Causal model of health literacy in dietary supplement use and sufficient health behavior among working-age adults

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ABSTRACT

Background: Sufficient health behavior (SHB) and health literacy in dietary supplement use (HL-DSU) are the key determinants of health status. However, the link between HL-DSU and SHB is not fully understood. Therefore, the objective of this research was to investigate the model and identify the size of its effect on HL-DSU and SHB among adults of working age.

Methods: The study employed a cross-sectional survey design, with cluster random sampling used for the selection of 696 working-age adults ranging from 20–59 years. Data on their SHB, HL-DSU, awareness of dietary supplement advertising (DSA), and social support were collected from August to October 2021 through questionnaires employing a 5-point rating scale. Content validity was determined using item-objective congruence (IOC) values ranging from 0.6 to 1.0 obtained for each item on the questionnaire. The Cronbach’s alpha values ranging from 0.93 to 0.96 indicated reliability, while the independent t-test, descriptive analysis, and structural equation modeling (SEM) were performed.

Results: SHB is defined as the health-beneficial behaviors based on a balanced lifestyle, utilizing conceptual approaches resulting in positive health outcomes relating to fundamental goals in the use of dietary supplements and other contexts emphasizing sufficiency. The causal model was found to fit the empirical data with an acceptable goodness-of-fit value. The findings indicate that social support, awareness of DSA, and HL-DSU directly affect SHB (Beta of 0.33, 0.20, and 0.13, respectively, p < .05) and could predict 34% of SHB overall. HL-DSU is shown to be significantly and directly impacted by social support and awareness of DSA, with influence coefficients of 0.36 and 0.57, respectively. The variance of HL-DSU can be predicted by these two factors as 67%.

Conclusion: The establishment of campaign activities to promote awareness regarding the advantage and disadvantages, as well as media literacy of supplementary food products in health centers and communities, should be the focus of healthcare providers.

1. Introduction

Dietary supplements (DSs) are increasingly being used worldwide. According to the National Health and Nutrition Examination Survey (NHANES), the prevalence of dietary supplement use (DSU) increased among U.S. adults aged 20 and over from 53% in 2003–2006 to 57.6% in 2017–2018, while women (63.8%) used DSs more than men (50.8%) [1]. The reasons given for DSU in females were vitamin deficiency (63.3%), hair condition (37.6%), and nail health (23.5%), while males took dietary supplements for vitamin deficiency (58.4%) and bodybuilding (34.4%) [2]. In addition, consumers have relied more on DSs to strengthen their immune systems in response to the COVID-19 pandemic [3]. People’s lifestyles have changed in ways that discourage healthy behavior, e.g., exercise and healthy eating, leading to more cases of non-communicable diseases [4]. Previous research shows that the majority of adults and elderly use DSs (85%) with vitamins, i.e., vitamin D (45%) and vitamin C (21%), and minerals, i.e., calcium (23%) and magnesium (14%) being the most popular. Information on DSs was usually obtained by word-of-mouth, i.e., from people who had previously used the products [5]. A study by Yang, Hsu, and Chiang reported that 72.4% of college students also used DSs (72.4%). The most commonly used supplements were vitamin B complex (54.0%), multivitamins (40.9%), and calcium (25.5%) [6]. Most college students, as revealed by Radwan et al., used whey proteins to boost their physical strength (29.4%) [7]. Similarly, in Thailand, most working-age people live a fast-paced existence, have no time to properly take care of their health,
and fail to consume a nutritionally adequate diet. The rate of DS consumption by Thai people increased from 19.1% in 2013 to 21.6% in 2017. Also, the market value of DSs grew from 20,876.2 million baht in 2019 to 23,916.8 million baht in 2020 [8]. The research results obtained by HTAP reflect the overclaims on the properties and advantages of DSs [9], aligning with the study by Ployearmsang et al., who found that 62% of DS advertisement content was illegal and Thai people use DSs and medicine without cogitation [10].

