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Mediators of Behavior Change in Intervention on Vitamins E and C Consumption Based on Protection Motivation Theory

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Abstract

Background: Studying the antioxidant vitamins consumption, particularly in high-risk groups such as factory workers with high exposure to toxic metals is emphasized. Few studies have investigated mediators in dietary interventions. Understanding the behavioral change mediators is important for indicating the most effective constructs of educational interventions. Aim: The purpose of this study was to determine mediators of vitamins E and C consumption behavior changing intervention based on Protection Motivation Theory for cement factory workers. Methods: Workers (N=140) were assigned to intervention group and a control. The content of intervention included lectures with power point presentation, group discussion, individual counseling sessions and educational pamphlets and booklets. Workers completed Protection Motivation Theory and Food Frequency Questionnaires at baseline, post-intervention, and at the six-month follow up. Results: Results showed that perceived severity, perceived vulnerability, intention and knowledge were mediators in the intervention group. This showed the efficacy and importance of these constructs as mediators of vitamins E and C consumption behavior. Conclusion: The results provided evidence that both educational intervention were successful in increasing vitamins E and C consumption through changes in the structures among cement factory workers.

Key words: Intervention, Vitamins Consumption, Protection Motivation Theory, Factory Workers, Metal Toxicity.

Introduction

Metal toxicity is one of the important environmental and clinical problems and remains a serious health concern today (Mohammadnabizadeh et al., 2012). Dusts of the cement industries include high levels of toxic metals and some toxic compounds. Some of these metals are known to be toxic and harmful for human health, even at low concentrations (Bermudez et al., 2010). Results of the previous studies that focused on the determination of the levels of metals in the blood of the cement factory workers, revealed that workers and the residents of the neighboring communities were at the risk of metals poisoning to which they were exposed (Babalola OO and Babajide, 2009, Salh et al., 2014). Continuous occupational toxic metals exposure can induce problems for the cardiovascular system, eliminative pathways such as liver and kidneys, gastrointestinal, immune, nervous and reproductive systems (K Das et al., 2013, Mohammadnabizadeh et al., 2013).

Recently, various studies have proposed the protective role of antioxidant vitamins such as vitamins C and E against toxic injury (Onunkwor et al., 2004, Zhai et al., 2015). Results of different reports showed that these vitamins can be useful as a prophylactic agents for metal toxicity, providing a convenient method of reducing metal poisoning, maybe by increasing the renal clearance and reducing the intestinal absorption of the metal, even when the occupationally exposed subjects were not removed from the source of metals exposure (Onunkwor et al., 2004, Zhai et al., 2015).

Micronutrient deficiency, particularly of vitamins, is one of the main problems of global health (Allen et al., 2006). Thus, there is a substantial need to increase knowledge of antioxidant vitamins, particularly in high-risk groups such as factory workers with high exposure to toxic metals. Nutrition education approaches attempt to urge people to purposely adopt healthier eating habits by increasing information about healthful diets (Shariatjafari et al., 2012). Education based on proper theory can increase the effectiveness of a behavioral intervention by determining which factors influence a behavior (Diep et al., 2014).

The Protection Motivation Theory (PMT) is a social-cognitive model that explains health related behavior change. PMT assumes that the intention (motivation) of safety behavior is influenced by two cognitive processes: coping appraisals and threat appraisals. Threat appraisal itself is influenced by perceived vulnerability: particular beliefs about the vulnerability to a special disorder, and perceived severity: beliefs about the outcomes of the disorder. Coping appraisals are influenced by self-efficacy: whether individuals suppose that they can perform the adaptive response and response-efficacy: whether they think a specific health

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practice will be influenced against the disorder (Tulloch et al., 2009, Floyd et al., 2000).

While it is common to mention a theoretical framework in different studies, few researches have conducted a mediation analysis to identify whether changes in diet were a result of changes in the theoretical structures and few studies have examined mediators in educational interventions (Calder et al., 2011, Dowd et al., 2016). A mediator can be explained as an intervening variable essential to complete the pathway from an intervention to the behavioral outcome (Lubans et al., 2008). Measurement of these change mechanisms is necessary for the systematic progression of dietary research because it allows researchers to show which constructs of an intervention provide to behavior change (Lubans et al., 2008).

PMT has been successfully used in predicting health and safety related behaviors in different research works such as smoking, nutrition, exercise, cancer prevention, breast and testicle self-examination and AIDS prevention (Floyd et al., 2000, Milne et al., 2000). However, the PMT literature has not been examined for vitamins E and C consumption for the prevention of diseases, in particular the protective role of antioxidant vitamins against toxic injury and this is the first study to examine behavior change mediators in educational intervention on vitamins E and C consumption among Iranian cement factory workers based on PMT over a 6-month follow-up.

