Mini Review
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Vitamin C and obesity: problems and solutions

Abstract

Obesity, a largely intractable health condition with incalculable health and financial and social costs and ramifications remains an immense challenge to mitigate effectively. Multiple interventions to offset obesity, and to mitigate its negative impact, while studied and implemented for many years, have generally failed to eliminate this growing global epidemic. Alternately, interventions that can limit the onset of obesity, or help to reduce this where present, including efforts to contain pain, depression, and lack of energy, would appear of high significance. Studied for over 40 years, various anti oxidants are proving to be of possible adjunctive benefit in efforts to reduce excess weight, and associated inflammatory responses, pain, and depression that are encountered by overweight persons. This mini review discusses some findings regarding vitamin C or ascorbic acid, a key ingredient of fruits and vegetables, and whether more emphasis on ensuring adequate vitamin C intake has a possible role in attenuating selected correlates of the global obesity burden. Extracted from current literature, it is concluded that this is a field of significant promise, but one requiring more insightful research, multiple intervention approaches, and dedicated collaborators.

Keywords: ascorbic acid, childhood obesity, fruits and vegetables, intervention, obesity, vitamin C, treatment

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Overview

The health status of the American nation is generally declining in the area of chronic diseases such as heart disease, stroke, cancer, diabetes, arthritis and others, a situation deemed attributable in part to the poor health practices of the population in the context of eating and physical activity practices.[1–4] In particular, the youth of today are especially affected by one or more of the aforementioned health problems, such that it is safe to say that a fair proportion of children and adolescents attending school already have one or more chronic diseases linked to obesity,[5] and are hence prone to lower levels of academic achievement and the ability to concentrate and attend to one's studies.[6] Also, less than healthy students are likely to be absent more frequently than their healthy counterparts and may not be able to make up the gap their absence causes in terms of achieving desirable grades and academic outcomes. Teachers who have to take time to assist learners in poor health who miss classes or examinations may feel excessively stressed and suffer burnout from this additional task. Conversely, healthy students cost the community less money in the long run overall, because healthy students do not need extra health services, and can carry out the academic activities at a higher level than those who feel less than healthy or who are clearly in distress due to poor eating and activity practices.

More recently and importantly, many premature COVID-19 deaths were found to be associated with the presence of obesity,[7,8] and an increase in childhood obesity since the onset of the pandemic has been reported.[9,10] At the same time, obesity linked cases of opioid abuse, chronic pain, and depression - plus multiple inflammatory conditions have emerged at increasing rates.[11–13] Among multiple factors, one key factor contributing to obesity and its dire long-term individual and socioeconomic consequences is the low fruit and vegetables intake possibly coupled with the high availability of processed and fast foods with high fat and sugar constituents, along with an increasing trend towards sedentary lifestyles, even for youth.[4,14] At the same time, antioxidant defenses promoted by various whole foods may be depleted in the presence of obesity and other associated chronic diseases.[4] In particular, low fruit and vegetable intakes have been recently highlighted as one of the key risk factors attributing to global mortality in adults and possible obesity associated enhanced oxidative stress status.[4,15] In addition, it appears that while the childhood years are potentially a highly critical period during which eating behaviors and food preferences evolve, and could offer a practical window of opportunity for developing and fostering healthy eating practices that includes adequate fruits and vegetables, which may carry into adulthood, where it is more likely to be resisted, evidence to the contrary is widespread, and possibly explains the unprecedented rates of youth, and later life overweight and obesity rates.