A survey by Thailand’s Department of Health Service Support showed that 70% of Thai adults living in urban areas with both high and low levels of education falsely believed that DSs are necessary and hence should be taken on a regular basis [11]. This has led to a reduction in main meal portion sizes and wrong weight control methods, resulting in a lack of nutrients and the increasing use of DSs among working-age groups. Working-age adults use proportionally more DSs than any other age populations. This is because they have sufficient salary to purchase DSs, adequate nourishment, slow aging, etc. Online sources were found to be the main sources of information on DSs due to the rapid growth in online DS business in Thailand [12]. Furthermore, the study by Smith et al. found that, according to the health information, the more they eat in appropriate portions and mutually use high-vitamin dietary products [19].

The study by Vamos et al. confirmed that HL could effectively predict health behavior and health outcomes [15]. The present study focuses on sufficient health behavior (SHB), which significantly affects Thai people's health by strengthening their immune system, allowing them to maintain good health amidst changes [16]. Adapted from the philosophy of a sufficient-life economy, the three elements of SHB are 1) sufficient-life behavior (living without exploiting oneself or others), 2) safe behavior (immunity to health risks arising from taking poor-quality dietary supplements), and 3) self-care behavior (eating, exercise, and regular self-checks).

The present study examines SHB among working-age groups using HL as a mediating factor. This current study therefore examines SHB among working-age adults aged between 20 and 59 due to their potential for seeking and using DSs. The findings can be used as guidelines for organizing activities to promote people's HL-DSU, leading to better health.

The study by Charoencheewakul et al. showed that patients with excellent HL were 2.64 times more likely to use DSs properly than those with lower HL. Patients also believed that HL skills would assist them in choosing DSs for blood sugar control [20]. A number of studies have indicated the direct effects of social support on sufficient health (informational support, emotional support from health providers, and instrumental support such as obtaining DS products from their friends and family). For example, Axon et al. reported that participants who received advice on herbal supplements were 3.5 times more likely to use them than those who received no advice [21]. In addition, those with higher levels of social support were more likely to use DSs accessed over the counter [13]. People's awareness of dietary supplement advertising (DSA) also directly impacted on sufficient health. As suggested by Yang et al., awareness of DSA refers to an individual’s ability to rationally analyze advertising messages so that they can properly use DSs, including their intentions for future use [6].

However, no research has been conducted to analyze a causal model of SHB among working-age groups using HL as a mediating factor. This current study therefore examines SHB among working-age adults aged between 20 and 59 due to their potential for seeking and using DSs. The causal relationship model of HL-DSU and SHB in working-age groups. According to the evaluation of theoretical concepts and relevant research, the following hypotheses arise. 1) The causal relationship model of HL-DSU and SHB in working-age groups is consistent with the empirical data; 2) The causal factors have influenced SHB through HL-DSU among working-age groups; and 3) Females have a greater awareness of DSA and HL-DSU than males.

2. Methods

This cross-sectional study examines the consistency between the causal relationship model of HL-DSU and SHB using the empirical data and determines the effect of independent variables on HL-DSU and SHB among working-age adults.

The population in this study consisted of Thai working-age adults using purposive selection. According to a survey conducted by Intarakamhang for the Department of Health Service Support in 2016, the population living in provinces received lower HL scores in comparison to others, i.e., Sing Buri, Sa Kaeo, and Bangkok received average scores of

