

Original Research Article

Perceived threats of vision impairment and its effect on consumption pattern of dietary supplement of lutein and zeaxanthin

Frank FC Pan^{1*}, Chen Sen-Chi², Chao Shun-Jung³

¹Department of Hospitality & Department of Pharmacy, Tajen University, Pingtung, Taiwan, ²CEO, Pao-Chien Hospital, Pingtung, Taiwan, ³President, Puudeng Pharmaceutical Co. New Taipei City, Taiwan

*For correspondence: **Email:** profpan900@gmail.com; **Tel:** +86-932-808695

Sent for review: 5 July 2019

Revised accepted: 24 November 2019

Abstract

Purpose: To explore perceived threats of vision impairment as well as the perceived benefits and barriers of lutein-containing supplements using a health belief model (HBM), and also to assess how these may affect dietary supplement consumption behaviours.

Methods: A structured questionnaire was developed on HBM through a focus group interview to gather information from 1,075 drugstore customers in Taiwan. Respondents were 55.16 % female, 64.47 % married, 53.12 % aged between 31 and 50 years, and 91 % with at least a high school education.

Results: Perceived severity was much higher than perceived susceptibility. Susceptibility was the most stable construct. Occupation, residence area, and workplace were the top three factors differentiating the variance in HBM constructs. Perceived benefits appeared as the most powerful predictor, followed by perceived barriers. HBM predictors jointly explained 21.9 % of the variance in lutein- and zeaxanthin-taking behaviour. Moderating effects of health-related information were not significant.

Conclusion: HBM is useful to understand this behaviour. Consumer behaviour is mainly affected by perceived benefits, and not the threat of vision impairment. Since people ignore the possibility of suffering severe vision impairment, more health education is required.

Keywords: Lutein, Zeaxanthin, Macular degeneration (AMD), Health belief model, Dietary supplement

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided the original work is properly credited.

Tropical Journal of Pharmaceutical Research is indexed by Science Citation Index (SciSearch), Scopus, International Pharmaceutical Abstract, Chemical Abstracts, Embase, Index Copernicus, EBSCO, African Index Medicus, JournalSeek, Journal Citation Reports/Science Edition, Directory of Open Access Journals (DOAJ), African Journal Online, Bioline International, Open-J-Gate and Pharmacy Abstracts

INTRODUCTION

A recent study estimated that 253 million people live with vision impairment, of which the most suffer with moderate to severe vision impairment (MSVI) patients [1,2]. Lutein and zeaxanthin have been found to be helpful in reducing the progression of the macular degeneration in the eyes, which is the main cause of blindness [3,4].

It is estimated that there are 183,567 people, or 8 % of the population, with severe vision impairment in Taiwan. To solve the high incidence rate of MSVI, Taiwan government has devoted huge investment in eye protection projects [5]. Since maintaining a sufficient level of lutein and zeaxanthin is an effective method for preventing AMD [6-11], people in Taiwan are eager to purchase lutein and zeaxanthin as pharma for their eye health [12].

This research applied the health belief model (HBM) [13] to predict the willingness of intake lutein and zeaxanthin. The association between perceived threats of becoming blind, the perceived benefits and barriers of intake lutein and zeaxanthin, the 'cues to action', and the willingness are hypothesised with four hypotheses as follow.

Hypothesis 1 (H1): Levels of perceived susceptibility, severity of blindness threats, perceived benefits and barriers of taking lutein and zeaxanthin to prevent severe vision impairment and intake willingness are variable along with demographic factors. **Hypothesis 2 (H2):** Perceived susceptibility, severity of threats of vision impairment, and the perceived benefits of taking lutein and zeaxanthin are positively correlated, whereas the correlation with perceived barriers is negative. **Hypothesis 3 (H3):** The intake behaviour of lutein and zeaxanthin is positively affected by the respondent's perceived susceptibility and severity of blindness, and perceived benefits of taking lutein and zeaxanthin, but negatively affected by perceived barriers. **Hypothesis 4 (H4):** The amount of action cues moderates the relationships between intake behaviour and its predictors.