This review specifically elected to examine and summarize if and how vitamin C or ascorbic acid, a powerful anti oxidant and a common component of many fruits and vegetables can contribute to the risk of excess weight and suffering in overweight cases, especially those who might already have a variety of comorbid health conditions-that are often associated with unbalanced oxidative stresses.[4]

Indeed, according to Hosseini et al.,[16] as well as Garcia et al.,[4] obesity has not only emerged as one of the major health threats worldwide in the past few decades, but is a condition associated strongly with cardiovascular events, type 2 diabetes, inflammation, asthma, sleep disturbances, gall bladder disease, and some types of cancer, even among young adults, and possibly school children, as well as the presence of a consistently low vitamin C status. At the same time, the appearance of these co-morbidities has been often related to an imbalance in oxidative stress processes, implying that perhaps antioxidant-based treatments could be considered as interesting approaches in efforts to possibly counteract obesity fat accumulation and its complications. It is also possible, that even though attempts have been made to develop vitamin C supplements, and fortified drinks, foods that can offset any prevailing or potential micronutrient deficiency, such as vitamin C, may prove helpful in efforts to both offset, as well as intervene upon obesity and overweight in the general population.[17,18]

This idea, although not novel, does appear especially worthwhile and possibly reasonably practical to pursue given that along with these multiple unquestionable negative health conditions that may

be associated with obesity, many may be worsened by the presence of vitamin C insufficiencies in their own right. In addition, evidence suggests vitamin C can help to directly counter obesity or overweight conditions, in a manner that is not inherently time consuming, and one requiring multiple resources, along with complicated and concerted long-term behavior changes and weight control recommendations and adherence strategies. In the absence of any cure for this condition with its predictable serious social and psychological ramifications, affecting virtually all ages and socioeconomic groups, and with only limited success in response to a variety of evidence based mainstream approaches, more emphasis on prevention or adjunctive strategies that can potentially be employed readily to control or mitigate one or more obesity correlates or consequences is strongly recommended.

As well, while commonly attributed in part to excess eating and poorly devised diets, and an energy imbalance due to sedentary behavior, unlike traditional epidemics, current evidence strongly implies the obesity epidemic cannot be defeated readily or solely without concerted efforts across multiple players and organizations to foster more sound food intake behaviors. While it is acknowledged that many have limited access to affordable, nutritious foods, challenges to encourage fruit and vegetable intake, where offered are commonplace, especially among youth.

That is, even when many barriers to food access prevail, for example through the use of low cost food carts and food stamps, there are many competing physiological as well as psychological barriers such as food preferences, lack of time, limited educational understandings, taste, and marketing messages that encourage alternate cheaper 'tastier and time saving' choices. Public health campaigns designed to reduce consumption of salty snacks, sodas, and other sugar sweetened beverages, and eat more healthily, while exercising often, are often less forceful and compelling in their delivery, scope and appeal compared to those offered by marketers of fast foods.

In short, and without doubt. having too high a body mass index, that is not impacted by traditional mitigation approaches or campaign slogans alone, and is commonly perpetuated by persistent harmful behavioral practices poses immense health risks to children, adolescents, and adults of all ages, as well as untold fiscal, social and emotional costs. These include, but are not limited to various degrees of:

a. Premature disability
b. Depression
c. Anxiety
d. Social isolation
e. Comorbid health conditions
f. Chronic pain
g. COVID-19 disease
h. Various addictions

Additionally, and as discussed by Ellula et al.,[13] obesity, defined as the accumulation of excessive fat may interfere with the maintenance of an optimal health state, while heightening the risk for cardiovascular diseases and others, and hence needs to be considered more thoroughly than is currently evidenced. In particular the benefits of vitamin C, a multifaceted molecule,[19] which protects against oxidative stress, while preventing or alleviating inflammation, among other desirable health benefits warrants consideration.

Reported to have a role in lipid metabolism,[20] the ability to foster improvements in obese-diabetic models, plus the lipolysis of adipocytes or fat cells, among other benefits,[4] it also appears that individuals with an adequate vitamin C status are able to oxidize 30% more fat during a moderate exercise bout than individuals with a low vitamin C status. On the other hand; vitamin C depleted individuals may be more resistant to fat mass than those who are not, as well as less active.[4]

Unfortunately, assuming these premises are valid, a systematic analysis of fruit and vegetable interventions for children under five years of age has shown dubious results,[21] even though fruits contain vitamin C are found to have anti-obesity properties[22] that can foster body weight reduction, as well as adipocyte numbers.[4] In addition, research shows some formula-based or bottle fed infants may be at risk for a vitamin C deficiency, as well as obesity.[23] This is very important because such as deficit may indeed be reversible as outlined by Ghosh et al.,[24] and Garcia et al.,[4] especially if fruits and vegetables are made available and are regularly ingested.