![Research framework](image-url)
The study sample comprised Thai working-age adults aged between 20 and 59 from public organizations, private organizations, and local communities in three provinces. Cluster random sampling was used for selection. An adequate sample size was determined for confirming factor analysis based on the sample size recommended by Hair et al. of 200 people per group [25]. In this study, data were collected from three groups, each with 200 participants, totaling 600 people. The sample size was increased by 16% to ensure the collection of sufficient data. Therefore, a total of 696 samples were obtained. The inclusion criteria were adults aged between 20 and 59, who experienced no diabetes, hypertension, or heart disease, had the ability to read and write, and expressed a willingness to disclose health-related information. The exclusion criteria were pregnancy or illness, resulting in the participants being unable to provide information, use conventional medicines for treating chronic diseases, and who expressed unwillingness or hesitation in disclosing information. A 5-point Likert rating scale was used for assessing the questionnaire items, ranging from 1 (not true at all) to 5 (absolutely true). The researchers constructed the questionnaire items based on operational definitions developed from conceptual assessment models. The measuring tools used in this study consist of 1) the HL-DSU measuring tool, adapted from the HL measuring tool in adult age [22, 26]. This was combined with 40 questionnaires examining four perspectives of information and health products: assess, understand, examine, and make correct decisions. 2) The SHB measuring tool, developed to correspond with the operative terms of 20 available questionnaires. This covers safe living to maintain personal health, combining three perspectives: sufficient-living behavior, health-safe behavior, and healthcare behavior [16]. 3) A measuring tool of social support, combining 20 questionnaires [23]. 4) Awareness of DSA, combining 12 questionnaires [24]. The assessments were examined by five experts for validity. The results showed that all assessments met the minimum criteria and achieved the index of item-objective congruence (IOC) requirement ranging from 0.6 to 1.00 [27]. The assessments were also tested on a group of 100 people with similar characteristics to the study sample. The assessments obtained Cronbach’s alpha coefficients ranging from 0.903 to 0.963 [28], while the corrected item-total correlation ranged from 0.446 to 0.887 [29]. Due to the COVID-19 situation, the researchers carried out data collection online by contacting provincial health offices, district health offices, and local community leaders to seek permission for data collection and schedule a date and time for meeting with the sample groups. The researchers, along with the research assistant and local representatives, explained the study objectives to the sample groups and gave instructions on completing the surveys in the local representatives’ Line group to avoid missing data. The researchers strictly followed the principles of ethics for research involving human subjects and received ethical approval (SWUEC/E, No. 210/2564E) from the IRB of the University.

### 2.1. Data analysis

SPSS 22.0 and LISREL 8.72 software packages were used to analyze the data. The demographic characteristics and measured variables were examined using descriptive statistics. The relationships among the measured variables were identified using Pearson’s correlation coefficients. The results of the mean scores for the latent variables were compared between females and males in the HL-DSU and SHB, while the causal model was conducted using an independent t-test. Furthermore, structural equation modeling (SEM) was implemented to analyze the causal relationships. The fit of the hypothesized model was evaluated through the use of SEM with maximum likelihood based on multiple criteria as follows: chi-square test (p > .05), the likelihood ratio (chi-square test/df) with the desired value of <3, root mean square error of approximation (RMSEA) with the acceptable value of ≤.08, comparative-fit index (CFI) with the desired value of ≥.90, normed-fit index (NFI) with the desired value of ≥.90, and goodness-of-fit index (GFI) with the desired value of ≥.90 [30]. The level of .05 was considered significant in this study.

### 3. Results

The demographic data of 696 participants revealed the following: 63.36% were female, 45.98% married, 29.02% aged between 20 and 30 years old, 65.09% had the highest level of education, graduating with a bachelor's degree, and 63.51% were employed by the public and private sector. Most variables were normally distributed, as shown in Table 1.

Bivariate analysis was conducted to examine the linear relationship between two variables by calculating the Pearson product-moment correlation coefficient using a significance level of 0.05. The following pairs of variables had the strongest relationships (r = 0.85): informational support and emotional support, instrumental support and emotional support, and awareness of pros and cons and awareness of advertising. The pair of variables with the second strongest relationship (r = 0.84) were information verification and information use. The weakest relationship (r = 0.30) was found between information access and sufficient-life behavior, as shown in Table 2.

To ensure data fitness, the bivariate correlation should not be greater than 0.85 to avoid the possibility of multicollinearity [30]. According to the results, all bivariate correlations among the variables were less than 0.85 and hence, suitable for further analysis.

