Assessing the effects of vegetable consumption on the psychological health of healthy adults: a systematic review of prospective research.

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Vegetable consumption and psychological health

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Abbreviations used:

BMI Body Mass Index

F&V fruit and vegetables

RCT Randomised Controlled Trial

SD Standard deviation

WEMWBS Warwick-Edinburgh Mental Wellbeing Scale

WHO World Health Organisation

ABSTRACT

Background: To alleviate the immense health and economic burden of mental illness, modifiable targets to promote psychological health are required. Emerging evidence suggests that both fruit and vegetable (F&V) consumption may play an important role. However, the precise contribution of vegetable consumption, which may represent a more potent target than the consumption of fruit, has received little attention.

Objective: This review aimed to synthesize and evaluate research investigating the effects of vegetable consumption on mental health and psychological wellbeing in non-clinical, healthy adult populations.

Design: To provide insight into the causal relationship between vegetable consumption and these outcomes, only studies with prospective or experimental data were included. The survey of the literature was last implemented 1st February 2019.

Results: Ten eligible studies were identified with a total sample size of *n*=33,645, that measured vegetable intake separately from fruit, or combined this with fruit intake. Where studies explored the independent effects of fruit and vegetable consumption on psychological health (*n*=3), two reported a preferential effect of vegetables (vs. fruit) on psychological wellbeing, whereas one reported a superior effect of fruit intake on odds reduction of symptoms of depression. More broadly, there was evidence that consuming the recommended amount of F&V (and exceeding this), was associated with increased psychological wellbeing. However, the effects of F&V consumption on mental health symptoms were inconsistent.

Conclusion: Increased F&V consumption has a positive effect on psychological wellbeing and there appears to be a preferential effect of vegetables (vs. fruit) from the limited data examined. The effect of F&V intake on mental health is less clear, and at present, there is no clear data to support a preferential effect of vegetable intake on mental health outcomes. Hence, additional research is warranted to investigate the influence of vegetables, compared to fruit, on psychological health in order to inform nutrition-based interventions.

INTRODUCTION

Psychological health can be broadly conceptualised as comprising two key components; mental health (i.e. the presence or absence of mental health disorders such as depression) and psychological wellbeing (i.e. a positive psychological state, which is more than the absence of a mental health disorder), as supported by the World Health Organisation (WHO) (1). At present, depression accounts for 4.3% of the global burden of disease, however, the WHO predicts that by 2030, depression will be the leading cause of disease burden globally (2). Thus, for policy makers, clinicians, and a significant proportion of the global population, addressing mental health is a key public health challenge. Furthermore, high levels of psychological wellbeing have been shown to be protective of physical health and longevity (3). Therefore, enhancing psychological wellbeing may assist in reducing the healthcare burden of mental and physical illness more generally.

Recent evidence suggests that nutrition may be an important resilience factor against mental disorders, given that diet quality is consistently associated with mental health across a range of age groups (4, 5, 6, 7, 8, 9). However, if changes to diet can induce positive changes in mental health, what foods or food groups should be targeted? A growing body of evidence suggests that there is a link between fruit and vegetable (F&V) consumption and psychological health. For instance, results from a cross-sectional study using participants' health records, indicated that vegetable consumption is associated with reduced risk of depression diagnosis by a physician (10). More broadly, greater F&V consumption has been consistently associated with lower odds of psychological distress and major depressive disorder (11, 12, 13). Previous research has also demonstrated an association between habitual F&V consumption and psychological wellbeing (14, 15, 16, 17). Further, a series of cross-sectional studies have reported that high F&V intake is also associated with positive psychological health outcomes (18).

Given the difficulty in raising the consumption of F&V by the general population, it is worth considering whether F&V are equally associated with, and exert effects on, mental health and psychological wellbeing. A previous systematic review reported that F&V consumption are independently protective against depression (19). Suboptimal intake of micronutrients (folate and iron) found in green leafy vegetables is associated with mental health being perceived as

poor, and symptoms of depression (20, 21). Further, a recent meta-analysis identified the consumption of vegetables, but not fruit, was associated with depression risk (22). Thus, it is plausible that vegetable consumption may provide additional benefits to psychological health, than fruit consumption.

The aim of this systematic review was to identify, appraise and evaluate evidence from studies with prospective data investigating the effects of vegetable intake on the mental health and psychological wellbeing of healthy adults. There is a need for research to quantify and focus on wellbeing gains in non-clinical populations in order to go beyond the reversal of ill-being. The synthesis of the research aims to elucidate what is currently known, and what future research is required, to understand the influence of vegetable intake (independent of fruit) on mental health and psychological wellbeing. It was hypothesised that vegetable intake would have a superior influence on psychological health (vs. fruit). To identify the extent to which vegetable intake has an effect on these outcomes, the findings from studies where fruit and vegetable intake were each measured separately, and from studies where fruit and vegetable intake were measured as a combined construct, were examined and compared.

METHODS

Review registration

The review was registered with PROSPERO International and can be accessed online using the web address https://www.crd.york.ac.uk/PROSPERO and entering the following registration ID: CRD42017072880.

