min-Max)	8 (0-34)
Residence	
Urban	88 (29.3)
Rural	212 (70.7)
Level of Education	
≤middle education	161 (53.7)
High education/ Postgraduate	139 (46.3)
Marital status	
Married	202 (67.3)
Unmarried	98 (32.7)
Monthly income	
Not enough	155 (51.7)
Enough	145 (48.3)
Family size	
Median (Min-Max)	4.0 (2-10)
Height (Mean ±SD)	160.76±12.17
Weight (Mean ±SD)	75.64 ±15.41
BMI (Mean ±SD)	29.90 ±8.87
History of VDD	86 (28.7)
Medical history	
No medical history	148 (49.3)
Bone disease	58 (19.3)
Autoimmune disease	26 (8.7)
Diabetes Mellitus	20 (6.7)
Cardiac /Renal diseases	12 (4.0)
Gastro-intestinal tract diseases	10 (3.3)
Medications	
No	208 (69.3)
Corticosteroid	26 (8.7)
Anticoagulant	14 (4.7)
Weight loss	10 (3.3)
Anti-cholesterol	28 (9.3)

Figure 2. Distribution of female employees' sources of information about vitamin D & VDD (n=300)

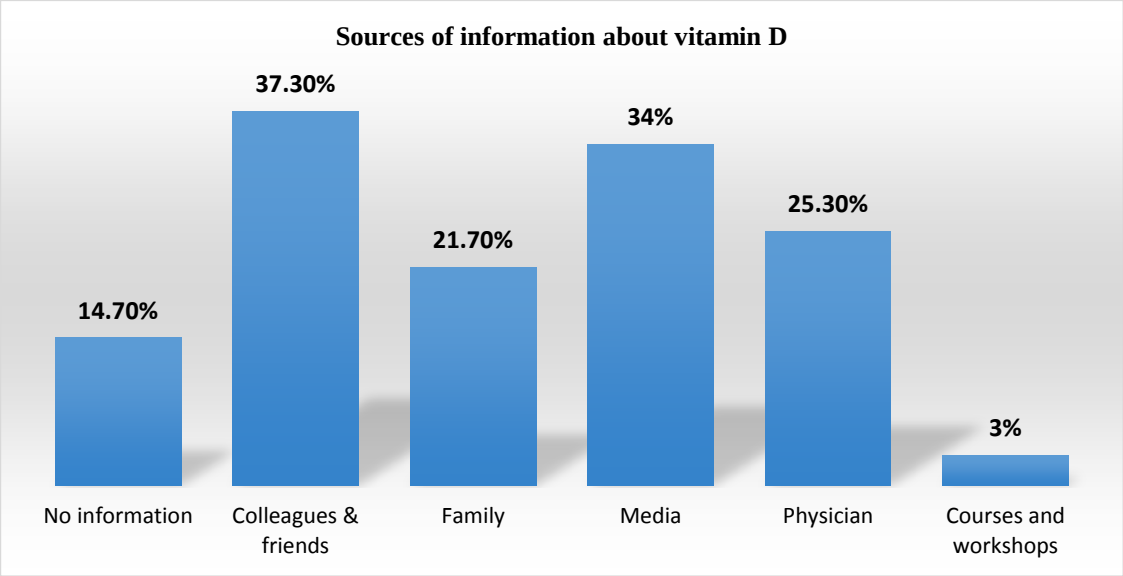


Table 4. Comparing the Participants Mean Scores of Knowledges, Behavior, and HBM Constructs before and Three Months after Educational Intervention

Variables	Before intervention (n=300)	Three months after intervention (n=300)	Mean difference (95% CI)	Test of sig. P value
	Mean (SD)			
Total knowledge score	21.97(11.97)	49.49(6.82)	27.5 (26.4-28.5)	t=50.7 **P≤0.001
Total VDD preventive behavior score	34.01±14.49	53.15±10.06	19.08 (18.1-20.02)	t=40.04 **P≤0.001
Perceived susceptibility	16.51(2.91)	20.42 (2.30)	3.9 (3.6-4.1)	t=31.5 **P≤0.001
Perceived severity	14.37(2.57)	19.03(1.59)	4.6 (4.3-4.9)	t=33.1 **P≤0.001
Perceived benefits	25.86 (3.99)	30.92 (2.49)	5.06 (4.6-5.5)	t=22.6 **P≤0.001
Perceived barriers	32.68(4.96)	45.63(5.23)	12.9 (12.1-13.7)	t=31.9 **P≤0.001
Perceived self-efficacy	19.99(4.95)	24.59(3.13)	4.6 (4.2-5.02)	t=21.3 **P≤0.001
Cues to action	20.54(3.97)	24.40(2.61)	3.8 (3.5-4.2)	t=23.8 **P≤0.001