The causal relationship model was analyzed in this study based on the constructed framework and used the null hypothesis in the estimation of relationship values. The obtained fit indices were: χ² = 220.10, df = 48, p-value = 0.00, χ²/df = 4.585, RMSEA = 0.07, SRMR = 0.02, CFI = 0.99, NFI = 0.98, and GFI = 0.95. As indicated by the results, the developed root mean square residual (SRMR) with the acceptable value of ≤.08, standardized

### Table 1. Mean, SD, Skewness, and Kurtosis after conversion to standard scores.

| Variables | Mean | SD  | Skewness | Kurtosis | Chi-Square | p-value |
|-----------|------|-----|----------|----------|------------|---------|
| **HL-DSU** |      |     |          |          |            |         |
| 1. Information Access | 3.782 | 0.847 | -0.944 | -2.194 | 5.706 | 0.058 |
| 2. Information Understanding | 3.798 | 0.833 | -0.919 | -2.184 | 5.614 | 0.060 |
| 3. Information Verification | 3.994 | 0.851 | -1.752 | -3.395 | 14.350 | 0.001 |
| 4. Information Use | 3.993 | 0.846 | -1.833 | -3.486 | 15.511 | 0.000 |
| **Social Support** |      |     |          |          |            |         |
| 5. Informational Support | 3.837 | 0.788 | -0.881 | -1.718 | 3.729 | 0.155 |
| 6. Emotional Support | 3.839 | 0.780 | -0.985 | -1.983 | 4.902 | 0.086 |
| 7. Instrumental Support | 3.866 | 0.721 | -0.636 | -1.454 | 2.519 | 0.284 |
| **Awareness of DSA** |      |     |          |          |            |         |
| 8. Awareness of Pros and Cons | 3.456 | 0.996 | -0.738 | -2.483 | 6.711 | 0.035 |
| 9. Awareness of Advertisements | 3.564 | 0.947 | -0.723 | -2.187 | 5.305 | 0.070 |
| **SHB** |      |     |          |          |            |         |
| 10. Sufficient-life Behavior | 3.491 | 0.993 | -0.646 | -2.264 | 5.544 | 0.063 |
| 11. Self-care Behavior | 4.208 | 0.786 | -2.664 | -4.195 | 24.695 | 0.000 |
| 12. Safe Behavior | 4.227 | 0.787 | -2.952 | -4.505 | 29.140 | 0.000 |

Notes: * means significant at 0.05 level of significance. The Chi-Square test for equality of variances was analyzed, and the assumption of homogeneity of variances was met (p > 0.05).
causal relationship model showed a low level of consistency with the empirical data because the cut-off value for statistical significance in the chi-square test was 0.05. To increase the fit index values to an acceptable level, the model was modified by adjusting the errors of certain observed variables to allow relationships between them.

After the adjustment, the model fitted with the empirical data according to the following fit indices: $\chi^2 = 133.32$, df = 45, p-value = 0.00, $\chi^2$/df = 2.96, RMSEA = 0.05, SRMR 0.03, CFI = 0.99, NFI = 0.99, GFI = 0.97. All values reached acceptable levels except the chi-square, which could possibly be explained by 1) the complexity of the causal relationship model with multiple paths, 2) the large sample size, and 3) the sensitivity of the chi-square to violations of the multivariate normality assumption [30]. The direct, indirect, and total effects among variables are presented in Table 3 and Figure 2.

Accordingly, social support, awareness of DSA, and HL-DSU directly affected SHB at a significance level of 0.05 with direct effects of 0.33, 0.20, and 0.13, respectively. The three variables could explain the 34% variance in SHB. Social support and awareness of DSA directly affected HL-DSU at a significance level of 0.05 with direct effects of 0.36 and 0.57, respectively. Both variables could explain the 67% variance in HL-DSU. They also had indirect effects on SHB through HL-DSU at a significance level of 0.05, with indirect effects of 0.05 and 0.08, respectively. In the absence of assessments on the determinants of DSU, it is recommended studies be conducted on DSU impacts, such as disease or effects caused by using too many supplements or opting to follow overclaims in advertisements which may be harmful to health.

The comparative results for the mean scores of latent variables in the causal model of HL-DSU and SHB between females and males are presented in Table 4.

