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Nutrition Self-Efficacy, Digital Engagement and Psychological Well-Being Among Women with Breast Cancer Using a Digital Nutrition-Education Programme: An Exploratory Cross-Sectional Study

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ABSTRACT

Purpose: Women receiving treatment for breast cancer are at risk of malnutrition and psychological distress. Digital nutrition education may help, but it only works if patients engage with it, and little is known about which patient factors go with engagement and psychological well-being. The objective was to describe engagement with a hospital-based digital nutrition-education programme and to explore associations among dietary behaviour change, nutrition self-efficacy, digital engagement, nutritional status, quality of life and psychological well-being.

Methods: This exploratory cross-sectional study included 50 women aged 20–50 years receiving active treatment for breast cancer at three tertiary-care hospitals in Visakhapatnam, India, who had used a six-module, blog-based programme. Self-report scales, platform analytics and anthropometry were collected at a single visit. Associations were examined with Pearson correlation and multiple linear regression adjusted for age and baseline health. The indirect association of self-efficacy with well-being through engagement was estimated as a secondary, hypothesis-generating analysis, with Monte Carlo confidence intervals.

Results: Self-efficacy was strongly correlated with digital engagement ($r = 0.80$, 95% CI 0.67 to 0.88) and with psychological well-being ($r = 0.70$, 95% CI 0.52 to 0.82). In the adjusted model ($R^2 = 0.50$), self-efficacy was independently associated with well-being ($B = 4.21$, 95% CI 1.84 to 6.57, $p < .001$), whereas digital engagement was not ($B = 0.01$, 95% CI −0.11 to 0.13, $p = .875$). The indirect association through engagement was not different from zero (0.15, 95% CI −1.67 to 2.01). Dietary behaviour change was associated with nutritional status ($B = 5.67$, 95% CI 3.71 to 7.63) and quality of life ($B = 4.93$, 95% CI 2.14 to 7.71).

Conclusion: Among women using a digital nutrition-education programme, nutrition self-efficacy, rather than the amount of platform use, was the variable most closely associated with psychological well-being. The design was cross-sectional, uncontrolled and small, so these findings do not show that the programme is effective. They identify self-efficacy as a candidate target to test in an adequately powered, controlled, longitudinal trial.

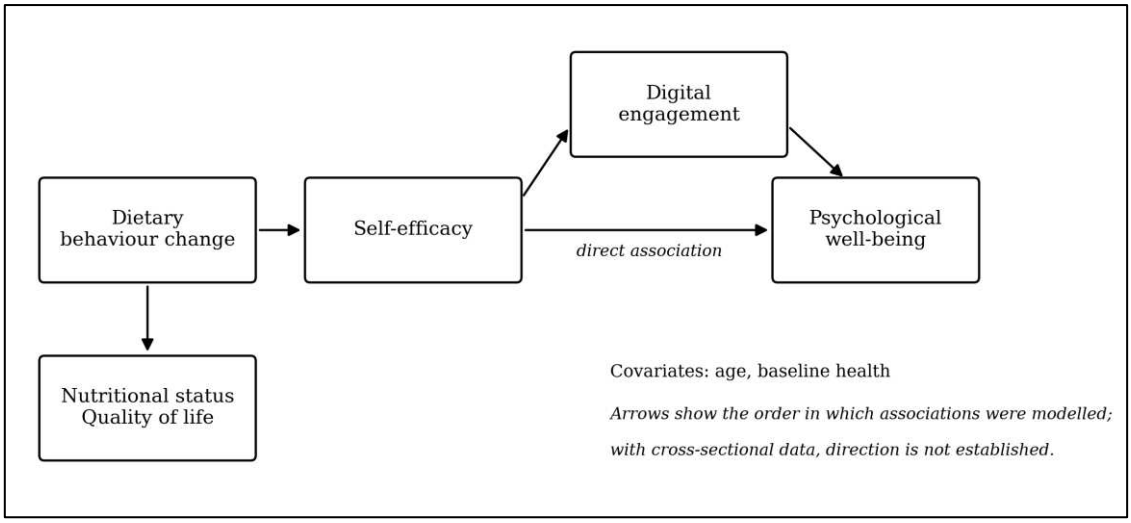
Keywords: breast cancer; nutrition education; digital health; self-efficacy; patient engagement; psychological well-being; cross-sectional study