Note. Statistically significant at ** $p \leq .001$.

Table 5. Correlation between the Female Employees' Total Knowledge, Behavior, and HBM Constructs Scores before and Three Months after Educational Intervention (n=300)

Variables	Total knowledge score			
	Before intervention (n=300)		Three months after intervention (n=300)	
	r	P value	r	P value
Total VDD preventive behavior score	0.041	0.483	0.364	≤0.001**
Perceived susceptibility	0.228	≤0.001**	0.390	≤0.001**
Perceived severity	0.238	≤0.001**	0.327	≤0.001**
Perceived benefits	0.297	≤0.001**	0.443	≤0.001**
Perceived barriers	0.097	0.093	0.486	≤0.001**
Cue to action	0.186	0.001	0.398	≤0.001**
Perceived self-efficacy	0.273	≤0.001**	0.420	≤0.001**

Note. Statistically significant at ** p ≤ .001.

Table 6. Relation between Total Knowledge and Behavior Scores, and Personnel Characteristics of Female Employees' before and after Three Months of the Educational Intervention n= (300)

Personnel characteristics	Total knowledge score				Total VDD preventive behavior score			
	Before intervention	Test of sig. P value	After three months	Test of sig. P value	Before intervention	Test of sig. P value	After three months	Test of sig. P value
	Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)	
Age (Years)								
<30 y	27.07±12.29	t=6.224	51.87±4.76	t=4.990	34.76±14.81	t=0.712	54.53±9.53	t=1.90
≥30 y	18.75±10.60	**p≤0.001	47.99±7.48	**p≤0.001	33.54±14.30	p=0.477	52.27±10.31	p=0.058
Workplace								
Practical faculties	22.72± 12.27	F=1.75	51.25± 6.05	F=7.24	35.76±15.53	F=1.36	55.4±10.52	F=5.11
Medical faculties	20.32± 13.05	P=0.18	47.87± 8.11	P=.001*	33.12±14.24	P=0.26	51.25±9.4	P=0.007*
Theoretical faculties	23.29± 9.39		49.25± 4.99		33.67± 13.0		52.54±9.74	
Occupation								
Administrative	20.89± 11.42	F=6.1	48.88± 6.94	F=9.1	35.07±14.83	F=6.2	53.71±10.05	F=12
Secretariat	25.06± 11.49	**p≤0.001	50.48± 6.67	**p≤0.001	35.2± 12.75	**p≤0.001	55.13± 8.31	**p≤0.001
Technician	23.4± 12.1		51.14± 5.65		34.28±14.37		53.98± 9.56	
Workers	15.16± 10.99		44.16± 7.65		26.62±12.13		44.89±8.4	
Level of Education								
≤middle education	19.62±11.14	t=13.943	49.31±6.01	t=0.241	29.97±11.47	t=4.65	51.45±8.49	t=2.74
High education/Postgraduate	24.69±12.36	**p≤0.001	49.70±7.67	p=0.624	37.53±15.88	**P≤0.001	54.61±11.06	p=0.006*
Marital status								
Unmarried	24.22±12.36	t=2.287	50.05±6.87	t=0.980	35.59±14.59	t=1.31	54.51±9.87	t=1.63
Married	20.87±11.66	p=0.023*	49.22±6.80	p=0.328	33.25±14.41	p=0.19	52.49±10.11	p=0.103
Monthly income								
Enough	23.30±11.84	t=1.873	50.33±5.10	t=2.077	34.06±13.42	t=0.053	54.08±9.93	t=1.56
Not enough	20.72±12.00	p=0.062	48.70±8.04	p=0.039*	33.97±15.46	p=0.958	52.28±10.13	p=0.121
Years of experience (Years)								
<8	26.43±11.75	t=7.389	52.13±4.40	t=7.741	32.91±13.87	t=1.39	53.54±9.11	t=0.715
>8	17.00±10.15	**p≤0.001	46.55±7.78	**p≤0.001	35.25±15.10	p=0.163	52.71±11.04	p=0.475
History of vitamin D def.								
Yes	24.04±11.96	t=1.912	52.01±3.90	t=4.155	33.84±14.77	t=0.313	52.29±10.48	t=2.34
No	21.13±11.90	p=0.057	48.48±7.46	**p≤0.001	34.43±13.84	p=0.754	55.27±8.61	p=0.02*
Medical history								
Yes	21.99±12.53	t=0.033	49.29±7.48	t=0.499	33.18±15.14	t=0.978	51.71±10.47	t=2.45
No	21.94±11.44	p=0.974	49.69±6.13	p=0.618	34.82±13.82	p=0.329	54.54±9.47	p=0.015*
Medications								
Yes	20.49±11.07	t=3.258	49.02±7.14	t=1.811	33.45±15.05	t=1.02	52.60±10.46	t=1.42
No	25.30±13.26	*p=0.001	50.56±5.93	p=0.071	35.29±13.11	p=0.311	54.39±9.01	p=0.156