### Table 2. The bivariate correlation coefficient of the variables used in this study.

| Variables | S_HL1 | S_HL2 | S_HL3 | S_HL4 | S_HS1 | S_HS2 | S_HS3 | S_SS1 | S_SS2 | S_SS3 | S_AW1 | S_AW2 |
|-----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| S_HL1     | 1.00  |       |       |       |       |       |       |       |       |       |       |       |
| S_HL2     | 0.78* | 1.00  |       |       |       |       |       |       |       |       |       |       |
| S_HL3     | 0.69* | 0.80* | 1.00  |       |       |       |       |       |       |       |       |       |
| S_HL4     | 0.69* | 0.78* | 0.84* | 1.00  |       |       |       |       |       |       |       |       |
| S_HS1     | 0.30* | 0.37* | 0.37* | 0.42* | 1.00  |       |       |       |       |       |       |       |
| S_HS2     | 0.36* | 0.41* | 0.42* | 0.45* | 0.81* | 1.00  |       |       |       |       |       |       |
| S_HS3     | 0.38* | 0.42* | 0.44* | 0.46* | 0.76* | 0.84* | 0.85* | 1.00  |       |       |       |       |
| S_SS1     | 0.47* | 0.51* | 0.50* | 0.57* | 0.44* | 0.44* | 0.41* | 1.00  |       |       |       |       |
| S_SS2     | 0.52* | 0.55* | 0.56* | 0.62* | 0.42* | 0.44* | 0.43* | 0.85* | 1.00  |       |       |       |
| S_SS3     | 0.47* | 0.51* | 0.49* | 0.54* | 0.42* | 0.43* | 0.43* | 0.82* | 0.85* | 1.00  |       |       |
| S_AW1     | 0.60* | 0.59* | 0.69* | 0.64* | 0.36* | 0.39* | 0.45* | 0.41* | 0.50* | 0.44* | 1.00  |       |
| S_AW2     | 0.60* | 0.61* | 0.70* | 0.65* | 0.38* | 0.42* | 0.47* | 0.40* | 0.49* | 0.43* | 0.85* | 1.00  |

Notes: * means significant at 0.05 level of significance.

### Table 3. Direct, Indirect, and Total effects between independent and dependent variables

| Independent Variables | Dependent Variables | HL-DSU (R² = 0.67) | SHB (R² = 0.34) |
|-----------------------|---------------------|-------------------|---------------|
|                       | DE | IE | TE | DE | IE | TE |
| Social Support        | 0.36* | -  | -  | 0.36* | -  | -  |
| Awareness of DSA      | 0.57* | -  | -  | 0.33* | 0.05* | 0.38* |
| HL-DSU                | -  | -  | -  | -  | -  | -  |

Chi-Square = 133.32, df = 45, p-value = 0.00, Chi-Square/df = 2.96, RMSEA = 0.05, SRMR 0.03, CFI = 0.99, NFI = 0.99, GFI = 0.97.

As can be observed, female participants have a mean score for awareness of DSA (t = -4.996, p-value = 0.000) and HL-DSU (t = -5.181, p-value = 0.000), significantly higher than males.

## 4. Discussion

The findings indicate that all variables included in the study could together predict SHB. More specifically, social support and awareness of DSA had indirect effects on SHB through HL-DSU, which agrees with the research hypothesis and can be explained as follows.

When people receive social support (informational support, emotional support, and instrumental support) relating to dietary supplements and are aware of DSA, their HL-DSU increases, leading to SHB. These results are consistent with several studies, such as that by Berkman et al., who found that health behavior was influenced by different factors through HL [10], and Manganello, who revealed that health behavior was directly and indirectly influenced by many factors through HL [31]. The results of this present study are also supported by those of Guo et al., who discovered the direct effects of personal factors, interpersonal factors, environmental factors, and HL on health behavior, as well as the indirect effects of personal factors, interpersonal factors, and environmental factors on health behavior through HL [32]. As also indicated by the present research, HL-DSU had a direct effect on SHB. This can be explained by the fact that HL-DSU refers to the ability to access, understand, and apply information relating to DS, helping to promote healthy behavior. These results are consistent with the study by Fleary et al., who found that functional and media HL directly affected health behavior [33].