1. INTRODUCTION

Chemotherapy, radiotherapy and hormonal therapy for breast cancer commonly cause systemic inflammation, loss of appetite and metabolic disturbance, which contribute to malnutrition, fatigue and reduced quality of life [1–3]. Nutritional support is a recognised part of supportive oncology care [4]. In routine practice, however, nutrition advice is often general and one-off. It seldom addresses the behavioural and psychological factors that decide whether patients adopt and keep up dietary change [5, 6]. Randomised trials suggest that structured nutrition education with behavioural support improves nutrition knowledge, attitudes and behaviour in people with cancer [7, 8], and integrative models that combine nutrition with psychological support are increasingly proposed [9].

Digital platforms can deliver structured nutrition education at scale. A digital programme can only benefit patients who use it, though, and engagement with digital behaviour-change interventions varies widely between individuals [10]. Social cognitive theory identifies self-efficacy, a person's confidence in their ability to carry out a behaviour, as a central driver of behaviour change and persistence [11]. Patients who feel more confident about managing their diet may therefore engage more with a digital programme, and both self-efficacy and engagement may relate to how patients feel psychologically during treatment. These relationships have rarely been examined among women with breast cancer in India, where digital nutrition support is still new.

This study was therefore designed as an exploratory, hypothesis-generating analysis in women who had used a hospital-based digital nutrition-education programme. It was not designed to test whether the programme is effective, and it cannot do so: there was no comparison group and no pre-intervention measurement. Its aims were (i) to describe engagement with the programme; (ii) to estimate associations among dietary behaviour change, nutrition self-efficacy, digital engagement, nutritional status, quality of life and psychological well-being; (iii) to examine whether self-efficacy and digital engagement are each associated with psychological well-being after adjustment for age and baseline health; and (iv) as a secondary analysis, to estimate the statistical indirect association between self-efficacy and well-being through engagement. The associations examined are summarised in the conceptual model shown in Fig. 1.



Arrows show the order in which associations were modelled. All variables were measured at the same time point, so the direction of the associations is not established. Covariates: age and baseline health (treatment modality described but not adjusted for; see Section 4.5).

Fig. 1 Conceptual model of the associations examined

2. METHODS

2.1. Study design and reporting

This was a multi-site (three hospitals), cross-sectional study of women with breast cancer who had been enrolled in a digital nutrition-education programme. All variables were measured once, at the same visit. The study is reported according to the STROBE guideline for cross-sectional studies [12].

2.2. Setting and participants

Participants were recruited from the oncology departments of three tertiary-care hospitals in Visakhapatnam, Andhra Pradesh, India (Mahatma Gandhi Cancer Hospital and Research Institute, CARE Hospitals and Medicover Hospitals) between January 2022 and November 2022. Eligible participants were women aged 20–50 years with a clinical diagnosis of breast cancer who were receiving chemotherapy, radiotherapy or hormonal therapy. Exclusion criteria were gastrointestinal conditions preventing oral intake, cognitive impairment that would prevent use of the digital modules, and comorbidities likely to influence nutritional or psychological outcomes. Participants were selected by purposive sampling from patients attending the oncology departments during the study period. Of 56 women approached, 6 declined to participate; the remaining 50 enrolled, used the programme, completed the study assessment and were included in the analysis (participation rate 89%).

2.3. The digital nutrition-education programme

The programme consisted of six interactive e-modules delivered through a purpose-built educational blog that participants could access on their own devices, covering the principles of immunonutrition (sources and roles of omega-3 fatty acids, selenium, zinc, antioxidants and probiotics), culturally adapted dietary guidance, and behaviour-change strategies. Participants were also given value-added food products enriched with these nutrients. Data on the food products (composition, sensory acceptability and intake) were not part of this analysis. This paper concerns the digital-education component only.

2.4. Variables and measurement

All measures were collected at a single study visit after participants had been given access to the e-modules. The operational definition, instrument and scoring of each variable are given in Table 1.

Dietary behaviour change was measured with the Dietary Behaviour Change Scale, on which participants rate on a 5-point Likert scale how far they have adopted the immunonutrition-consistent dietary practices recommended in the programme. The score is the mean item score (range 1–5); higher scores indicate more change.