Note. Statistically significant at ** p ≤ .001.

Table 7. Relation between Total Health Belief Model Constructs Score and Personnel Characteristics of Female Employees' before and Three Months after Educational Intervention n= (300)

Personnel characteristics	Total Health Belief Model constructs scores			
	Before intervention	Test of sig. P value	Three months after intervention	Test of sig. P value
	Mean (SD)		Mean (SD)	
Age (Years)				
<30 y	134.11±12.97	t=4.363	167.92±8.61	t=2.847
≥30 y	127.36±13.07	**p≤0.001	163.17±16.58	p=0.005*
Working place				
Practical faculties	132.04± 11.78	F=22.9	167.73± 10.35	F=15.4
Medical faculties	123.93± 13.69	**p≤0.001	159.42± 18.93	**p≤0.001
Theoretical faculties	135.93± 11.8		169.27± 6.29	
Occupation				
Administrative	128.32± 11.24	F=4.87	165.27± 13.45	F=3.37
Secretariat	134.51± 15.59	**p≤0.001	167.37± 8.38	P=0.01*
Technician	130.59± 13.45		166.11± 15.25	
Workers	125.27± 13.53		157.45± 16.45	
Residence				
Urban	128.18±11.57	t=-1.495	164.70±16.08	t=-0.242
Rural	130.72±14.07	p=0.136	165.14±13.41	p=0.809
Level of Education				
≤middle education	129.80±12.91	t=0.055	163.64±15.59	t=3.237
High education/Postgraduate	130.17±14.03	p=0.815	166.59±12.30	p=0.073
Marital status		t=1.417		
Unmarried	131.55±14.51	p=0.157	167.07±13.30	t=1.752
Married	129.21±12.82		164.01±14.57	p=0.081
Monthly income				
Enough	133.86±11.62	t=5.044	168.95±6.07	t=4.808
Not enough	126.34±13.99	**p≤0.001	161.32±18.16	**p≤0.001
Family size				
<4	130.89±13.62	t=1.344	165.66±12.73	t=0.897
>4	128.80±13.11	p=0.180	164.18±15.92	p=0.370
Years of experience (Years)				
<8	133.64±12.36	t=5.208	169.06±7.96	t=5.447
>8	125.89±13.41	**p≤0.001	160.50±17.87	**p≤0.001
History of vitamin D deficiency				
Yes	136.00±8.96	t=5.132	171.41±3.54	t=5.153
No	127.55±14.15	**p≤0.001	162.43±15.98	**p≤0.001
Medical history				
Yes	126.20±13.61	t=4.994	160.81±17.05	t=5.272
No	133.65±12.19	**p≤0.001	169.10±9.11	**p≤0.001
Medications				
Yes	127.80±13.16	t=4.332	163.71±15.29	t=2.394
No	134.88±12.74	**p≤0.001	167.94±10.94	p=0.017*

Note. Highly statistically significant at ** p ≤ .001.

