



# **Fruit and Vegetable Intake: Benefits and Progress of Nutrition Education Interventions- Narrative Review Article**

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## **Abstract**

**Background:** Sufficient intake of fruits and vegetables has been associated with a reduced risk of chronic diseases and body weight management but the exact mechanism is unknown. The World Health Organisation and Food and Agriculture of the United Nation reports recommend adults to consume at least five servings of fruits and vegetables per day excluding starchy vegetables. This review focuses on the importance of fruits and vegetables as well as the benefits and progress of nutrition education in improving intake.

**Methods:** For this narrative review, more than 100 relevant scientific articles were considered from various databases (e.g Science Direct, Pub Med and Google Scholar) using the keywords Fruit and vegetable, Nutrition education, Body weight, Obesity, Benefits and challenges.

**Results:** Existing data suggests that despite the protective effects of fruits and vegetables, their intakes are still inadequate in many countries, especially developing ones. Consequently enhancing strategies to promote fruit and vegetable intake are essential for health promotion among population. A number of reviews confirm that a well planned and behaviour focused nutrition education intervention can significantly improve behaviour and health indicators.

**Conclusion:** Despite challenges in nutrition education intervention programs, they are considered as a good investment in terms of cost benefit ratio. Rapid improvement in trends of nutrition education can be seen in many countries and majority of interventions has been successful in increasing fruits and vegetables intake. It is recommended that health professionals use multiple interventions to deliver information in several smaller doses over time to ensure improved outcomes.

**Keywords:** Fruit and vegetable, Nutrition education intervention, Body weight, Obesity, Benefit and challenges.

## **Introduction**

“Fruits and vegetables (F&V) are considered in dietary guidance because of their high concentrations of dietary fiber, vitamins, minerals, especially electrolytes; and more recently phytochemicals, especially antioxidants” (1). Various reviews have associated low intake of fruits and vegetables with chronic diseases such as cardiovascular diseases, blood pressure, hypercholesterolemia, osteoporosis, many cancers, chronic obstructive pulmonary diseases, respiratory problems as well as mental health (2- 6). Despite an increasing focus on the

health benefits of fruits and vegetables, their consumption is below the recommended intake among adults (7, 8). Therefore, considering how nutritional related health problems have risen drastically globally, it seems critical that formal nutrition education aiming to increase knowledge and fruits and vegetables intake be given priority in health education programs and health promotion. This review provides an insight into the importance of fruits and vegetables as well as the

benefits and progress of nutrition education in improving intake.

### **Importance of F&V in the diet**

Sufficient intake of fruit and vegetables (F&V) has been related epidemiologically with reduced risk of many non-communicable diseases. Currently, much interest are focused on the vital role of antioxidants which impart bright colour to F&V and act as scavengers cleaning up free radicals before they cause detrimental health effects (9). Moreover, fibers found in F&V have been shown to reduce intestinal passage rates by forming a bulk, leading to a more gradual nutrient absorption (10) hence preventing constipation. They can be fermented in the colon, increasing the concentration of short chain fatty acids having anticarcinogenic properties (11) and maintaining gut health. Several studies have highlighted the CVD risk-reducing potential of F&V whereby their intake were strongly associated with lower cardiovascular risk factors such as lower blood pressure (BP), cholesterol and triacylglycerol thus preventing premature cardiovascular disorders (2). Recently Habauzit et al. (12) reported that fruits containing a high amount of anthocyanins, flavonols and procyanidins, such as berries, grapes and pomegranate are effective at decreasing cardiovascular risk while citrus fruits and apples had a moderate effect on BP and blood lipid level. An increased consumption of carotenoid-rich F&V maintains the cholesterol level in blood since they reduce oxidative damage and cause an increase in LDL oxidation resistance (13). An increased consumption of cruciferous vegetables was also reported to cause a decrease in the risk of intestinal, bowel, thyroid, pancreatic and lung cancer (4).