Literature search

The search strategy used three medical, health, psychiatric and social sciences databases. The first, Web of Science (all databases), is a research focused search engine that allows the user to search a number of subscribed databases in tandem. The subscribed databases available to Web of Science were: Web of Science Core Collection, BIOSIS Citation Index, KCI-Korean Journal Database, MEDLINE, Russian Science Citation Index and SciELO Citation Index. The second database utilised was Scopus and the third was PubMed. The search terms included vegetable* combined with psychological* and health. The search involved the topic (title, abstract and keyword) approach. All references were downloaded into the computerised

bibliographic program Endnote (Endnote citation) that facilitated the handling of the large numbers of publications obtained. The searches were last implemented on the 1st February 2019. The database searches yielded 2536 citations, with one additional article identified through hand searching the reference lists of relevant studies. After removal of duplicates, 1647 citations remained. Screening of titles or abstracts for relevance resulted in 161 papers being identified for full-text assessment. Additionally, one hand searched paper was identified. Of these, 152 articles were excluded; the outcome of the searches and reasons for exclusion are detailed in the PRISMA flow diagram (Figure 1). Ten full-text articles were included in the final analysis.

Study selection

This review included studies with healthy adult populations and the majority of participants were aged between 16 and 62 years of age. The healthy adult population were defined as participants without clinical characteristics and whom were not referred to as patients. Two community sample studies represented a wide range of ages. The first study involved participants aged 16 years and older, however, no upper age cut off was reported (23). The second study involved participants aged 16 years and older with some participants being 65-74 years old (8%) and 75+ years old (7%) (24). Studies that focused on older adults were excluded as the increased prevalence of health complications for older individuals might alter the influence of vegetable intake on psychological health. Also, studies involving children and adolescents (<16 years of age) were excluded because analysis of psychological health is difficult in this population. In addition, recommended F&V intake tends to be age-dependent, therefore, this review focused on the adult population. Studies involving clinical populations were also excluded because physiological changes due to health complications might confound the results. For example, studies involving primary care or cancer patients were excluded. There were no case-control design studies where healthy and clinical samples were compared that met the inclusion criteria.

To provide insight into the temporal association between vegetable intake and psychological health, only studies with prospective or experimental data were included. Studies that met the inclusion criteria were observational or epidemiological designs, including before and after, macro-longitudinal or micro-longitudinal studies, a randomised-controlled trial and cohort

studies. Cross-sectional studies, qualitative research, study protocols, reviews or proposals were excluded. Studies were included regardless of the use of a comparison group. Papers were excluded on the basis of their availability (access to the full paper was required) and language (only those written in English were included).

This review included studies that reported intake of vegetables independently of fruit, but also included those that combined vegetable with fruit intake. This was in order to compare the effect of vegetable consumption against combined F&V consumption. The review included intervention studies or those that measured self-reported vegetable consumption. The review did not include studies focussed on dietary patterns unless they were referred to specifically as a vegetable dietary pattern. This review only considered studies that evaluated outcome measures related to mental health or psychological wellbeing, however, given the large number of measures in these respective fields, individual measures were not prespecified as specific inclusion or exclusion criteria. Risk of suicide as an outcome was excluded because this was considered an extreme end point of mental health.

Data extraction

The review was undertaken using PRISMA guidelines (25). The details from all studies were organised by one review author (NT) and checked by the additional review authors (JT & CF). The data extracted included specific details about the study aims, duration, sample size, age, population, assessment or implementation of F&V intake, psychological health assessment tool, adjustment for confounders and outcomes of significance to the review question (as presented in Table 1). Due to the early nature of the research area, the limited number of studies available, and high heterogeneity between study methodologies, the risk of bias was not assessed and studies were not synthesized for meta-analysis.

Quality assessment

One of the authors (NT) and an independent researcher, separately coded the quality of the studies using an adaptation of Lievense et al.'s scoring system (26) that includes the questions applicable to prospective studies. Where scores differed, both coders discussed the items to reach full agreement. This quality checklist has been used in systematic reviews of diet and mental health in children and adolescents (27) and the association between diet

patterns and depression in adults (28). Therefore, it was deemed a suitable assessment of methodological quality for this systematic review. The methodological quality assessment of the included studies involved evaluation of the use of validated measures, outcome reproducibly, follow up time, withdrawals and variables adjusted for during data analysis. Each of the 11 criteria items were scored as follows: positive (1), negative (0), or unclear (?) with 100% representing a maximum possible score. Studies were defined as high quality if the total quality score was above the mean of all quality scores (69%). See Table 2 for the quality scores of the studies organised in descending order.