METHODS

Subjects

This research is conducted with care on human rights that conform to *The Universal Declaration of Ethical Principles for Psychologists* [14]. Included in this research were 1,075 subjects at selected stores that specialised in selling pharmaceuticals (including naturaceuticals and cosmeceuticals) around the country of Taiwan. Customers at these stores were approached by the store managers with a structured questionnaire. Researchers and assistants are required to sign a confidentiality agreement to not disclose any information regarding the subject. All data are anonymous and disconnected with any personal identity. Data collection occurred between October and December 2015.

Research framework

Based on HBM, the current research proposed several hypotheses, as shown in Figure 1. The research hypothesises that the perceived threats (perceived susceptibility and severity) and the perceived net benefits will directly affect the intake behaviours (H2 and H3, respectively). H1 states that all HBM constructs are variable

according to demographic factors. Action cues are hypothesised by H4 as activators of perceived threats and net benefits for captioned behaviour.

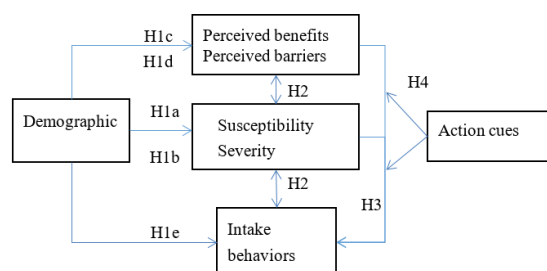


Figure 1: Research framework

Instruments

A focus group interview was conducted with a group of 12 adults who experienced moderate and severe eyes problems to generate question items on the questionnaire. Open questions for the interviews were drawn from the HBM literature [13,15]. A pre-test was conducted with 50 customers at the drug stores to test the reliability of the instrument.

Four items of the questionnaire were adopted to measure perceived susceptibility, with *Cronbach's* $\alpha = 0.863$ in the pre-test and *Cronbach's* $\alpha = 0.831$ in the official test. Three items were adopted to measure perceived severity, with *Cronbach's* $\alpha = 0.833$ in the pre-test and *Cronbach's* $\alpha = 0.855$ in the official test. Four items were adopted to measure perceived benefits with *Cronbach's* $\alpha = 0.809$ in the pre-test and *Cronbach's* $\alpha = 0.831$ in the official test. For perceived barriers, six items were adopted to measure this construct with *Cronbach's* $\alpha = 0.739$ in the pre-test and *Cronbach's* $\alpha = 0.774$ in the official test. For lutein and zeaxanthin-taking behaviour, six items were adopted to measure this construct with *Cronbach's* $\alpha = 0.916$ in the pre-test and *Cronbach's* $\alpha = 0.921$ in the official test.

Action cues

Internal cues represent the information or suggestions the individuals obtained from their social network, whereas external cues are information the individuals received from sources such as public media or governmental agencies. It was assumed that, with more sources of health information, the impacts of action cues would be stronger. The action of taking lutein and zeaxanthin should be more activated when multiple sources deliver similar information. In other words, the impacts of action cues on the

intention of taking lutein and zeaxanthin will be stronger for those people who are exposed to multiple information sources.

RESULTS

Demographic factors

Participants included in this research were 593 women (55.16 %) and 482 men (44.84 %); 693 were married (64.47 %) and 382 were single (35.53 %). Most of the respondents were aged between 31 and 50 years ($n = 291 + 280 = 571$, 53.12 %), with more than 91% high-school educated. General office workers and unemployed were the two major occupations in this research, with 355 (33.02 %) and 356 (33.12 %) respectively. The majority of respondents had a monthly income between 20,000 NTD (\$667 USD) and 65,000 NTD (\$2,167 USD) (784, 72.92 %). Most of the respondents reside in the downtown areas (615, 57.21 %) and suburbs (225, 20.93 %), as shown in Table 2.