F&V have also been suggested to prevent osteoporosis in adults mainly for their rich sources of calcium and other vitamins which are vital in bone health (3). The high fiber content of F&V may play a role in calcium absorption and reduce the 'acid load' of the diet (14) enhancing bone formation and suppressing bone resorption which consequently result in greater bone strength (15). Moreover, phytoingredients in F&V such as gooseberry, curcumin, and soya isoflavones have

shown to be protective against lens damage which occurs due to hyperglycemia (16) and certain flavonoids such as quercetin can prevent oxidative stress in the pathogenesis of glaucoma (17). Also, a high intake of F&V was inversely associated with the risk of COPD and respiratory symptoms (5). Higher total fruit and vegetable intake is also associated with lower risk of cognitive decline hence proved beneficial for mental health (6, 18). Based on available evidence, a clear relationship between F&V and diseases has been well established however no protective effect of overall fruit and vegetable intake (FVI) against lung diseases were found. Green leafy vegetables, rather than fruit, were suggested to have a genuine protective effect against lung cancer (19). Risk of proximal colon cancer, rectal cancer (20) and aggressive and non-aggressive urothelial cell carcinomas (21) are not associated with FVI and no protective role were seen on the risk of endometrial cancer in post menopausal women (22). The accepted recommendation is to consume a variety of F&V because studies demonstrate that a combination of F&V have more potential benefits rather than a single fruit or vegetable (23). However further studies are warranted.

### **Fruits and Vegetable Intake (FVI), Body Weight and Obesity**

Interestingly, phytochemicals in F&V have been found to act as anti-obesity agents because they may play a role in suppressing growth of adipose tissue (1, 24). Adiposity is closely related to biomarkers of oxidative stress and inflammation and a diet rich in F&V can modify these adiposity related metabolic biomarkers in overweight women (25). A recent study by Vilaplana et al. (26) demonstrated that *Carica papaya* and *Morinda citrifolia* exhibited high lipase inhibition which can be considered as potential options for the management of obesity and maintaining body weight. To date, the red varieties of *Allium cepa*, *Lactuca sativa*, *Capsicum annum*, *Brassica oleracea var sabellica* and orange-fleshed type of *Ipomoea batatas* appear to be the richest vegetables sources of potential anti-obesity phytochemicals that can control the initiation and development of obesity (27).

It is also understood that fruits and non-starchy vegetables are very low in energy since they contain high amount of water and fiber and can be consumed in a relatively larger amount contributing to increased satiety to maintain normal weight (28). Fibers also form a gel-like environment in the small intestine, resulting in reduced activity of the enzymes involved in the digestion of fat, protein and carbohydrates (29). Hence an increased FVI can help to ease weight loss and this can be achieved when F&V displace high-energy-dense foods such as saturated fats, sugar (30) so that the overall energy density of the diet is reduced (31). Additionally, fruits have been suggested to prevent obesity since they add up to dietary variety both between and within food groups and palatability to the diet which has been revealed to be an important predictor of body fat (32). However discrepancies exist with respect to F&V with high glycemic index carbohydrates that are related to a more immediate decrease in appetite and increase in food intake in the short term (33). High consumption of fructose in F&V is related to obesity in rodents but no effect has yet been demonstrated in humans (34). FVI in overweight and obese people is much lower than the recommendation since they tend to restrict intake of these F&V when trying to lose weight.

A significant relationship was observed between BMI and vegetable intake whereby overweight participants had lower intake of vegetables (35-37). This finding is consistent to that of Epuru et al. (38) who also found a clear trend between prevalence of obesity and low FVI. Furthermore given that fruits are often eaten raw but vegetables are frequently prepared by adding fatty substances (e.g. oil while frying) which reduce the low energy dense uniqueness of vegetables, nutritionists should be careful when promoting FVI among population because the idea may not work with all target population. For instance, the intake of vegetables is associated with a higher risk of obesity in Chinese adults due to use of oil for stir frying vegetables and this highlights the importance of choosing the right cooking methods (39). Interestingly, many studies report a decrease in body weight with increased FVI (40- 42). For instance, in a 10 year fol-

low up study, high FVI reduced long-term risk of weight gain and obesity among Spanish adults (43, 44) demonstrated greater weight loss from high vegetable intake when a high vegetable diet was compared with a control diet comprised of 'usual intake'.