Nutrition self-efficacy was measured with the General Nutrition Self-Efficacy Scale, rated on a 5-point Likert scale and scored as the mean item score (range 1–5); higher scores indicate greater confidence in maintaining healthy dietary behaviour during treatment.

Digital engagement was obtained from e-module platform analytics and comprised three indicators: log-in frequency, module completion rate and time on the platform. These were combined into an engagement index; higher values indicate greater engagement. Engagement was not self-reported.

Nutritional status was assessed with anthropometry (body mass index and mid-upper arm circumference) and a 24-hour dietary recall, combined into a nutritional status score; higher scores indicate better nutritional status.

Quality of life was measured with the EORTC QLQ-C30 [13, 14], summarised as a composite score; higher scores indicate better quality of life.

Psychological well-being was assessed using the psychological well-being measure administered to participants and expressed as a total score, with higher scores indicating better psychological well-being.

Because the quality-of-life and psychological well-being composites are on transformed scales that include negative values, they are interpreted in relative terms (associations) and not against clinical cut-offs.

Covariates were age (years), treatment modality (chemotherapy, radiotherapy or hormonal therapy) and baseline health status, rated on a 5-point scale (1–5) at enrolment, with higher scores indicating better health status.

Table 1 Operational definitions, instruments and scoring of study variables

Variable	Operational definition	Instrument / source	Scoring and range
Dietary behaviour change	Self-reported adoption of the immunonutrition-consistent dietary practices taught in the programme	Dietary Behaviour Change Scale	Mean item score, 1–5; higher = more change
Nutrition self-efficacy	Confidence in ability to sustain healthy dietary behaviour during treatment	General Nutrition Self-Efficacy Scale	Mean item score, 1–5; higher = more confident
Digital engagement	Frequency, completion and duration of e-module use	Platform analytics: log-ins, completion rate, time on platform	Engagement index; higher = more use
Nutritional status	Anthropometric and dietary-intake indicators	BMI, MUAC, 24-hour recall	Composite score; higher = better
Quality of life	Multidimensional health-related quality of life	EORTC QLQ-C30	Composite score; higher = better; interpreted relatively
Psychological well-being	Emotional stability and coping	Psychological Questionnaire	Total score; higher = better; interpreted relatively
Age	Age at assessment	Medical record	Years (20–50)
Treatment modality	Current treatment	Medical record	Chemotherapy / radiotherapy / hormonal therapy
Baseline health	Health status at enrolment	Rating at enrolment	1–5; higher = better

BMI, body mass index; EORTC QLQ-C30, European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire-Core 30; MUAC, mid-upper arm circumference

2.5. Sample size

An a priori calculation for the originally planned mediation and moderation models indicated that about 180 participants would be needed. Only 50 women completed the programme and the assessment during the study period. We therefore narrowed the scope of the analysis: the

planned age-moderation (interaction) analysis was dropped, and mediation was restricted to one secondary, exploratory model.

Post-hoc "observed" power is not informative, because it is a direct function of the observed p-value [15], so we report a sensitivity analysis instead. With N = 50 ($\alpha = .05$, two-tailed, 80% power), the smallest correlation that could be reliably detected is $r = 0.39$. For an indirect association, a Monte Carlo simulation indicated about 60% power when both component paths are of medium size (standardised $a = b = 0.39$), and under 20% when one path is small, consistent with published requirements for mediation [16]. The study was therefore adequately sized only for moderate-to-large associations, and the indirect-association estimate is treated as exploratory.

2.6. Statistical analysis

Continuous variables are summarised as mean (SD), median (interquartile range, IQR) and observed range; categorical variables as n (%). Associations between continuous variables were estimated with Pearson's correlation coefficient, with 95% confidence intervals obtained by Fisher's z transformation.

The primary analysis was a multiple linear regression with psychological well-being as the outcome and self-efficacy and digital engagement as explanatory variables, adjusted for age and baseline health. We report unstandardised coefficients (B) with 95% CIs, standardised coefficients (β), R^2 and adjusted R^2. Because self-efficacy and engagement were expected to be highly correlated, multicollinearity was assessed with variance inflation factors (VIF). In secondary models adjusted for the same covariates, dietary behaviour change was the explanatory variable and nutritional status and quality of life the respective outcomes.