Table 1: Survey responses around Taiwan

Area	Population ^a	% ^b	Subjects	% ^c
North 1	7,048,243	30.35	325	30.2
North 2	3,649,046	15.71	168	15.6
Central	4,544,569	19.57	207	19.3
South 1	3,104,268	13.37	143	13.3
South 2	3,619,660	15.58	167	15.5
East	1,114,481	4.80	52	4.8
Islands	145,528	0.63	13	1.2
Total	23,225,795		1,075	

^a Population census as at January 2016. **Source:** Ministry of the Interior, Taiwan, Republic of China; ^b Percentage of population of area to the entire nation. ^c Percentage of sample subjects to the entire subjects

Constructs

The survey results revealed that respondents generally agreed on the severity of the captioned health problem with an average of 4.23 (SD = 0.834) on a five-point scale. However, the possibility of suffering such a disease did not receive equal concern (mean = 3.22, SD = 0.876). This means that, although the respondents are highly afraid of becoming blind, they believe that they will not be part of this victim group.

As to the benefits and barriers to the intake of lutein and zeaxanthin as a preventive treatment for severe eye diseases and blindness, the respondents appeared to be rather optimistic. Respondents showed a satisfactory level with the behaviour of taking lutein and zeaxanthin, a level that is similar to the perceived benefit, as shown in Table 3.

Table 2: Sample distribution by demographic factors

Variable	Item	n	%	
Gender	Male	482	44.84	
	Female	593	55.16	
Marriage	Married	693	64.47	
	Single	382	35.53	
Age (years)	<30	183	17.02	
	31-40	291	27.07	
	41-50	280	26.05	
	51-60	212	19.72	
	>61	109	10.14	
Education	Junior school	76	7.07	
	High school	215	20.00	
	Bachelor	640	59.53	
	Post-graduate	144	13.4	
Place of work	None	94	8.74	
	School	90	8.37	
	Hospital	179	16.65	
	Pharmacy	115	10.7	
	Office building	266	24.74	
	Home	89	8.28	
	Outdoor	71	6.6	
	Factory	44	4.09	
	Others	127	11.81	
	Occupation	Officers	355	33.02
Gov. employee		89	8.28	
Professionals		122	11.35	
Services		153	14.23	
None		356	33.12	
Personal income		<20K	133	12.37
		20-35K	325	30.23
	35-50K	279	25.95	
	50-65K	180	16.74	
	65-85K	90	8.37	
Residence area	>85K	68	6.33	
	Downtown	615	57.21	
	Industrial area	33	3.07	
	Suburb	225	20.93	
	Rural	133	12.37	
	Mountain/seaside	69	6.42	

Table 3: Means and standard deviations of constructs

Construct	n	Min.	Max.	Mean	SD
Susceptibility	1,075	1.00	5.00	3.22	0.876
Severity	1,075	1.00	5.00	4.23	0.834
Perceived benefits	1,075	1.25	5.00	3.65	0.655
Perceived barriers	1,075	1.00	5.00	3.05	0.683
Lutein behaviour	1,075	1.33	5.00	3.68	0.774

Sources of health information

In average, respondents accessed 1.92 information sources for health-related decisions, of which TV and the internet were the top two sources, followed by healthcare institutions. Nearly 50 % of the respondents relied on TV (49.35 %) and the internet (49.07 %) to receive

health-related information, whereas only about one third accessed information from healthcare institutions such as hospitals, as shown in Table 4. It is worth noting that healthcare institutions are usually requested by the government to share certain health education missions in Taiwan.

Table 4: Sources of health-related information

Sources	Responses		Observation (%)
	n	%	
TV	530	25.60	49.35
Newspaper	48	2.32	4.47
Radio	74	3.57	6.89
Internet	527	25.46	49.07
Health institution	391	18.89	36.41
Sum	2,070	100.00	192.74

N = 1,075

Analysis of variance

The analysis of variance delivers some valuable information regarding the differences along with major demographic factors, which are summarised and shown in Table 5; these findings partly support hypothesis 1.

The constructs in this research did not vary much according to the demographic factors of sex, marriage status, or eye diseases in relatives. This means that these personal factors may not cause differences in HBM constructs. However, the place of work, occupation, and residence area were the most significant factors that differentiated the variance of constructs. The major results of the analysis are illustrated in the following sub-sections.