Discussion

Vitamin D deficiency (VDD) is common throughout the world, especially among female's population, with a higher risk of a number of diseases has been connected to it. High blood levels of VD have a history of being

advised for good health. A crucial VDD prevention tactic is the use of community-based intervention programs that employ behavior modification models like the HBM.

Health education and promotion programs can effectively and affordably increase the information and skills necessary to build behavioral changes through their curative and preventive plans for VDD. Therefore, the aim of this study was to assess how knowledge, health beliefs, and VDD-preventive behaviors among female employees were affected by the educational intervention based on BM. Regarding socio-demographic characteristics, it is noted that the mean age of the female employees was 33.21 years old, with more than 60% of them above 30 years old. This Egyptian female age group had significant criteria that increased their susceptibility to VDD. According to the study done by Botros et al. (2015) on VDD among healthy Egyptian females, VDD was present among 72.6% of women nurses, 54.4% among pregnant women, 72.2% among childbearing women, 39.5% among elderly people, and 77.2% among people of advanced age. Additionally, the current study revealed that 67.3% of the participants were married, 53.7% had at least a middle-level education, and 48.3% had a sufficient household income. Participants were mostly overweight, with a mean BMI of 29.90 kg/m2. This is in agreement with the finding of a study done by Jamil et al. (2019), who studied VD and its connection to VD status in Malay and concluded that most participants were married, between the ages of 30 and 39 years old, had a high diploma, and had a middle-class household income, which were the characteristics of nearly half of the participants. In addition, the majority of them were overweight, with a median BMI of 26.5 kg/m2.

In the present study, 50.7% of the participants complained from diseases such as bone disease, DM, autoimmune disease, cardiac and renal disease, and GIT diseases. Moreover, 30.7% of them taking medications such as corticosteroid, antiepileptic, anticoagulant, weight loss, and anti-cholesterol drugs. This result was consistent with research done by Al-Daghri et al. (2022) on VD status among Arab adults which reported that the most prevalent diseases among them were 9.3% DM, 9.2% HTN, 3.2% heart disease, 5.8% with dyslipidemia, 3.4% osteoporosis, 6.2% with arthritis, and 2.3% with bone fracture history. Also according to several studies, there is an association between such diseases, the medication, and the development of VDD (Aziz, & Azeez, 2020; Sohl et al., 2012; Wakeman, 2021).

The current study findings also showed that informal sources from friends and colleagues were the main sources of knowledge for females concerning VD. This demonstrated their function as a source of information because they influence and encourage behaviors related to eating and sun exposure as well as provide the resources and direction necessary to determine the level of VD. So our study findings are in line with those of Al-Ghraibawi, Al-Ghabban, & Al-Zubaidy, (2018) who conducted research on VDD knowledge and practices. They noted that information from friends and family ranked as the top two participant knowledge sources. These findings necessitate providing educational intervention to the working females regarding VDD.

The findings demonstrated that the study's hypothesis was confirmed. This indicates that following an educational intervention based on HBM, females' knowledge, preventative behavior, and perceived beliefs regarding VD and VDD have improved.

After receiving our educational intervention based on HBM, the participants' knowledge of VD and VDD has increased. After three months of the educational intervention, the mean scores for all domains of knowledge increased by around 28. The educational booklets distributed to the female employees helped them remember the information more easily, and the phone calls they had as part of the counselling process helped them retain what they had learned about VDD. This outcome is consistent with a study done by El-Aty et al. (2022) who found that knowledge of VDD among women significantly improved following the implementation of the education program. Another study was conducted by Shaheen, Tawfeek, & Alkalash (2021) on changes in maternal knowledge after

the application of educational program. The study demonstrated that the mean ± SD of mothers' knowledge of VD increased significantly from 14.7 ± 4.9 to 50.6 ± 1.8 with (P<0.001) after the implementation of an educational program.