As a secondary, exploratory analysis, we estimated a simple mediation model (equivalent to PROCESS Model 4 [17]) adjusted for age and baseline health, with self-efficacy as the predictor, digital engagement as the intermediate variable and psychological well-being as the outcome. The 95% CI for the indirect association ($a \times b$) was obtained by the Monte Carlo method with 100,000 draws [18]. With cross-sectional data, an indirect path does not establish temporal order or causation [19]. We therefore also fitted the model with self-efficacy and engagement in reverse order and report both, to show how far the data can distinguish the two orderings.

All regression and indirect-association estimates were computed from the Pearson correlation matrix and standard deviations of the study variables. For complete data these fully determine the ordinary least-squares estimates. There were no missing data for the 50 participants analysed. Given the exploratory aims, no correction was made for multiple comparisons; results are interpreted by effect size and confidence interval rather than by p-values alone. Analyses were carried out in R version 4.3.3 (R Foundation for Statistical Computing, Vienna, Austria).

2.7. Ethical considerations

The study was approved by the Institutional Human Ethics Committee, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore (approval no. AUW/IHEC/FSMD-22-23/FHP-2). All participants gave written informed consent. Participation was voluntary, and participants could withdraw at any time without any effect on their clinical care. Permission to recruit patients was obtained from each of the three participating hospitals. Data were de-identified and stored in encrypted, access-controlled repositories. The study was conducted in accordance with the Declaration of Helsinki.

3. RESULTS

3.1. Participant characteristics

The 50 participants had a mean age of 37.8 years (SD 8.2; range 20–50) and a mean baseline health rating of 3.09 (SD 1.47) on the 1–5 scale. All three treatment modalities (chemotherapy, radiotherapy and hormonal therapy) were represented in the sample. Table 2 presents characteristics and scores for all study variables.

Table 2 Characteristics of participants and study variables (N = 50)

Variable	Mean (SD) or n (%)	Median (IQR)	Observed range
Age, years	37.8 (8.2)	38.0 (28.0–46.0)	20.0–50.0
Baseline health (1–5)	3.09 (1.47)	3.00 (2.00–4.00)	1.00–5.00
Dietary behaviour change (1–5)	3.31 (0.44)	3.33 (3.02–3.60)	2.10–4.41
Nutrition self-efficacy (1–5)	1.97 (0.41)	1.96 (1.68–2.24)	1.04–3.15
Digital engagement index	24.55 (7.64)	24.34 (19.30–28.98)	5.36–47.52
Nutritional status score	16.74 (3.87)	16.79 (14.05–19.30)	7.20–26.94
Quality of life composite	13.05 (4.41)	13.33 (10.33–16.16)	−2.35–24.43
Psychological well-being	7.14 (2.61)	7.15 (5.27–9.06)	−0.20–15.41

IQR, interquartile range. Quality-of-life and psychological well-being composites are on transformed scales and are interpreted relatively.

3.2. Engagement with the programme

Engagement varied considerably between participants. The digital engagement index had a median of 24.34 (IQR 19.30–28.98) and ranged from 5.36 to 47.52, a nine-fold difference between the least and most engaged participants. Engagement was not related to age (r = 0.00, 95% CI −0.28 to 0.28) and was weakly related to baseline health (r = 0.30, 95% CI 0.02 to 0.53).

3.3. Bivariate associations

Correlations among study variables are shown in Table 3. Self-efficacy was strongly correlated with digital engagement (r = 0.80, 95% CI 0.67 to 0.88) and with psychological well-being (r = 0.70, 95% CI 0.52 to 0.82). Digital engagement was also correlated with psychological well-being (r = 0.56, 95% CI 0.33 to 0.73). Dietary behaviour change was correlated with self-efficacy (r = 0.70, 95% CI 0.52 to 0.82), nutritional status (r = 0.73, 95% CI 0.57 to 0.84) and quality of life (r = 0.55, 95% CI 0.32 to 0.72). Age was not significantly correlated with any study variable.

Table 3 Pearson correlations among study variables (N = 50)

Variable	1	2	3	4	5	6	7	8
1. Age	—							
2. Baseline health	0.27	—						
3. Behaviour change	0.20	0.46***	—					
4. Self-efficacy	0.16	0.35*	0.70***	—				
5. Digital engagement	0.00	0.30*	0.53***	0.80***	—			
6. Nutritional status	0.19	0.48***	0.73***	0.54***	0.46***	—		
7. Quality of life	0.15	0.35*	0.55***	0.30*	0.26	0.42**	—	
8. Psychological well-being	0.19	0.27	0.48***	0.70***	0.56***	0.35*	0.23	—

* p < .05; ** p < .01; *** p < .001 (two-tailed). 95% confidence intervals for key coefficients are given in the text.