Objective

This introductory review was designed to examine the strength of the case for examining vitamin C in the context of efforts to understand the factors contributing to obesity and whether more could be done in the clinical realm to offset obesity and its multiple negative outcomes via efforts to increase vitamin C containing fruits and vegetables, rather than through the use of vitamin C supplements.

Methods

To achieve the review objectives, PUBMED, PUBMED CENTRAl, and GOOGLE SCHOLAR believed to house salient topical peer reviewed articles were searched. Key terms used included, *obesity, overweight* and *vitamin C/ascorbic acid*. No limitations were placed on document type or year of publication and while some articles may have been overlooked, an effort to select most of the salient published articles in these data bases was made. The ultimate goal was to broaden awareness of any link between vitamin C (ascorbic acid) and obesity that would be of clinical value. After an extensive search, all pertinent data were downloaded and carefully scanned and if relevant are presented in this overview solely in a narrative form, given the low number of well controlled studies or studies in general on this topic.

Results

In addition to the aforementioned points concerning obesity reiterated in numerous articles for more than 20 years [with more than 34,000 in 2021] already published in the first 8 months on PUBMED], are 845 articles are listed in total from 1980-October 2021 when using the key words, obesity and vitamin C, including those focused on treatment as well as prevention, vitamin C inadequacy and diabetes and metabolic disorders as related to obesity, inflammation and diabetes, COVID-19, and sarcopenic obesity. Of these, many show adverse outcomes not only in later life, but that childhood overweight or obesity during youth is increasingly common including cardiovascular and endocrine health impacts, mental health complications, high levels of psychological stress, social stigmatization, social exclusion, reactive depression, low self-esteem and peer rejection, along with low self-expectations, even if health status is not directly impaired.

As recounted by Mason D'Croz et al.,[25] globally, the population suffering from overweight and obesity now outnumber those with insufficient caloric intake. In addition, more than 2 billion people

are said to experience micronutrient deficiencies, attributable in part to, unbalanced diets, including overconsumption of some nutrients that are found to foster states of obesity, as well as states of premature mortality. Garcia-Diaz et al.,[4] who reported a very insightful and valuable set of understandings specifically concerning the micronutrient known as vitamin C or ascorbic acid in the context of obesity prevention and intervention almost eight years ago noted that the absence of an adequate vitamin C intake is consistently found to be negatively associated in humans as well as animal models with the onset and progression of several chronic health conditions such as hypertension, gallbladder disease, stroke, cancers, and atherosclerosis, as well as obesity. Moreover, among the possible beneficial effects of ascorbic acid on obesity-related mechanisms, data imply this vitamin may: (a) favorably impact adipocyte lipolysis; (b) adrenal glucocorticoid release; (c) glucose metabolism and leptin secretion of adipocytes; (d) states of hyperglycemia and glycosylation in obese-diabetic models; and (e) obesity provoked inflammatory responses.[26]

According to Wilson et al.,[18] vitamin C, an essential micronutrient in humans that must be taken into the body actively and principally through fruits and vegetables,[26] and one required for facilitating a number of important biological functions, including several co-enzyme functions[26] does not only have the capacity to foster weight reduction processes in humans if present in sufficient quantities, but can be shown to impact lipid metabolism[27] and to have an adipogenic effect on preadipocytes.[28] In contrast, the presence of an insufficient or low plasma ascorbic acid or vitamin C level is found to be positively associated with a possible excess deposition of body mass and an increased waist circumference,[29] among other negative health attributes. Parallel, but equally important evidence shows that persons suffering from type 2 diabetes, who are often obese, may have lower than desirable plasma vitamin C concentrations, when compared to those with normal glucose tolerance. Harnroongroj et al.,[30] also observed the presence of a significantly lower vitamin C level in cases defined as overweight or obese, compared to those of normal weight, hence it appears adults with a history of type 2 diabetes, and/or comorbid obesity, may not only have lower than desirable vitamin C levels, but may have greater vitamin C requirements than is currently acknowledged.