Methods

Participants were randomly assigned using a random number table from a possible 300 (Munro, 2005). Cement factory workers were then divided into two groups: intervention group (n = 70) and control (n = 70). All workers provided written, informed consent and participation was voluntary.

Measures

The vitamins E and C intake were measured by using a Food Frequency Questionnaire (FFQ). The FFQ contained questions regarding a list of foods and a standard serving size for each commonly consumed by Iranians (Movahedi and Roosta, 2000, Mirmiran et al., 2010). Whereas Iranian Food Composition Table (FCT) is not comprehensive and complete, for some food items the United States Department of Agriculture Food Consumption Table (USDA)FCT was used, too. Workers were asked to report their frequency of consumption of a given serving of each food during the previous year on a daily, weekly or monthly basis. Portion sizes of consumed foods were converted to grams by using household measures (Movahedi and Roosta, 2000). Daily vitamins E and C consumption for participants were computed by Nutritionist IV software which was designed for evaluation of Iranian foods. Results were expressed as milligrams of vitamins E and C per day (mg/day).

PMT constructs were adopted based on previous food consumption behavior studies (Calder et al., 2011, Dowd et al., 2016). PMT constructs were assessed by to self-reported questionnaire. Self-efficacy was assessed by eight items. The 2 week test/retest reliability of the self-efficacy scale was $r = 0.77$ and the (α) was 0.90. Response efficacy was measured with eight items. The 2 week test/retest reliability was $r = 0.78$ and the (α) was 0.83. Perceived severity was measured with twelve items. The 2 week test/retest reliability of the perceived severity scale was $r = 0.89$ and the alpha coefficient (α) was 0.83. Perceived vulnerability was measured with seven items. The 2 week test/retest reliability of the perceived vulnerability scale was $r = 0.71$ and the (α) was 0.78. Intention to consume vitamins E and C was measured with one item asking participants about their intention during the next months. The 2 week test/retest reliability of the intention scale was $r = 0.69$ and the (α) was 0.88. Response-efficacy, self-efficacy, perceived severity, perceived vulnerability and intention were assessed using a 5-point Likert scale (from1 = strongly disagree to 5 = strongly agree). Participants' knowledge was assessed by thirteen items, which measured workers' capabilities to understand information about risk factors and antioxidant vitamins (α = 0.83). Possible responses were correct answers = 1 and incorrect or don't know answers = 0.

Interventron

The intervention was composed of eight sessions (two sessions per week). Each session took 30-45 minutes and consisted lectures with power point presentations, discussion, questions and answers, and the distribution of educational pamphlets and booklets. Education sessions focused primarily on increasing knowledge. Sessions also concentrated on changing related beliefs of response efficacy, self-efficacy, perceived vulnerability and severity. Lectures was about the benefits of vitamins for health, effects of vitamins E and C on reducing metals toxicity, introduce vitamins-rich foods and effects of toxic metals. The intervention targeted participants' perceived vulnerability beliefs by providing incidence rates for conditions such as different cancers, and perceived severity by highlighting the seriousness of the threat condition like heavy costs of disease treatment. Response efficacy was targeted by providing information regarding the role of vitamins in decreasing the risk of different diseases and metals toxicity, and also necessity of testing vitamins. Furthermore, attempts were made to increase participants' confidence in their ability to overcome obstacles and increase self-efficacy through goal setting, positive feedback and increased awareness of the benefits of a healthy diet consumption. In addition to group counseling sessions, participants received individual sessions based on baseline assessments (15-20 minutes each). These sessions helped workers to review their personal purposes and intentions as well as recognize strategies to overcome obstacles. The control group received no educational or counseling sessions but did receive the educational pamphlets and booklets after the final follow-up questionnaires were administered. Workers completed PMT and FFQ questionnaires at baseline, post-intervention, and at the six-month follow up.

Statistical Analysis

The data analyses were done using SPSS 24.0. Values were given in means and Standard Deviations (SD). To assess for mediation, intervention group were compared with the control group. Because product of coefficients test has good statistical power in small samples, it was used to measure mediation (Baron and Kenny, 1986). To indicate whether each construct was a mediator, the following steps identified were completed using regression models and controlling for baseline scores: 1) establish an association between the vitamins consumption and interventions; 2) establish an association between the hypothesized mediators and the interventions. Analyses were only conducted if the program had at least a marginally significant effect ($p < 0.1$) on the mediators; 3) establish if the mediators were associated to vitamins consumption: 4) define if the association between the vitamins consumption and treatment condition was considerably decreased when controlling for the mediators. The Sobel test was used to indicate if the decrement could be observed considerable (Sobel, 1982).