### *Global Intake of Fruits and Vegetables*

According to World Health Organisation STEP-wise approach to surveillance surveys on chronic disease risk factors conducted in several African countries including Mauritius and in line with existing Food and Agriculture Organisation data, fruit and vegetable intake (FVI) levels were found to be below the recommended daily intake of 400g/person (45). With the current '5 A day' message, a large gap still exists between the recommended and actual intake and many worldwide are not receiving the quantity or variety of F&V that they should have (46, 47). Table 1 shows the mean fruits and vegetables intake (FVI) in selected countries.

Available data reveals that the average FVI is not positively linked to the status of the country since greater consumption can be seen in developing countries such as Uganda and PR China compared to developed countries such as Denmark, Germany, UK and France. Data from GEMS/Food cluster diet shows that in US, mean F&V intake is 189.30 g/day and 255 g/day respectively, and recently, adults were found to have F&V about 1.1 times and 1.6 times/day respectively (48). F&V are consumed in the amount of 146.81 g/day and 176.96 g/day respectively in Hong Kong accounting for a total of 324 g/day (49). 209 g/day and 228.6 g/day F&V were reported among adults respectively in Germany and recent German Health Interview and Examination Survey data report that women and men consume 3.1 and 2.4 servings of F&V per day respectively (50). Mean F&V were 179g/day and 133g/day respectively in Malaysia (51). Current data based from the Canadian Community Health Survey which measured the number of times participants consumed F&V, rather than the actual quantity consumed, reported that only 40.8% Canadians aged  $\geq 12$  years consume F&V 5 or more times per day (52).

**Table 1:** Fruits and vegetable consumption in adults in selected countries

Country	Year of updated data	Mean Fruit intake (g/d)	Mean Vegetable intake (g/d)
<b>Developed</b>			
Hong Kong ( SAR, PR China)	2010	146.81	176.96
Denmark*	2013	151.70	162.08
Germany*	2013	171.36	118.02
UK*	2013	130.02	97.86
France*	2013	136.56	145.15
US**	2015	189.30	255.00
Netherlands*	2013	102.36	127.79
Italy*	2013	90.83	150.81
Austria*	2013	163.58	89.52
<b>Developing</b>			
Malaysia	2012	179.00	133.00
India**	2015	158.20	105.70
PR China**	2015	222.10	262.80
Ghana**	2015	149.80	36.10
Ethiopia**	2015	114.70	51.20
Uganda**	2015	464.10	24.40
Samoa**	2015	441.00	9.10

\* Data from EFSA database, updated 2013 (53)

\*\* Data from GEMS/Food database, updated 2015 (54)

Likewise, The Healthy People 2010 report (8) stated that the trends in FVI over the previous decade were relatively flat and has not been able to meet the Healthy People 2010 goals. The latter targets increasing to 75% the proportion of persons aged  $\geq 2$  years who consume two or more servings of fruit daily and to 50% those who consume three or more servings of vegetables daily. Recently published Global Phytonutrient Report (55) reveals that to achieve the WHO recommendation, most adults should at least double their current intake of F&V worldwide. Many countries like France, Spain (56), US, (57) and Mauritius (58) follow the ‘5 A Day’ recommended guidelines. However presently, it has been reported that 5 servings a day are not enough since those consuming 7 or more servings of fruits and vegetables a day, are having more health benefits and prolonged lives [e.g. those who ate 5 to 7 servings of fruits and vegetables per day had a 36% lower risk of dying from any cause; 3 to 5 servings was associated with 29% lower risk while 1 to 3 servings was linked with a 14% lower risk] (59). Countries

like Canada, Australia, and Denmark have a recommendation in the range of 6 to 10 servings of F&V daily (60- 62). Since different countries are using different guidelines, the ideal recommendation of F&V is still being debated and there is need of a unified message to promote intake around the world.