On the other hand, Thomas-Valdés et al.,[31] argue that inappropriate food behavior that contributes to obesity can in turn, induce vitamin deficiencies commonly found in obese individuals, especially water soluble-vitamin C. Calder et al.,[32] urge vitamin C assays be conducted in this respect because they argue that low-grade inflammation, a characteristic of the obese state, is strongly linked to the release of many inflammatory mediators believed to play a role in causing insulin resistance and other metabolic disturbances, but that could be offset by the presence of adequate vitamin C levels.[4]

Evidence does tend to show vitamin C can exert positive effects in human as well as animal studies,[4] and may do this by activating the peroxisome proliferator-activated receptor that regulates fatty acid β-oxidation.[33] In this respect, Lee et al.,[33] noted that a high fat diet coupled with ascorbic acid did reduce body weight gain, visceral adipose tissue mass, and visceral adipocyte size without affecting food consumption profiles in an animal model. Concomitantly, the researchers also found circulating ascorbic acid concentrations were significantly higher in those mice receiving vitamin C supplementation. These mice also showed increases in the mRNA levels of the peroxisome proliferator-activated receptor and its target enzymes involved in fatty acid β-oxidation in visceral adipose tissues. Similarly, hepatic inflammation, fibrosis, and apoptosis were also decreased during ascorbic acid-induced inhibition of visceral obesity, and serum levels of other harmful products such as total cholesterol levels were lower in those mice who received vitamin C supplements.

Another study by Kim et al.,[28] noted vitamin C to have a similar favorable adipogenic effect on 3T3-L1 preadipocytes, as well as having the potential to reduce body weight in humans. Using a rat model, it was shown that lipid accumulation in well-differentiated 3T3-L1 adipocytes showed a significant reduction when ascorbic acid was applied 10 days after induction of obesity, and reduced the rat's body weight as well as the subcutaneous fat layer after four weeks.

Research by Eslami et al.,[34] who studied the association between a variable known as the dietary phytochemical index and overweight/obesity in children, showed subjects in the higher quartiles of the index to have a significantly higher vitamin C profile, among other health promoting biochemical factors compared to those in the lower quartiles. Using multiple regression analyses, this group further showed that subjects in the highest quartile of the index also had a significantly lower odds of being overweight/obese compared to those in the lowest quartile. Pearson et al.,[26] too, found 50 year old adults in New Zealand with higher vitamin C levels exhibited lower weight, BMI and waist circumference, and better measures of metabolic health, including HbA1c, insulin and triglycerides levels, all risk factors for type 2 diabetes. Lower levels of mild cognitive impairment were also observed in those with the highest plasma vitamin C concentrations and plasma vitamin C levels showed a strong correlation with markers of metabolic health as well as cognitive impairment.

An allied report[35] showed that ascorbic acid is not only able to inhibit vascular remodeling, but also yields more effective weight loss than not when assessed in a controlled trial of mentally stressed overweight/obese men. Its presence was also linked to observed reductions in harmful oxidative stresses,[36,37] and supported other evidence of successful weight loss in the face of vitamin C ingestion when compared to a control situation.[38]

More recent mechanistic work[39] implies a compound known as Glucose Transpoter-10 which regulates adipogenesis does so via ascorbic acid-dependent DNA demethylation to benefit proper white adipose tissue development and protect mice against high fat diet-induced metabolic dysregulation. Ellulo et al.,[13] who examined the effect of vitamin C on inflammation and metabolic markers in hypertensive and/or diabetic obese adults found that vitamin C (500 mg twice daily) does have the potential to alleviate inflammatory status in hypertensive and/or diabetic obese patients, commonly elevated in the obese [32].