The most sensitive constructs to the difference of personal factors of the model were the constructs of perceived severity, perceived barriers, and lutein-taking behaviour, whereas the construct of susceptibility was the most stable and varied only by place of work and residence area.

Occupation

One-way ANOVA results show that four of five variables of the model varied along with type of occupation. The test results indicated that the professional group (mean = 4.43) perceived the strongest level of severity ($F = 4.56, p = 0.001$) and was stronger than the group of unemployed subjects (mean = 4.11) who perceived the lowest level. In contrast, this group perceived the lowest barrier (mean = 2.85) and was significantly lower ($F = 3.79, p = 0.005$) than the groups of office workers and unemployed in terms taking lutein and zeaxanthin supplements to prevent eye

problems. However, the professional group did not appreciate the benefits taking lutein and zeaxanthin as much as the service workers did; see Table 6 for details.

The professional group including doctors, lawyers, and certified public accountants in was characterised by better socio-economic status and better education. People with higher socio-economic status may have greater accessibility to and knowledge of health-related information, and therefore may perceive fewer barriers when performing a health-related behaviour including such as taking lutein and zeaxanthin, as shown in the current study.

Workplace

Environmental factors of the workplace and job features have significant impacts on the occurrence of eye diseases. Pharmacists generally suggest that jobs requiring frequent interaction with monitors significantly jeopardise workers' eyesight because of excessive exposure to blue light [4]. The results of the current study indicate that all constructs of susceptibility, severity, benefits, barriers, and behaviours varied by the type of workplace, as shown in Table 7. Of note are the people who work in pharmacies, who had a significantly higher perceived severity and perceived better benefit and lower barrier to lutein and zeaxanthin intake, and were more willing to take lutein and zeaxanthin.

Regression analysis

The overarching purpose of this research was to examine how the threat of blindness affects people's intention to take lutein and zeaxanthin supplements. According to HBM, this study identified susceptibility, severity, perceived benefit, and perceived barriers as independent variables, and the behaviour of taking a lutein and zeaxanthin supplement as the dependent variable. The results of the regression analysis are shown in Table 8. The model that integrated four predictors could explain 22.1 % of the variance in the behaviour of taking lutein and zeaxanthin supplements. The test results support hypothesis 3.

The perceived benefit of lutein and zeaxanthin supplementation appeared as the most powerful predictor ($\beta = 0.431$), followed by the perceived barriers in a negative direction ($\beta = -0.151$). Perceived susceptibility is a major source of threat, which plays the most important factor in exploring people's intention to take a lutein and zeaxanthin supplement.

Table 5: Variance analysis by demographic factors

Variable	1	2	3	4	5	6	7	8	9	10
Susceptibility	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	*	*	n.s.	***
Severity	n.s.	n.s.	***	***	***	***	***	n.s.	n.s.	*
Perceived benefit	n.s.	n.s.	n.s.	n.s.	***	*	***	***	n.s.	n.s.
Perceived barrier	n.s.	*	**	***	**	n.s.	***	**	n.s.	n.s.
Lutein behaviour	n.s.	n.s.	*	n.s.	*	***	*	**	*	n.s.

1 = Gender, 2 = Marriage, 3 = Age, 4 = Education, 5 = Occupation, 6 = Income, 7 = Place of work, 8 = Residence area, 9 = Nature of residence, 10. Eye diseases in relatives; n.s., non-significant, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6: Variance analysis by occupation category

Variable	Groups	n	Mean	SD	F	Sig.	Scheffe's	LSD
Severity	1	355	4.23	0.78	4.56***	.001	3>5	-
	2	89	4.33	0.88				
	3	122	4.43	0.75				
	4	153	4.31	0.76				
	5	356	4.11	0.91				
Benefit	1	355	3.57	0.61	6.51***	.000	4>1.2	-
	2	89	3.47	0.52				
	3	122	3.69	0.61				
	4	153	3.84	0.78				
	5	356	3.67	0.66				
Barrier	1	355	3.10	0.69	3.79**	.005	1.5>3	-
	2	89	3.08	0.48				
	3	122	2.85	0.65				
	4	153	2.98	0.78				
	5	356	3.08	0.68				
Behaviour	1	355	3.63	0.74	2.55 [†]	.038	n.s.	3>1.2; 4>1.2
	2	89	3.55	0.82				
	3	122	3.81	0.75				
	4	153	3.79	0.83				
	5	356	3.67	0.78				