#### *Requirement and strategies for nutrition education to boost FVI*

Nutrition education is defined as “any combination of educational strategies, accompanied by environmental supports, designed to facilitate voluntary adoption of food choices and other food and nutrition-related behaviors conducive to health and wellbeing”(63). Educational interventions to encourage Americans to improve their diets may prevent rising incidence of heart diseases and save health care expenditures (64). The high prevalence of nutrition-related chronic illnesses with obesity and overweight among the most challenging and steadily rising public health problems suggests that nutrition education needs to be a priority for

adults and nutrition educators must be knowledgeable about diet and disease relationships specific to the population (65). The scope of nutrition education is broader than just educating about nutrition in relation to personal health. It can cover a wide range of issues and topics such as an increase in quantity and quality of foods, ways of improving nutritive value of a diet, importance of sanitary food handling practices at home, in market, factories and institutions serving food to large numbers of people such as schools, hospitals and restaurants (66) hence ensuring food safety and reducing morbidity.

To meet current F&V recommendation, many countries have developed targeted campaigns and interventions to increase FVI to adequate level. Pollard et al. (67) monitored changes in behaviors regarding FVI in Western Australia before and after the "Go for 2&5" and found that most changes mainly in knowledge, attitudes, and behaviors concerning FVI took place after the campaign. In particular, respondents who correctly identified the recommended intake of F&V doubled indicating that health campaign with nutrition education as an integral component is fruitful. Resnicow et al. (68) also reported that an "Eat for Life program", a multicomponent intervention to increase FVI conducted resulted in a significant increase in FVI. These studies are consistent to that of Ammerman et al. (69) who reviewed the efficacy of behavioral interventions to modify FVI emphasizing on studies in North America, Europe and Australia and noted a significant effect in increasing FVI. Moreover, in an intervention using a general nutrition course, participants increased consumption of not only total F&V but also fresh F&V along with a significant decrease in intake of high energy density French fries (70). Bensley et al. (71) compared traditional nutrition education to that of an internet one and found that both required follow-up counseling to achieve FVI levels and in both interventions, those who were provided counseling consumed more vegetables, fruits and fruit juice. In order to achieve and sustain FVI at the recommended levels, intervention alone is not enough as it requires a combination of other approaches such as social marketing, be-

havioral economics approaches, and technology based behavior change models to ensure that required goals are met (72). The findings from previous reviews are interesting showing that most of the interventions lead to an increased consumption of F&V at least in the short term. However no such review has conducted a Meta analysis quantifying the effectiveness of the interventions. Few intervention reviews have been done to see whether nutrition education is effective. One of such review is that of Taylor et al. (73) who conducted a Meta analysis of various intervention studies whereby five of them reported significant positive changes in weight and BMI. Four studies had effective interventions targeting determinants of dietary intake and dietary behaviors and nutritional intake. However uncertainty do remains due to insufficient details provided for nutrition intervention protocols, inconsistency in approach of delivery and comparisons between delivery modes and content of information provided to participants between studies. Eyles et al. (74) found that tailored nutrition education was a promising strategy for improving the diets of adults over the long term but stated that future studies should ensure adequate reporting of research design and reduce the chances of false-positive findings via more objective measures of diet. Likewise tailored interventions were more effective than non-tailored interventions in improving the short-term dietary behaviors of participants whereby delivery of information in several smaller doses over time was more likely to improve effectiveness (75). Lara et al. (76) noted that nutrition education was a significant factor in increasing fruit and vegetable intakes and are therefore effective, sustainable in the long term and considered it to be of public health significance. Table 2 below summarises findings of some successful nutrition education intervention.

Overall nutrition education contributes significantly to a change in food and nutrition related behaviors but where many components are involved, it achieves positive results in some and negative in others. Guillaumie et al. (77) concluded that most psychosocial variables significantly increased in an intervention group exposed

to a nutrition education plan with the exception of vegetable intake. Assema et al. (78) found an intervention effect in saturated fat intake during the main meal and fruit juice consumption but not for daily intake of fruit and vegetables. Contento et al. (79) stated that “the reported effectiveness, or lack thereof, of nutrition education interventions in various studies depends on many factors, including the nature, duration, and power of the interventions and the degree to which the interventions were implemented as designed”. The author remarked that in order to assure the success of a nutrition education strategy, major implications need to be considered such as developing and testing instruments with each new target audience before any intervention study, it will then be feasible to make judgments about the effectiveness of nutrition education and impact of interventions on mediating variables would be understood.