Other related research has shown:

I. Ascorbic acid dietary supplementation reduced body weight and the retroperitoneal and subcutaneous fat depots in cafeteria diet-induced obese rats, without affecting food intake.[40]

II. Fruit or vegetable intake decreased circulating levels of pro-inflammatory mediators such as C-reactive protein and tumor necrosis factor-α ($P < 0.05$) and increased immunity via the γδ-T cell population ($P < 0.05$) [16].

III. Zinc chelated vitamin C may be useful as a novel therapeutic agent for the management of diabetes and related metabolic disorders.[24]

IV. Vitamin C suppresses high fat diet-induced visceral adipocyte hypertrophy and glucose intolerance, partially by decreasing visceral adipose lipogenic gene expression.[41]

V. Treatment with ascorbic acid partially reverses lipid accumulation in mature adipocytes.[42]

VI. Local adiposity injections designed to induce apoptosis of adipocytes using an ascorbic acid derivative appears safe and effective method for eliminating subcutaneous abdominal fat.[43]

Konstantinidi and Koutelidakis[44] further stress the possible role of functional foods and their bioactive compounds as alternative way to promote weight management and prevent obesity and its metabolic consequences, including those containing vitamin C such as berries. The possible mechanisms that foster weight control and more optimal metabolism include its effect on lipid absorption, fatty acids beta oxidation, and satiety.

Caro-Sabido and Larrosa-Haro[45] who conducted a scoping review of studies on nutritional and educational interventions and physical activity in pediatric patients with non alcoholic fatty liver disease found nutritional counseling as one strategy that appeared efficacious in the treatment of this disease when associated with obesity in children and adolescents.

However, when prepackaged foods are consistently poor in quality, and fail desired standards, and may be addictive, it is hard to see how youth can escape possible situations of excess overweight and obesity unless parents make a concerted effort in this regard. Indeed, it appears 93% of all products with child-focused promotions and 73% of products without such promotions were classified in one study as "not permitted". At the same time, the proportion of foods defined as "not permitted" were significantly higher in products with child-targeted promotions, compared with products not targeting children, a trend observed in the context of most food categories.[46]

In short, a number of diverse perspectives can be seen to have been examined in the context of both efforts to prevent, as well as mitigate obesity in various populations, especially youth, where excessive adipose tissue is a well documented factor that compromises the functioning of multiple organs and body systems, adaptive immune response, and perpetuation of the chronic inflammatory response.[8]

The possible multidimensional psychological, and physical benefits conceptualized to occur in cases of excess adiposity and in the face of the intake of adequate vitamin C is shown in Figure 1.

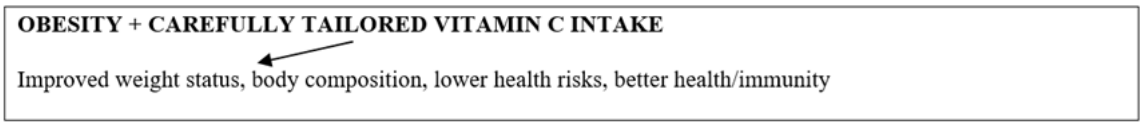

Figure 1 Schematic representation of possible benefits of adequate vitamin C serum levels and intake in cases of intractable obesity or those at risk for obesity due in part to poor food choices and food associated behaviors.

Summary and discussion

Obesity is not just being overweight. It is a metabolic disorder due to the accumulation of excess dietary calories into visceral fat and the release of high free fatty acid concentrations into that target various organs. Considered to represent a state of chronic oxidative stress and low-grade inflammation whose intermediary molecules may include leptin, adiponectin and cytokines., obesity may progress to hyperglycemia, and possibly to type 2 diabetes, and obesity exacerbation,[47] especially in the face of a persistent deficit in desirable plasma levels of vitamin C.[4]

That is, even though very limited research has been published on this essential life affirming molecule in the context of preventing excess body fat, and its consequences, its possible application for reducing obesity is a topic that appears to have considerable promise and merit, even if this is only deemed marginal.[47]

Indeed, alone or in combination with exercise and other strategies, it does appear that vitamin C ingested in its various forms in adequate amounts is likely to help rather than hinder efforts to limit or reduce excess weight, while promoting weight loss, as well as ameliorating inflammation and diabetes onset or extent, among other debilitating health issues.