$N = 1075$; 1. Office workers, 2. Government employee, 3. Professional, 4. General services, 5. None or others [†] $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Moderating effects

The literature generally suggests that action cues act as a moderator between the independent variables of threats, perceived benefits, and barriers and the dependent variable of targeted health behaviour. The current study included the amount of health information the respondents perceived in their decision-making regarding health-related behaviour. The test results are shown in Table 9.

The interactions between the independent variables and moderating variable show that the p -values were greater than 0.05 at 0.174, 0.186, 0.957, and 0.063, respectively. The magnitude of information received by the respondents as an action cue did not moderate the relationship between the predictors and the behaviour of taking lutein and zeaxanthin; hypothesis 4 was not supported.

DISCUSSION

The eyes are the windows of the mind. Severe

vision impairment that is eventually irreversible jeopardises quality of life forever, and consequently jeopardizes the patient's quantity and quality of connections with the world. Blindness or severe vision impairment may not be caused by infectious diseases in the developed and modern world, but the morbidity rate remains high. This is particularly true in the current living pattern that features overwhelming use of vision-based appliances. Lutein and zeaxanthin are major sources of eye health and help prevent vision impairment.

The current study showed that respondents were not very aware of the threat of severe vision impairment, no matter their sex, age, marital status, education level, occupation, or income level.

Despite the fear of blindness being significantly high, the effects of such dimensions on behaviour were small. Moreover, few respondents recognised the possibility of suffering such severe diseases. Thanks to advances in health technology and public health efforts in terms of health education and frequent

Table 7: Variance analyses by workplace

Variable	Groups	N	Mean	SD	F	Sig.	Scheffe's	LSD
Susceptibility	1	94	3.36	0.85	2.008*	.043	n.s.	6.7>3.5.9; 1>3.5
	2	90	3.35	0.83				
	3	179	3.13	0.90				
	4	115	3.20	0.82				
	5	266	3.14	0.86				
	6	89	3.40	0.89				
	7	71	3.40	0.97				
	8	44	3.20	0.81				
	9	127	3.14	0.90				
Severity	1	94	3.94	0.85	4.785***	.000	2.4>1	-
	2	90	4.48	0.72				
	3	179	4.23	0.85				
	4	115	4.43	0.78				
	5	266	4.31	0.76				
	6	89	4.08	0.84				
	7	71	4.09	1.11				
	8	44	4.36	0.59				
	9	127	4.09	0.86				
Benefits	1	94	3.49	0.62	3.952***	.000	4.6>3	-
	2	90	3.68	0.67				
	3	179	3.48	0.58				
	4	115	3.79	0.62				
	5	266	3.67	0.65				
	6	89	3.83	0.70				
	7	71	3.61	0.64				
	8	44	3.66	0.66				
	9	127	3.69	0.72				
Barriers	1	94	3.24	0.54	3.220***	.001	1.6>4	-
	2	90	3.08	0.56				
	3	179	3.00	0.61				
	4	115	2.84	0.70				
	5	266	3.05	0.71				
	6	89	3.22	0.68				
	7	71	3.04	0.67				
	8	44	3.07	0.70				
	9	127	3.00	0.83				
Behaviour	1	94	3.62	0.85	2.413*	.014	n.s.	2>3; 4>1.3.5.7
	2	90	3.82	0.72				
	3	179	3.55	0.67				
	4	115	3.86	0.72				
	5	266	3.66	0.78				
	6	89	3.79	0.85				
	7	71	3.53	0.82				
	8	44	3.67	0.75				
	9	127	3.72	0.81				