Moreover, to be successful, nutrition education needs to be much more comprehensive than giving basic nutrition information. It should address food preferences and sensory affective factors; person-related factors such as perceptions, beliefs, and attitudes; meanings and social norms; and environmental factors (80). Effective nutrition interventions should have a behavioral focus that will reduce the targeted risk factors and comprise strategies that are developmentally and culturally appropriate (81). Barriers pertaining to health preventive behaviors along with the determinants of intake should be taken into account and solutions should be designed (67). For example, low income groups can be targeted to opt for cheap sources of F&V to meet the 5 a day demand (78). Where possible, consumption of tropical fruits should be encouraged and at the same time this will increase the profits of fruit vendors and that of the country at large. Men can be targeted through educational campaigns at work and through eye catching advertisement (73). The government can review tax on F&V and promote more display areas such as farmers markets and shops in most regions to increase availability (56). Involvement of stakeholders, ministries, and legislation at higher level can be thought-out concerning produce and distribution channel related factors as well as for food

labeling which are sometimes misleading and difficult to interpret (82). Furthermore, accounting for the high prevalence of diabetes with 387 million cases reported globally which is expected to rise to 592 million by 2035 (83) and with more than 1.9 billion adults having obesity problems (84), diabetes concept of not consuming certain fruits may lead to further health detriment. Research shows that diabetic people would benefit greatly from consuming a variety of F&V, which help to lower degrees of inflammation, to have better glycemic control, and reduce odds of diabetic retinopathy (85). Additionally, there is no evidence to support that fructose present in fruits under normal conditions has a negative impact on the glycemic control in Type 2 diabetes (86). However, the role of fructose and fruit sugars in the development of the current obesity and diabetic epidemic remains controversial and the general population including overweight and obese person should be given correct information. Nutrition intervention programs should aim healthy food habits including the consumption of F&V together with physical exercise aiming to reduce body weight and improve health status. Messages and interventions should be creative, engaging, supportive and inexpensive (87) with realistic goals ensuring that the Mauritian population, also type 2 diabetic and obese people understand the message of having fruits just as the general population, without fearing worsening of their glycemic control.

### *Challenges on nutrition education intervention programs*

Despite clear evidence on the benefits of nutrition education intervention, there are major challenges that are faced by nutrition educators. These are: a) realistic educational goals, b) thorough research designs, c) explicit theoretical bases, and d) valid and reliable measurements (88). Assuring effective communication skills of nutrition educators and the quality of nutrition education or behavior change interventions implemented is questionable (89). Quality assurance tools and validated guidelines targeting specific target population are uncertain (90). Monitoring and evaluation within inte-

grated programs does not always capture the impact on nutritional status sufficiently or in a timely manner to allow for improving implementation (91). Methodological challenge such as small sample size and mostly female respondents may prevent experimentally conclusive and sustainable evidence (78). Nutrition education is also influenced by several barriers (92- 95) and predisposing factors such as attitudes, beliefs, values, capacity, self-efficacy, individual differences (96) that need to be overcome. Thus, several drawbacks of nutrition education deserve attention.

## Conclusion

The relationship between FVI and reductions in risk for many major health problems is strongly supported in many research studies but the effects of F&V on plasma lipid levels, diabetes, and body weight have yet to be explored. Still, F&V are believed to be protective against adiposity and are considered as a potential treatment in the management of obesity. Despite their numerous health benefits, few countries fulfilled 400g daily requirement for FVI. Many nutrition education strategies have positively impacted on people's nutrition and health behavior yet there are many factors which need to be considered and challenges that need to be overcome when designing nutrition education strategies. To be successful, nutrition education needs to be much more comprehensive than giving basic nutrition information. Current focus is on the effectiveness of methods of information dissemination and validation of educational tools. It is important for nutrition educators to deal with dietary behaviors that are associated with specific diseases adapted to explicit target population. Nutrient-based information alone is inadequate. Most successful strategies have been the delivery of information in several smaller doses over time. Although promoting healthy lifestyles is a challenge, it can be realized by focusing on positive "to-do" behaviors, rather than on "not-to-do" behaviors aiming at increasing the percentage of people adopting healthier eating habits.

## Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Table 2: Summary and findings of some successful nutrition education interventions

Author, (Year), Location	Sample	Study groups	Follow-up	Outcomes	Results
Anderson (2001), USA (97)	N= 296	-Tailored (n= 148) -Control (n= 148)	6 months	- Fiber intake (g/1000 kcal) - Fruit & Vegetable intake (g/1000 kcal daily)	+
Resnicow (2001), France (68)	N= 861	-Comparison -Self help intervention with 1 telephone cue call -Self help with 1 cue call and 3 counseling calls ( motivational interviewing)	12 months	-FV intake ( servings/ day, by FFQ) change in FVI was significantly greater in motivational interview group than in comparison and self-help groups	+
Campbell (2002), USA (98)	N= 660	-Tailored ( n= 89) -Control( n= 93)	6 months	- Fruit intake -Vegetable intake ( servings/ day) Total fat ( g/day)	+ - -
Assema (2005), Netherlands (78)	N= 74	Intervention (n=35) Control (n=39)	1 month	Vegetable (g per meal) Fruit (pieces per day) Fruit juice (glasses per day) Saturated fat intake ( en % per meal)	- - + +
Gans et al. (2009), USA (75)	N= 1841	- Non tailored comparison (NT) (n=451) - Single Tailored packet (ST) (n=454) -Multiple tailored packet (MT) (n=474) - Multiple Re- Tailored packet (MRT) (n=462)	7 months	- Fruit & Vegetable intake (servings/day) -Fat intake (g/day) MT groups reported significantly higher FVI compared to other groups.	+ + -
Liu et al. (2009), China (99)	N= 410	Intervention ( n=154) Control (n=148)	6 weeks	Fruit intake (g/day) Vegetable intake(g/day) Soybean & products (g/day) Meat, poultry & Fish(g/day) Dairy (ml/day) Eggs (g/day) Grain/ Cereals(g/day)	+ + + + + + -
Guillaumie et al. (2012), Canada (77)	N=163	-implementation intentions (II) (n=36) - Self Efficacy ( SE) (n=47) - Combination of II + SE group (n=52) - control (n=28)	3 months	Fruit & Vegetable intake Fruit Intake Vegetable Intake FVI increased significantly in the II and II+ SE groups. Slightly larger increase was observed in II+SE group	+ + + +
Lopez et al. (2013), Spain (100)	N= 14	Control (baseline) Intervention ( week 16)	4 months	Energy ( Kcal/day) Protein (g/day) Carbohydrate ( g/day) Fat ( g/day) Saturated Fatty Acids ( g/day) Monounsaturated fatty acids( g/day) Polyunsaturated fatty acids( g/day)	+ + + - - + -
Shahril et al. (2013), Malaysia (101)	N= 380	Intervention (n= 205) Control (n=212)	10 weeks	Energy intake (Kcal) Carbohydrate (%) Calcium Vitamin C Thiamine Fruits (servings/day) 100% fruit juice (servings/day) Fish (servings/day) Egg (servings/day) Milk (servings/day) Dairy products (servings/day) Processed foods (servings/day)	+ + + + + + + + + + + +
Bhurosy et al. (2013), Mauritius (102)	N= 189	Intervention ( n= 98) Control ( n=91)	2 months	Calcium intake scores Self efficacy Knowledge scores Physical activity level Alcohol consumption	+ + + + +

Abbreviations: FV: Fruit & vegetable; FVI: Fruit & Vegetable Intake; FFQ: Food Frequency Questionnaire; +: positive intervention effect; -: negative intervention effect