As well, even though more research is clearly needed in multiple spheres wherein its application in the wider context of weight loss should be differentiated as this applies to different age groups and health conditions, the importance of assessing whether those at risk for obesity have low vitamin C levels or hypovitaminosis, a global deficiency or insufficiency found common in low- and middle-income countries and not uncommon in high income settings[48] and the degree to which this is deficient[49] must surely be relevant to consider in efforts to impact on childhood as well as adult obesity, as this is indicated to foster obesity in its own right[31] and to heighten the presence of central adiposity.[50] In addition, the presence of low vitamin C levels, does nor only appear to impact multiple body systems later on in life, but may be a key factor in mediating childhood overweight, inflammation, insulin resistance, and lipid metabolism,[49] while fostering a lower perception of stress during moderate exercise participation among obese persons.[51] On the other hand, it appears that the thoughtful selection of whole foods, specifically vitamin C associated fruits and vegetables with low glycemic content may help moderate, modulate, or counter one or more obesity associated adverse health consequences, such as excess tissue oxidation processes, and pain[52] as is increasingly supported by a fairly wide array of in vitro and in vivo studies that all point to its apparent efficacy to safely impact one or more obesity correlates, or fat cells of adipose tissue directly and effectively, presumably due in part to vitamin C as a source in these foods. Coupled with a recommended exercise schedule, and other needed possible behavior change strategies, its application among those obese cases who have mobility challenges, or are too intimated to attend the gym, or both, or have excess chronic pain and inflammation, may be especially helpful and may yet obviate the need for narcotics due to associated inflammatory mediators and persistent joint pain, plus psychotropic drug usage due to major depression and sleep challenges, plus bariatric surgery in those who are already quite ill, while increasing immunity and wound healing in the case of surgery. Its immediate use may be especially indicated in efforts to reduce COVID-19 risk and excess morbidity that continues to affect obese persons incrementally and more severely than not.

Yet Carr and Rowe[52] indicate a persistent and high prevalence of vitamin C deficiency in many countries continues to prevail, including high-income countries.[53] Largely attributed to the persistent ingestion of a poor dietary foods, including foods contributing negligible amounts of vitamin C to the diet, the authors argue that these facts

are not always taken into consideration during the setting of global dietary intake recommendations.

At the same time, even though whole foods, fruits, and vegetables, or antioxidant foods, recommended in this respect[32,47] may have a favorable impact in countering those any predisposition to obesity,54 as per Wood[55] diets in many parts of the world continue to be characterized by excess energy intake as well as regular consumption of processed or "fast" foods and limited consumption of fruit, vegetables, and whole grains associated with an increased risk of low grade inflammatory processes[32] and reduced levels of circulating plasma vitamin C as well as obesity.[56,57]

Based on past as well as emerging research data, it is hence hypothesized that consistent with this literature there will be a significant improvement in parent's and children's eating practices, as well as their physical activity practices as a result of a well considered multi-pronged efforts to maximize the participant's health status through increased fruit and vegetable consumption.

To this end, we would strongly encourage medical care providers and public health officials to consider the role vitamin C may play in the context of obesity prevention, and if deemed clinically sound to encourage and support its thoughtful usage where possible. At the same time, researchers are encouraged to pursue this possible line of inquiry so as to offer sustainable efforts to harness fruit and vegetable supplies and accessibility, and to examine the reasons behind the observation that even though fruit juice intake has fallen substantially over the past three decades, the vacuum has not been filled by a comparable increase in servings of whole fruit.[58] Moreover, concerns that 100% fruit juice may be associated with childhood weight gain or metabolic consequences that has not been supported by recent systematic reviews and meta-analyses should be examined in more depth as juice consumption may be particularly important vitamin C source among those with limited socioeconomic resources[58] and may lead to the consumption of fewer harmful beverages (for example, sugar-sweetened beverages).[59] Efforts directed towards limiting promotions of unhealthy foods to all children, and others are also needed.[46]