Participants in this study reported higher levels of perceived susceptibility, severity, and benefits, as well as higher levels of perceived barriers, perceived self-efficacy, and cues to action following the educational intervention. The training sessions, which based on the participants needs identified during the pre-assessment, may also have contributed to this improvement. As it included warnings about illness risks, the presentation of visuals on Power Point presentations, and the distribution of leaflets outlining the advantages of sun exposure and VD intake. Along with the increased participant interaction brought on by group discussions and question-and-answer sessions. This finding is compatible with a study done by Elnagar, Salam, & Abdel-Sadik, (2020) who reported that the mean score of all health belief model constructs had increased three months after the HBM-based education program for mothers of children with VDD was implemented.

This study found that educating female employees based on HBM, promoted their VDD-preventive behaviors, and improved their eating of foods rich in VD and using nutritional supplements. Increasing the females' perceived self-efficacy and their awareness as well increased their capacity to adopt healthier behavior, which they continued to do after the educational intervention. This result was in line with the finding of study done by Hosseini, et al (2021) who concluded that the intervention group's performance in retinopathy-preventive behaviors improved after the intervention, rising from 2.95 ± 1.42 to 4.48 ± 1.45 with ($p < 0.001$).

Individuals' health perceptions and engagement in appropriate health maintenance behaviors can be significantly influenced by their level of knowledge. Therefore, along with people's beliefs and attitudes, it is a fundamental component of behavior change (Mahmoud et al., 2018). The results of the current study showed a statistically significant positive correlation between the overall knowledge of female employees and HBM constructs subscale scores before and after educational intervention. This result was supported by Ali, Mekhamier, & El Sayed. (2020), who explained that, before and after program implementation, the study women's total knowledge and total health beliefs scores showed a favorable statistically significant correlation.

The current study found a significant relation between the mean VDD knowledge of female employees in the pre- and post-test and their age. In study done by Abdel Nabi et al. (2020) and Patali (2018) who reported the same outcome, indicating a significant relationship between mothers' knowledge and their age and educational status. This finding, however, was contradicted with the finding of a study done by Alotaibi et al. (2019). The current study also revealed a statistically significant relationship between the mean knowledge of VDD in the pre- and post-tests for female employees and their place of employment and occupation. In study done by Hashem et al, (2020) who found relation with the participants' working status. In contrast, a study done by El-aty et al., (2022) who found no relationship between female employees' knowledge and their working status in the pre- and post-test with p-values= 0.677 and 0.067 respectively. There was a statistically significant difference in the pre-test results regarding the relationship between the participants' knowledge and their level of education and marital status, according to the study. Similar results were obtained by Alamoudi et al, (2019).

Regarding to the relation between total VDD-preventive behavior scores of female employees and their personal characteristics, the current study clarified that there was statistically significant relation with their working place, occupation, level of education history of VDD and medical history. In a study done by Abdel Nabi et al, (2020) who clarified that there was a positive relation between female's total reported practice score regarding sunlight exposure and their place of residence and level of education with P-values= 0.009 and 0.023 respectively. Moreover, in a study done by Haluza et al, (2016) who assessed the prevalence of sun exposure and associated skin

health habits and suggested that occupation had significant relation which stimulated leisure time sun exposure practices.

Regarding factors affecting female employee's health belief about VDD; there was statistically significant relation between female employees' age, working place, occupation, income, years of experience, medical and medications history and their mean of health belief scores among the pre and post-test. According to study finding done by Soliman et al. (2020), who reported that mothers' attitudes were significantly correlated with their ages and educational levels.

The use of self-reported questionnaires, which may be subject to recall bias and desirability bias, is one of this study's limitations. Furthermore, a longer follow-up period may yield more reliable results when assessing female employees for VDD-preventive behaviors.

Conclusion

The present study concluded that the research hypotheses are supported and the HBM-based educational intervention had a significant impact on improving female employees' knowledge about VD and VDD, raising all constructs of the HBM, and positively altering their VDD-preventive behavior. There was a statistically significant positive correlation between overall knowledge score, total VDD-preventive behavior scores and total HBM constructs scores three months after the educational intervention implementation.

Recommendations

Health Belief Model construct should be an essential part into existing VDD management program. More research is required to examine the effectiveness of HBM for a longer period of follow-up time after the intervention.

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