Results

Demographic characteristics for control and intervention group are displayed in Table 1. There were no significant differences between groups for demographic characteristics.

Table 1. Demographic characteristics of the workers in groups.

Demographic characteristics	Intervention	Control	*p*-value
Age (year), Mean (SD)	34.60 (4.50)	34.69 (4.78)	0.48
Education, Number (%)			
Under diploma	4 (5.71)	3 (4.29)	0.67
Diploma	29 (41.43)	30 (42.86)	
Bachelor science	25 (35.71)	25 (35.71)	
Master science	12 (17.14)	12 (17.14)	
Marital status, Number (%)			
Married	52 (74.29)	53 (75.71)	0.48
Single	18 (25.71)	17 (24.29)	
Working experience (year), Mean (SD)	9.21 (4.52)	8.09 (4.27)	0.24

SD: Standard Deviation.

At baseline, participants in the two groups reported similar amounts of vitamin C and E. Values for vitamins and PMT constructs are reported in Table 2.

Table 2. Specific values for pretest, posttest and change scores for vitamins and hypothesized mediators.

Variable	Baseline		6-month follow-up		Change scores	
	Intervention	Control	Intervention	Control	Intervention	Control
Vit C (mg/day)	10.07 (5.44)	9.54 (4.96)	21.65 (9.36)	9.87 5.04)	11.57 (4.43)	0.33 (1.53)
Vit E (mg/day)	0.87 (0.38)	0.87 (0.40)	3.47 (0.80)	0.88 (0.40)	2.60 (0.52)	0.01 (0.03)
PS	2.96 (0.51)	2.93 (0.50)	3.72 (0.47)	2.97 (0.51)	0.76 (0.30)	0.04 (0.19)
PV	2.46 (0.49)	2.47 (0.50)	3.67 (0.39)	2.51 (0.51)	1.21 (0.46)	0.03 (0.15)
RE	3.00 (0.52)	3.07 (0.45)	4.16 (0.44)	3.08 (0.45)	1.16 (0.36)	0.01 (0.04)
SE	2.47 (0.39)	2.46 (0.39)	3.45 (0.32)	2.54 (0.42)	0.98 (0.26)	0.08 (0.32)
K	1.34 (0.20)	1.38 (0.29)	2.67 (0.31)	1.40 (0.29)	1.33 (0.21)	0.01 (0.06)
I	1.59 (0.50)	1.60 (0.49)	3.87 (0.80)	1.64 (0.54)	2.29 (0.62)	0.04 (0.20)

Means reported and standard deviations in brackets. Vit: Vitamin, PS: Perceived Severity, PV: Perceived Vulnerability, RE: Response Efficacy, SE: Self-efficacy, K: Knowledge, I: Intention.

The first stage of mediation was to assess the effect of the treatment condition on vitamins consumption. When the vitamin change scores in the intervention group were compared to the control a significant intervention effect was identified, $F = 584.13$, $\beta = 0.90$, $p < 0.0001$ for vitamin E and $F = 85.82$, $\beta = 0.62$, $p < 0.0001$ for vitamin C.

The second stage was to test the association between treatment condition and changes in mediators in the intervention group (Table 3). Analysis of Linear regression showed that the intervention group reported increased knowledge, increased intention and increased response efficacy at follow-up. Moreover, there were statistically significant differences between control and intervention group for perceived vulnerability, self-efficacy and perceived severity in intervention group.

Table 3. Effect of treatment condition on hypothesized mediator variables in intervention group.

Variable	Beta	Confidence interval
Perceived severity	0.82	0.63-0.80
Perceived vulnerability	0.87	1.06-1.29
Response efficacy	0.91	1.06-1.23
Self-efficacy	0.84	0.81-1.00
Knowledge	0.97	1.27-1.37
Intention	0.93	2.09-2.40

Significances: $p < 0.001$.

The third stage was to determine the association between vitamins changes and the mediators' changes. Changes in knowledge, intention, response efficacy, perceived vulnerability, self-efficacy, and perceived severity were all related to vitamin C and also vitamin E changes, in the intervention group (Table 4).

Table 4. Effect of mediator variables on vitamins controlling for baseline in intervention group.

Variable	Vitamin C		Vitamin E	
	Beta	Confidence interval	Beta	Confidence interval
Perceived severity	0.66	7.98-11.74	0.75	1.98-2.66
Perceived vulnerability	0.68	5.37-7.72	0.79	1.36-1.77
Response efficacy	0.76	7.72-9.00	0.83	1.59-1.99
Self-efficacy	0.68	6.81-9.78	0.80	1.76-2.26
Knowledge	0.81	6.85-8.74	0.91	1.67-1.95
Intention	0.84	4.06-5.03	0.91	0.94-1.09

Significances: $p < 0.001$.