With so many obesity sufferers worldwide, and an unexpected increase in their incidence due to one or more ensuing and recent lockdown associated factors, food security, and economic challenges, and with no ready solutions to lessen this immense degree of burgeoning distress, research directed towards extending the current promising study findings applied sooner rather than later appear highly indicated as supported by Totan et al.[61] In particular, examining if simple steps to enhancing vitamin C containing vegetable and fruit consumption, or the use of vitamin C supplements has a bearing on weight control should be studied more intently in long term prospective studies, as well as short term studies. Examining the magnitude of effects of one or more of these strategies in various subgroups, may similarly yield important far-reaching and clinically relevant insights and salient ideas for addressing obesity and its immense toll on individuals, families, and society at large, including toddlers. The possible role of vitamin C in ameliorating vascular and mental health stresses among obese youth and others, shown to have promise, also warrants more scrutiny in our view.[61]

In the meantime, specifically stressing the functions of vitamin C and how failure to attain a consistent and desirable vitamin C serum level can possibly induce or perpetuate obesity and its correlates should be borne in mind by care givers, especially given its possible unexplored influence on the brain during brain development and beyond.[62]

Although Hodder et al.,[21] came to no definitive conclusion after reviewing 78 clinical trials, as discussed by Epstein et al.,[63] and McCarthy et al.,[64] collective solutions that may heighten vitamin C plasma levels to desirable levels, and lessen the risk of excess obesity or overweight through increased fruit and vegetable consumption, especially low glycemic fruits and vegetables, include, but are not limited to those listed below:

Systematic public policy and equitable political solutions[25]

Legal ordinances

Agricultural subsidies and sustainable farming practices

Evidence based environmental, nutritional, and pricing policies[65]

Personalized counseling, educational and nutrition based programs[66]

Cooking classes, culinary coaching, literacy and behavioral skills trainings[67]

e-health and m-health initiatives[68]

Financial incentives[69]

Food co-operatives[70]

Food labeling improvements

Programs that reduce/eliminate food insecurity/hunger

Programs reducing psychological barriers eg, boost self-efficacy/positive beliefs[67]

Programs fostering affordable convenient food access and economic support[71]

Feed infants whole foods-including a variety of fruit and vegetables

Concluding remarks

Obesity, a well established negative health concern in all spheres of the globe and in all age and health status groups, is increasing in prevalence and lethality due to its impact on COVID-19 and chronic pain, among other factors. With few immediate or satisfactory long –term solutions, and well documented challenges to reduce obesity once it prevails, all efforts towards, reducing this immensely costly largely irreversible problem warrant attention. Among the potential mechanisms for offsetting some degree of obesity, the role of vitamin C intake and persistent low intakes of vitamin C and other essential nutrients appears to have increasing merit in this regard. It is also an obesity correlate amenable to remediation, through sound educational approaches,[30] as well as a more conclusive research, and supportive public health policies directed towards affordable fruit and vegetable access, along with ordinances and rulings that enforce restrictions on the marketing and sale of counter-productive highly processed sugar, salt, and fat laden food products to minors, along with warnings on processed products. Indeed, recognizing the possible value of vitamin C in the realm of the pathogenesis of obesity and its prevention and treatment, is more likely than not to greatly help ensure the optimal wellbeing of untold numbers of citizens of all ages in all parts of the globe. It is hoped the current topical insights can hasten a concerted call to action in this regard before another generation is vicariously impacted across their lifespan from a possibly preventable and remediable antecedent.

Settings where more insightful point of purchase or related information and prompt sheets or videos may be helpful to disseminate include:

Child care settings, schools

Churches and community center settings

Health insurance companies

Hospitals, clinics

Non-profits, newsletters

Restaurants, fast food venues, food trucks

Supermarkets, corner grocery stores

Pharmacies

Public transport systems

Primary care and dental care settings

Neighborhoods

Social media/other media modalities

Worksites

In addition, the availability of fresh produce by means of community garden or farm to table projects should not be overlooked.[72]

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Conflicts of Interest

The authors declare that they have no competing interests.

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