$n=1075$; * $p<0.05$, ** $p<0.01$, *** $p<0.001$. 1. NA, 2. School, 3. Hospital, 4. Pharmacy, 5. Office building, 6. Residence, 7. Outdoor, 8. Factory, 9. Other not specified

Table 8: Regression analysis in predicting lutein-taking behaviour

Model	Non-standardised		Standardised	t	p	Covariance	
	B. est.	SE	β			Tolerance	VIF
(Constant)	1.973	0.177		11.167	0.000	-	-
Susceptibility	0.082	0.025	0.092	3.282	0.001	0.916	1.091
Severity	0.026	0.025	0.028	1.024	0.306	0.966	1.035
Benefits	0.509	0.033	0.431	15.590	0.000	0.952	1.051
Barriers	-0.171	0.032	-0.151	-5.414	0.000	0.934	1.071

Dependent: Behaviour; $R=.471$, $R^2=.221$, $Adj. R^2=.219$, $F=76.093$, $d. f.=4/1070$

Table 9: Moderating effects of the amount of information

Parameter	Non-standardised		Standardised	t	p
	B Est.	S.E.	Beta		
Constant	3.678	0.021		175.422	0.000
Z_Suscep.	0.066	0.022	0.085	3.000	0.003
Z_Sever.	0.020	0.021	0.026	0.949	0.343
Z_Benefit	0.330	0.021	0.426	15.42	0.000
Z_Barrier	-0.119	0.022	-0.154	-5.44	0.000
Z_Info.	0.045	0.021	0.058	2.122	0.034
Suscep x Info.	-0.032	0.023	-0.039	-1.362	0.174
Sever. x Info	0.026	0.020	0.037	1.323	0.186
Benefit x Info.	0.001	0.022	0.002	0.054	0.957
Barrier x Info.	-0.043	0.023	-0.053	-1.864	0.063

vision checks, infectious disease is no longer a vital threat to eyesight. As in previous research, the current study indicates that perceived susceptibility is more powerful than perceived severity as an independent variable to understand this preventive health behaviour [16].

Although the country and society have devoted substantial efforts with multiple support systems to help the blind, the life of patients who have lost their eyesight is restricted to a specific area, for example, their homes, schools, and other particular places with special designs for their safety. Because blind people rarely appear in public, there is no vigilance of losing vision for healthy people. Healthy people tends to ignore the possibility of suffering such a problem. Lacking the effects of 'Seeing is believing' and 'Facts speak louder than words', the efforts of eyesight protection education are difficult to achieve the goals of proper use of vision-based appliances, particularly among the younger generation. To educate or persuade people to be aware of eye protection in their daily life remains an important challenge to the health promotion institutions.

Other than the proper use of vision-based appliances (e.g. smartphones), wearing sunglasses, and regular exercise, the intake of sufficient lutein and zeaxanthin from natural foods, health foods, or dietary supplements is perceived to be beneficial to eye protection. 'Perceived benefit' is the most powerful of the HBM dimensions in predicting the captioned health behaviour, instead of 'perceived barriers', as was noted by previous research [16].

Subject showed good levels (3.65 out of 5.0) of perceived benefits. This may be affected by the intensive advertisements produced by large suppliers of products that contain lutein and zeaxanthin, including dietary supplements and drinks. On the other hand, people perceived average levels of barriers to taking lutein and

zeaxanthin. Although the literature generally agrees that the 'perceived barrier' is the most powerful of the HBM dimensions across various study designs and behaviours [16], it was the second most powerful predictor with a moderate impact on behaviour, according to the current study. The reasons behind this may stem from widespread advertising as well as the broad distribution of dietary supplements. Lutein and zeaxanthin-based products in the form of dietary supplements or drinks are allowed to be sold in the market as general products and are not required to conform to the rigorous regulation needed for health foods or pharmaceuticals. Thus, they are available in almost all distribution channels such as drugstores, supermarkets, catalogue sales, department stores, and all kinds of online stores. Accessibility is high for the people in Taiwan. Although the selling prices of these products are varied across different providers, most of them are at acceptable levels. This means the cost is not a barrier to prevent the respondents from taking lutein and zeaxanthin.