3.4. Multivariable analysis

In the adjusted model (Table 4), self-efficacy was independently associated with psychological well-being (B = 4.21, 95% CI 1.84 to 6.57, β = 0.66, p < .001), whereas digital engagement was not (B = 0.01, 95% CI −0.11 to 0.13, β = 0.03, p = .875). Age and baseline health were not associated with well-being. The model explained 50% of the variance in well-being (adjusted R^2 = 0.45). VIFs were ≤ 3.04, indicating that the correlation between self-efficacy and engagement did not produce problematic collinearity. In secondary models adjusted for age and baseline health, dietary behaviour change was associated with nutritional status (B = 5.67,

95% CI 3.71 to 7.63, β = 0.64, p < .001; R^2 = 0.56) and with quality of life (B = 4.93, 95% CI 2.14 to 7.71, β = 0.49, p < .001; R^2 = 0.31).

Table 4 Multiple linear regression of psychological well-being on self-efficacy and digital engagement, adjusted for age and baseline health (N = 50)

Variable	B	95% CI	β	p	VIF
Nutrition self-efficacy	4.21	1.84 to 6.57	0.66	< .001	3.04
Digital engagement	0.01	−0.11 to 0.13	0.03	.875	2.94
Age (years)	0.03	−0.05 to 0.10	0.08	.472	1.15
Baseline health	0.01	−0.40 to 0.43	0.01	.947	1.21

B, unstandardised coefficient; β, standardised coefficient; VIF, variance inflation factor. R^2 = 0.50; adjusted R^2 = 0.45; F(4, 45) = 11.10, p < .001.

3.5. Exploratory indirect association

In the model with self-efficacy as the predictor (Table 5, Model A), self-efficacy was associated with engagement (a = 14.96, 95% CI 11.51 to 18.41). Engagement was not associated with well-being once self-efficacy was accounted for (b = 0.010, 95% CI −0.115 to 0.135). The indirect association through engagement was therefore small and not different from zero (0.15, 95% CI −1.67 to 2.01), and almost all of the total association between self-efficacy and well-being (c = 4.36) was direct (c′ = 4.21, 95% CI 1.84 to 6.57). When the ordering was reversed (Model B), the indirect association of engagement with well-being through self-efficacy was 0.175 (95% CI 0.077 to 0.285), and the direct association of engagement with well-being was close to zero (c′ = 0.010). Thus the correlation between engagement and well-being was accounted for by their shared association with self-efficacy.

Table 5 Exploratory indirect associations with psychological well-being, adjusted for age and baseline health (N = 50)

Path	Model A: estimate	Model A: 95% CI	Model B: estimate	Model B: 95% CI
a path (X → M)	14.959	11.505 to 18.413	0.042	0.032 to 0.051
b path (M → Y | X)	0.010	−0.115 to 0.135	4.209	1.845 to 6.573
Direct association (c′)	4.209	1.845 to 6.573	0.010	−0.115 to 0.135
Indirect association (a × b)	0.147	−1.673 to 2.006	0.175	0.077 to 0.285
Total association (c)	4.356	2.920 to 5.791	0.185	0.099 to 0.271

Model A: X = self-efficacy, M = digital engagement. Model B (reverse ordering): X = digital engagement, M = self-efficacy. Y = psychological well-being in both. CIs for indirect associations are Monte Carlo intervals (100,000 draws). With cross-sectional data these are statistical associations, not causal effects.

4. DISCUSSION

4.1. Principal findings

In this exploratory study of women with breast cancer who had used a digital nutrition-education programme, nutrition self-efficacy was strongly associated with engagement with the programme and with psychological well-being. Self-reported dietary behaviour change was associated with nutritional status and quality of life. After adjustment for age and baseline health, self-efficacy remained independently associated with well-being, whereas the amount of platform use did not. The indirect association of self-efficacy with well-being through engagement was not different from zero. Engagement's correlation with well-being appeared to reflect its shared association with self-efficacy, not an independent contribution.