The final stage was to determine whether the association between the vitamins and intervention were attenuated after controlling for the mediators. Treatment conditions and hypothesized mediators were entered into the model of regression explaining changes in vitamins (Table 5). In the intervention group, perceived vulnerability satisfied the criteria for mediation as indicated by the Sobel test for vitamin C. Furthermore, intention was found to satisfy the criteria for mediation with the contribution of treatment reducing from $\beta = 0.86$ to $\beta = 0.57$, after its inclusion. Both knowledge and treatment condition were significant predictors of vitamin C and the Sobel test was significant, suggesting that knowledge satisfied the criteria for mediation. For vitamin E, both treatment condition and perceived vulnerability were significant predictors and the Sobel test was significant, suggesting that perceived vulnerability satisfied the criteria for mediation. Also, the Sobel test was suggesting that changes in perceived severity could satisfy the criteria for mediation. Intention was also found to satisfy the criteria for mediation with the contribution of treatment reducing from $\beta = 0.96$ to $\beta = 0.83$, after its inclusion.

Table 5. Sobel test for mediation in the intervention group.

Variable	a	S_a	b	S_b	z-Value	*p*-Value
Vitamin C						
Perceived severity	0.71	0.04	-1.84	1.10	-1.66	0.09
Perceived vulnerability	1.18	0.06	-2.48	0.80	-3.06	0.002**
Response efficacy	1.15	0.04	-1.78	1.08	-1.64	0.09
Self-efficacy	0.91	0.05	-1.74	0.96	-1.80	0.07
Knowledge	1.32	0.03	-5.04	1.74	-2.89	0.004**
Intention	2.24	0.08	1.72	0.60	2.85	0.004**
Vitamin E						
Perceived severity	0.71	0.04	-0.29	0.12	-2.39	0.02*
Perceived vulnerability	1.18	0.06	-0.36	0.09	-4.23	0.000***
Response efficacy	1.15	0.04	-0.57	0.11	-5.09	3.41
Self-efficacy	0.91	0.05	-0.08	0.11	-0.73	0.47
Knowledge	1.32	0.03	-0.94	0.18	-5.18	2.21
Intention	2.41	0.08	0.16	0.07	2.28	0.02*

a: raw (unstandardized) regression coefficient for the association between intervention and mediator, s_a: standard error of a, b: raw coefficient for the association b/w mediator and vitamin consumption, s_b: standard error of b. Significances: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Discussion

In this study, for vitamin E, intention, perceived severity and perceived vulnerability satisfied the criteria for mediation in the intervention group.

Intention is a key mediator of the association between behavior and threat and coping appraisal (Gu et al., 2013). Studies showed that threat appraisal and coping appraisal incorporate to form the intention, which serves as the theoretical mediator between cognitions and health protective behaviors (Gu et al., 2013, Plotnikoff et al., 2010). Relationship between behavior and intention was the most consistent and strongest relationship found in the meta-analysis (Tulloch et al., 2009, Plotnikoff and Higginbotham, 2002). Tulloch et al showed that intention mediated the relationship between self-efficacy, response-efficacy, severity, and exercise behavior based on PMT after 6 months follow-up in coronary artery disease patients (Tulloch et al., 2009). According to previous PMT research, intention had a significant role and strong predictor on behavioral changes (Calder et al., 2011, Sainsbury et al., 2013). Therefore, specific attention should be paid to it when designing intervention plans.

One of the other components of PMT is related to the individual's evaluation of the possible health threat, referred to as threat appraisal (perceived vulnerability and perceived severity). Together, vulnerability and severity increase the likelihood of performing protective behaviors (Dowd et al., 2016). Evaluation of the cross-sectional design with university students based on PMT indicated that the threat appraisal was significantly linked with the intention to consume Omega-3 and was found to mediate changes in behavioral intention (Calder et al., 2011). Due to the low level of participants' knowledge and perceived severity about vitamin E and also severe deficiency of this vitamin in the majority of participants (based on PMT and FFQ completed questionnaire before intervention), more educational sessions focused on discussing the importance of vitamin E consumption. Perhaps this was a cause to influence participants' perceived severity and the mediation role of it in intervention group.

For vitamin C, perceived vulnerability, knowledge and intention satisfied the criteria for mediation in the intervention group.