In addition, the study findings reveal social support directly affects HL-DSU and SHB. This is because support is an interpersonal process, allowing individuals to access information relating to DSs and learn how to use them properly. In this way, people can evaluate and manage themselves, leading to the development of their SHB. These results agree with the findings of Mette Jorgine et al., who discovered that social support was a significant factor in HL [34], and Park et al., who found that social support had direct and indirect effects on the health behavior of college students through their perceptions of stress [35].

Awareness of DSA was also found to have a direct effect on HL-DSU and SHB. One possible explanation is that an individual’s awareness of DSA arises when they receive information about DSs from advertisements that enhance their HL in relation to a particular product, leading to SHB. These results are consistent with the study by Fatima and Lohi, who found that awareness of DSA promoted DSU [36].

In this study, differences in DSA and HL-DSU were revealed between females and males, which was consistent with the work of Mishra et al., who found that more women used DSs than men [1]. However, there
were no differences in social support and SHB between females and males. For this reason, the majority of participants in this study were married, with a similar family context and way of life.

This study has two limitations. Firstly, during the COVID-19 pandemic, data were collected online. This led to the sample group having high HL. Most of them graduated with a bachelor's degree. They used smartphones to browse health information from various sources. The participants were difficult to control because only those with Internet access could take part in the study. As a result, the sample may not truly reflect all population groups. Secondly, as a cross-sectional study, all data were collected at one specific point in time. Therefore, the context must be carefully considered when relying on the results of this study.

This research has the following strengths. Firstly, a measuring instrument with high reliability was developed through the research process using advanced statistics to remove the errors. Secondly, the large sample size could be representative of the real population. The results of the instrument test revealed it to be of high quality. New variables were developed during the research process, along with new theories based on empirical data.

This study contains academic benefits for guiding future education and practice. A body of new knowledge has been developed in terms of a theoretical variable measurement to acknowledge the studied variables, e.g., awareness of supplementary food product advertisements, omniscience in the use of supplementary food products, and sufficient health behavior. These are all reintegrated variables, with their measurement components acknowledged. Thus, a new concept from the measurement model has been developed in this study. The new model has been developed from the structural relationship model into a new measuring instrument to assess the omniscient levels of health in the use of supplementary food products and initially screening the risk groups with low SHB scores to improve their health. Thus, the risk group was screened before participating in the health promotion program.

Moreover, the results of this study revealed the factors strongly influencing omniscience in the use of supplementary food products and SHB. For example, high awareness of supplementary food products was found to influence omniscience in the use of supplementary food products and SHB. Thus, health personnel should focus on implementing campaign activities to raise awareness of the advantages, disadvantages, and media literacy of supplementary food products.

5. Conclusion

The causal model of SHB was shown to be consistent with the empirical data. Social support, awareness of DSA, and HL-DSU were each found to have a direct effect on SHB. Moreover, social support and awareness of DSA indirectly affected SHB through HL-DSU, demonstrating agreement with the research hypothesis.

The promotion of SHB at an individual level should start with developing awareness and HL skills and then with the provision of informational support relating to DSU since this is a significant factor in SHB. Such a program would lead to the effective and sustainable development of SHB.

Furthermore, instructional materials with clear and concise content should be developed to enhance the skills of healthcare personnel to provide informational support to people. The awareness of DSA should also be raised among working-age groups with advice and accurate information provided on dietary supplements that can be accessed anytime through channels such as applications and websites to promote HL-DSU and SHB.
Future studies should compare the overall SHB of the entire country for clearer results and future reference and compare the effectiveness of different SHB promotion programs.

Declarations

Author contribution statement

Ungsinun Intarakamhang, Ph. D; Pitchada Prasittichok, PhD: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data included in article/ supp. material/referenced in article.

Declaration of interests statement

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Additional information

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