4.2. Comparison with previous research

The association between self-efficacy and engagement is consistent with social cognitive theory, which holds that people who are more confident in their ability to act are more likely to take up and persist with a behaviour [11], and with evidence that engagement with digital behaviour-change interventions varies between users according to their characteristics [10]. Our findings also fit trial evidence that nutrition education combined with behavioural support improves dietary behaviour in people with cancer [7, 8], and proposals that nutrition and psychological support be integrated in cancer care [9]. Unlike those trials, our design cannot show that the programme changed behaviour, nutritional status or well-being. It shows only how these variables relate to one another among women who used it. The finding that confidence, rather than the amount of platform use, tracked well-being suggests that the content a programme delivers to build confidence may matter more than how much patients use it.

4.3. Interpreting the indirect association

Cross-sectional mediation estimates can be seriously biased and do not establish the temporal order that a mediation claim requires [19]. In our data, the model with engagement as the intermediate variable showed no indirect association, whereas the reverse ordering did. This pattern is compatible with several explanations: using the platform may build confidence, which in turn relates to well-being; confident and psychologically well patients may simply use the platform more; or all three may reflect a common factor such as overall health, education or family support. Cross-sectional data cannot distinguish between these explanations, and with 50 participants the study had limited power for indirect associations

(Section 2.5). The results should be read as a description of the pattern of correlations, not as evidence of a mechanism.

4.4. Implications for research and practice

These findings suggest hypotheses rather than changes to practice. If a controlled longitudinal study confirms that self-efficacy is the key correlate of well-being, digital nutrition programmes could include explicit self-efficacy-building components such as graded goal setting, mastery experiences and personalised feedback, rather than aiming simply to maximise use. Such a study should (i) randomise patients to the digital programme or usual care, (ii) measure self-efficacy, engagement and well-being at baseline and at two or more follow-up points so that temporal order can be examined, (iii) use fully specified, validated instruments, and (iv) be powered for the indirect effect of interest, using published sample-size tables or simulation [16]; for medium-sized paths this means substantially more participants than were available here.

4.5. Strengths and limitations

Strengths of the study include objective measurement of engagement from platform analytics rather than self-report, adjustment for age and baseline health, examination of both orderings of the indirect association, and transparent reporting of the study's capacity to detect effects.

The study also has important limitations. First, the cross-sectional, single-group design means that no inference can be drawn about the effectiveness of the programme or about causal or temporal relationships between variables. Second, the sample (N = 50) was smaller than originally planned. The study was adequately powered only for moderate-to-large associations, and the planned moderation analysis was abandoned. Third, purposive sampling from three tertiary hospitals in a single city, restricted to women aged 20–50 years, limits generalisability to older women, to women with limited digital access and to other settings. Fourth, dietary behaviour change and self-efficacy were self-reported and are open to social-desirability and recall bias; behaviour change was reported retrospectively and not measured against a baseline. Fifth, the quality-of-life and psychological well-being composites are on transformed scales and cannot be compared with published norms or clinical cut-offs. Sixth, treatment modality was not included as a covariate, so residual confounding by type of treatment is possible. Seventh, the value-added food component of the programme was not analysed, so its possible contribution to the associations observed is unknown. Finally, several correlations were

estimated without adjustment for multiple comparisons, which increases the risk of chance findings.

5. CONCLUSION

Among women with breast cancer who used a digital nutrition-education programme, greater nutrition self-efficacy was associated with greater engagement with the programme and with better psychological well-being. Self-efficacy, not the amount of platform use, remained associated with well-being after adjustment. The design was cross-sectional, uncontrolled and small, so these results do not establish that the programme is effective or explain how any benefit arises. They identify nutrition self-efficacy as a plausible target for digital nutrition interventions, to be tested in an adequately powered randomised trial with repeated measurements.

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Competing interests: The authors declare no conflicts of interest.

Ethics approval: The study was approved by the Institutional Human Ethics Committee, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore (approval no. AUW/IHEC/FSMD-22-23/FHP-2). The study was conducted in accordance with the Declaration of Helsinki.

Consent to participate: All participants gave written informed consent.

Author contributions: P.K.P.: conceptualisation, methodology, investigation, data curation, formal analysis, writing – original draft. S.T.: conceptualisation, supervision, methodology, writing – review and editing.

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