Based on completed questionnaires, participant's knowledge about toxic metals and protective role of antioxidant vitamins was low and insufficient. Studies showed that knowledge significantly influenced behavior and can play an important role on the proper performing of behavioral changes based on PMT (Li et al., 2011). According to various studies, face to face training is more effective to perform a behavior (Mahram et al., 2009). Perhaps, the higher effectiveness of face to face intervention and more emphasis on vitamin consumption in educational sessions, were the reason for the mediation role of knowledge in intervention group. These findings bolster the importance and significance of increasing the knowledge of protective behaviors to reduce the workplace risk factors. So, it is important to conduct further interventions to see how changes in knowledge levels can influence the PMT constructs and related behaviors.

Results showed that response efficacy and self-efficacy did not satisfy the criteria for mediation. This is difference from some previous research. For example, study of college students' healthy eating behavior according to the PMT, indicated that self-efficacy mediated the behavior change of fruits and vegetables consumption (McKinley, 2009). There are potential reasons for differences in our findings with other studies. First, these variables may not have been the most suitable mechanisms for mediation of vitamins E and C consumption behavior in this sample. Second, perhaps the instrument used to measure the PMT constructs and measuring the amount of vitamins consumption was insufficiently sensitive to detect the variability and hypothesized meditators. Moreover, assessment time points for each study can make effect on mediators. Also, the size of sample was not large enough to discover minor mediators changes, though the power calculation based on the Sobel test recommended that a size of 90 for samples was needed to determine mediation (Taymoori et al., 2014). Furthermore, design, setting (e.g., community, home, or university), theory, various intervention channels (e.g., face to face, telephone or tailored print materials) and statistical methods for each study can make effect on mediators and results of education (Lubans et al., 2008, Nabizadeh et al., 2018a). Consistent with studies to date according to the PMT components, response efficacy and self-efficacy were found to be the most influence on protective behavioral intentions (Plotnikoff and Higginbotham, 2002; Nabizadeh et al., 2018b). So, we cannot conclude that these variables are not important and considerable in preventive behaviors performance.

Some limitations also need to be mentioned for present study. The sample size limitations should be considered. Moreover, this study relied on self-reported PMT and FFQ questionnaire, which introduces the biased outcome possibility. Furthermore, we did not have access to blood samples to increase the accuracy of assessment for dietary vitamins. Therefore, conducting concurrent evaluation was not possible to measure the amount of vitamins consumed according to FFQ and blood samples. Despite these limitations, there are some novel points to which attention should be paid. It is the first nutrition–intervention study that examine mediators of vitamins E and C consumption behavior based on PMT among cement factory workers. According to the previously mentioned research on vitamin deficiencies, investigating deficiency among a high risk populations has greater potential for impact, so the scope of this research with cement workers without sufficient knowledge and with exposure toxic metals is important. One of the strengths of present study was the longitudinal follow-up of workers with testing at six months for PMT and FFQ questionnaire after the intervention to determine the effectiveness, stability, and durability of the nutrition education programmed. In addition, as well as the main constructs of PMT, knowledge was used to predict mediators for behavior of consume vitamins E and C. Increasing knowledge about using vitamins in a daily diet is important. Especially in a

sample of workers in deprived areas which have a lack of availability to information resources, making research very difficult. Moreover, there is not sufficient support from factory officials to educate workers and check for vitamin deficiency probability in them. Most workers did not know the values of their body vitamin levels so did not feel that they might have vitamin deficiency. Furthermore, measuring the behavior of vitamins consumption was objective in the present study.

We suggest future surveys with larger sample-sizes and diverse participants to allow the results to be extrapolated to a larger population. In addition, about data collection, it is recommended that a laboratory experiment of blood vitamins measurement be used along with FFQ in order to establish concurrent validity and to increase the accuracy in vitamin evaluation. Moreover, because there is some evidence that specified mediators may be more important at specific time points (Lewis et al., 2002) future studies should examine mediators at different times, including both short-term and long-term time points. Finally, factors including socioeconomic characteristics and cultural norms and their effect on food habits and vitamin consumption should be considered. Thus, with respect to future studies, a representative sample would be needed to confirm and support the results of this research. In addition, an examination of the influence of theory-based education on behavior and mediators about antioxidant vitamins consumption to prevent health problems and disease will provide useful and effective findings for health service and factories.

Conclusion

The results of study provide evidence that perceived vulnerability, intention, knowledge and perceived severity, satisfied the mediation criteria in the intervention group. This shows the importance of these structures for mediating vitamin E and C consumption behavior. Therefore, specific attention should be paid to them when designing intervention plans. However, an absence of significant mediating effects does not necessarily mean these particular components are not important.

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Declaration of Conflicting Interests

The Authors declares that there is no conflict of interest.

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