It is interesting to note that the group of hospital workers perceived lower susceptibility and lower lutein and zeaxanthin benefits, and thus were less willing to take lutein and zeaxanthin to prevent severe eye diseases and blindness. Pharmacists, physicians, nurses, and medical technicians were broadly included as healthcare professionals. However, their perceptions toward blindness threats as well as the benefits and barriers of lutein and zeaxanthin were significantly affected by their place of work. This may come from the fact that the needs of their customers are different. Hospitals may offer a full line of healthcare services, including physical examinations, medication, surgery, physical therapies, nutritional advices, and other possible alternative medicines, whereas the pharmacies may only provide drugs as prescribed by the physician, or offer healthy foods or diet

supplements as extra nutrition in response to particular health problems.

Compared to patients who visit hospitals, customers at pharmacies have more specific demands for particular diseases. As a result, people who work in a pharmacy may become more medication-oriented. Another reason may be that the pharmacies are closer to the drug and health food markets, so the workers have better information accessibility.

The construct of perceived benefit of lutein and zeaxanthin was the most powerful predictor in the current research, similar to a study on vaccines review report of Europe, 1984 [16].

Lutein- and zeaxanthin-taking behaviour appeared to be at a satisfactory level as well. Since people perceive a small possibility of suffering severe vision impairment, the lutein- and zeaxanthin-taking behaviour received fractional effects from this threat. In other words, people buy and take lutein and zeaxanthin products because they believe the products are healthful to their eyes, not because they perceive a risk of losing their eyesight.

The moderating effects of information were not significant as a moderator on the relationship between the independent and dependent variables, as the literature generally suggested. This means that action cues in the context of this research were not working. This may stem from the prevalence of knowledge on vision impairment and lutein and zeaxanthin. Accessibility to knowledge of this kind is still low in the general public. Patients rely on professionals to support their healthcare decisions, such as pharmacists, nutritionists, or physicians. In the current research, the reliability of the information source may be more influential than the amount or frequency of the information.

Lutein and zeaxanthin as ingredients in dietary supplements were introduced to Taiwan in 2003, and as of 2016 there were some 700 brands of lutein and zeaxanthin products competing in Taiwan. For the purposes of marketing and competition, some other ingredients are also included in lutein and zeaxanthin-containing products to attract the consumer's attention. It is worth noting that some of these combinations may cause fatal drug interactions. For example, β -carotene is helpful to eye health, yet may contradict the effects when taken with lutein and zeaxanthin [19].

Limitations of the study

The current study has several limitations. It concentrated on a single theory, which is the first limitation of the study. Although the theory HBM is appropriate for this use and provided a good theoretical background for understanding a subject's lutein and zeaxanthin intake behaviour, alternative health behaviour theories were not included or discussed. Although HBM was accepted as the most appropriate theory in explaining disease-related behaviours, future studies may adopt alternative theories to enrich our knowledge on this particular issue.

As a second limitation, subjects of the current study were customers at pharmacies in Taiwan. This may prevent the generalisability of the research findings. However, pharmacies are a popular source for healthcare products in Taiwan, as well as for healthy foods and some groceries. We are confident that the subjects included in this research represent the Taiwanese customer since they were collected roughly in accordance with the population distribution.

Unlike some other studies that included the concept of self-efficacy as part of the theoretical background, this may be considered as a third limitation since this particular concept was not included. The concept of self-efficacy was not in the original HBM, and was borrowed from another theory to obtain a better explanation of some research. The purpose of this research was to reveal the functions of the respondent's perceived threats of a particular disease and the perceived benefits of and barriers to a preventive treatment, i.e. lutein and zeaxanthin intake. Self-efficacy was not under consideration. However, carefully interpreting the findings of the current research based on this theory is recommended.

CONCLUSION

The theory of Health Belief Model has a good capability to understand lutein and zeaxanthin-taking behaviour. The perceived benefit as a variable was the most powerful predictor of the captioned preventive behaviour, followed by perceived barriers in the reverse direction, whereas the perceived threats contributed comparatively lower.

Fear was usually adopted to attract a desirable behaviour in pharmaceutical marketing, but may not workable for lutein and zeaxanthin products. Educating people to accept effective treatments to protect their vision remains a major issue in

public health campaigns because people are not aware of the risks of severe vision impairment.

DECLARATIONS

Acknowledgement

The authors appreciate the helpful comments and suggestions of Dr Wen of the School of Medicine, National Chen Kung University, Taiwan, and Dr Ying of School of Medicine, I-Shou University, Taiwan. The research was approved by Tajen University for ethical purpose.

Contribution of authors

We declare that this work was done by the authors named in this article and all liabilities pertaining to claims relating to the content of this article will be borne by the authors. Contributions of the authors to this work are more or less equal.

Open Access

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided the original work is properly credited.

REFERENCES

- Bourne RR, Flaxman SR, Braithwaite T, Cicinelli MV, Das A, Jonas JB, Keeffe J, Kempen JH, Leasher J, Limburg H, Naido K et al. Magnitude, temporal trends, and projections of the global prevalence of blindness and distance and near vision impairment: a systematic review and meta-analysis. *Lancet Glob Health* 2017; 5(9): e888-e897.
- World Health Organization. Vision impairment and blindness. [cited 2019 May 1]. Available from: <http://www.who.int/mediacentre/factsheets/fs282/en/>
- Carpentier S, Kraus M, Suh M. Associations between lutein, zeaxanthin, and age-related macular degeneration: an overview. *Crit Rev Food Sci Nutr* 2009; 49(4): 313-326.
- O'Shea JG. Age-related macular degeneration: a leading cause of blindness. *Med J Aust* 1996; 165(10): 561-564.
- Liberty Times. Taiwan has highest rate of retinal detachment in the world. [cited 2019 May 1]. Available from: <http://news.ltn.com.tw/news/focus/paper/1134080> (in Chinese), 2017.
- Musch DC. Evidence for including lutein and zeaxanthin in oral supplements for age-related macular degeneration. *JAMA Ophthalmol* 2017; 132(2): 139-141.
- Wu J, Cho E, Willett WC, Sastry SM, Schaumberg DA. Intakes of lutein, zeaxanthin, and other carotenoids and age-related macular degeneration during 2 decades of prospective follow-up. *JAMA Ophthalmol* 2015; 133(12): 1415-1424.
- Eisenhauer B, Natoli S, Liew G, Flood VM. Lutein and Zeaxanthin—Food sources, bioavailability and dietary variety in age-related macular degeneration protection. *Nutrients* 2017; 9(2): 1-15.
- Abdel-Aal ESM, Akhtar H, Zaheer K, Ali R. Dietary sources of lutein and zeaxanthin carotenoids and their role in eye health. *Nutrients* 2013; 5(4): 1169-1185.
- Johnson EJ. Role of lutein and zeaxanthin in visual and cognitive function throughout the lifespan. *Nutr Rev* 2014; 72(9): 605-612.
- Ueda K, Fujimura S, Yanagi Y. The short-term effects of supplement containing lutein on macular pigment optical density, contrast sensitivity, and serum amino acid. *Invest Ophthalmol Vis Sci* 2014; 55(13): 5233-5233.
- Street A. Food as pharma: marketing nutraceuticals to India's rural poor. *Crit Public Health* 2015; 25(3): 361-372.
- Rosenstock IM (1974). Historical origins of the health belief model. *Health Educ Monogr* 1974, 2(4): 328-335.
- Gauthier J. The universal declaration of ethical principles for psychologists: Third draft. *International Union of Psychological Science, International Association of Applied Psychology, International Association for Cross-Cultural Psychology*. Retrieved May, 2008, 31: 2009.
- Rosenstock IM, Strecher VJ, Becker MH. Social learning theory and the health belief model. *Health Educ Q* 1988; 15(2): 175-183.
- Janz, NK, Becker MH. The health belief model: A decade later. *Health Educ Q* 1984; 11(1): 1-47.