RESULTS

A total of ten studies were identified, one of which was hand-searched (29) with a total sample size of *n*=33,645. One study was a randomised controlled trial (RCT) involving an intervention to increase F&V consumption in young adults (30). Three of the studies were prospective cohort designs which analysed longitudinal health survey data retrospectively (31, 32, 33). Two of the studies were micro-longitudinal studies involving daily diary surveys within the young adult population (34, 29). These studies explored fluctuations in wellbeing as a function of daily F&V consumption by the same person over time (correlational analysis on a day-to-day basis). Two studies evaluated outcomes associated with community lifestyle change projects; the first examined a major government-funded community development initiative by analysing longitudinal data (23), the second involved a twelve-week healthy lifestyle intervention and was a before and after study (24). Two before and after studies changed eating behaviour by implementing a vegetable-focused diet (35) and a micronutrient-dense, plant rich diet and measured the outcomes (36). The majority of studies were published after 2013 (*n*=9, 90%).

Sample sizes ranged from fourteen adult participants (35) to a cohort study with 10,419 participants (23). Two of the reviewed studies examined a middle-aged cohort comprising women only (32, 33), seven studies were mixed with regards to gender and one study did not report the distribution (23). Three of the studies were conducted in New Zealand (29, 30, 34) and two involved data from the Australian Longitudinal Study on Women's Health (32, 33). Additionally, two studies involved UK based community samples (23, 24). The remaining studies were undertaken in Canada (31), the USA (36) and Korea (35). While two studies

were population-based (24, 31), there were some specific population groups investigated including: teachers (35), university employees with a BMI ≥ 25 (36), university students (29, 30, 34), residents living in deprived English communities (23) and middle-aged women (32, 33).

Assessment of vegetable intake

Three studies evaluated the effects of fruit and vegetables independently, one on measures of psychological wellbeing (34), the second on symptoms of depression (32) and the third on daily experiences of negative and positive affect (29). One study analysed the outcomes of dietary patterns including a 'cooked vegetables' dietary pattern, which included intake of cauliflower, cabbage, Brussels sprouts, broccoli and green beans (33). The RCT study (30) assigned participants to a F&V intervention condition in which two daily portions of fresh F&V (carrots, apples, kiwi-fruit or oranges) were provided that supplemented their normal diet. The comparison condition involved text-message reminders and a voucher to purchase F&V, both aimed to increase consumption. The control group maintained their normal diet. Another study (35) explored the effects of adopting a vegetarian diet, where: the supply of vegetable-focused foods was increased; educational sessions on vegetable-related nutrition were provided, and the consumption of processed foods was restrained to maximize the effectiveness of the vegetarian diet. The final study (36) involved the implementation of a vegetable-based, micronutrient-dense, plant rich diet (referred to as the Nutritarian diet). Participants were also encouraged to minimize the consumption of processed or refined foods and limit the consumption of animal products (due to the low intake of animal products a multi-vitamin was also encouraged). Both of these vegetable-based dietary interventions (35, 36) did not include the assessment or reporting of vegetable consumption or a control, comparison group. However, blood profiles were analysed in the vegetarian diet study (35) before and after for mineral contents of zinc, iron, B12, calcium and magnesium as biological proxies of food intake.

To assess F&V intake a variety of techniques were employed across studies, including: online daily diaries (29, 34) quantifying the portions of vegetables consumed using questions modified from the New Zealand Nutrition Survey (37); surveys accessed via smartphones (30); food frequency questionnaires (33); self-reported items of typical daily F&V intake

(24); independent questions of how many portions or pieces of vegetables and fruits were consumed per day (32); diet quality scores using one to five portions of F&V consumed per day as the indicator (23); and food frequency questions (31) taken from the Behavioral Risk Factor Surveillance System of the USA Centers (38). The time frame for these F&V intake measures were for habitual daily intake as portions, with the exception of one study (33) that used frequencies of foods consumed over the last twelve months to calculate a 'cooked vegetables' dietary pattern score measured twice with a three year gap between measurements, and two studies that did not measure self-reported F&V intake (35, 36). The studies that used online daily diaries or surveys accessed via smartphones required participants to recall daily F&V consumption for a duration of twenty-one days (29), thirteen days (34) or fourteen days (30). Further studies assessed F&V consumption twice, before and after a twelve-week lifestyle intervention (24), on two occasions two years apart (23) and three times at two year intervals (32). One study (31) assessed F&V intake every two years between 2002/2003 to 2010/2011 and the sample included participants with at least one assessment of F&V intake between 2002/2003 and 2010/2011.

Assessment of mental health

A wide range of measures were used to examine mental health; the most common aspect measured was symptoms of depression. Three studies (30, 32, 33) used the 10-item Centre for Epidemiologic Studies Depression Scale (39) to assess symptoms of depression. One study (30) also explored anxiety symptoms using the 7-item Hospital Anxiety and Depression sub-scale (40). Another study (31) explored depression status and major depression incidence using the Composite International Diagnostic Interview Short Form (41), supplemented with the Kessler Psychological Distress scale (42), which assesses the frequency of six non-specific symptoms of anxiety and depression. Another study (36) measured symptoms of depression using the Beck Depression Inventory-II (43). One study (35) used the Perceived Stress Questionnaire (44.). Another study examined a global indication of mental health (23) by using the mental health items from the Medical Outcomes Study Questionnaire Short Form 36 Health Survey (45) to quantify a self-rated mental health score.

Assessment of psychological wellbeing

Three studies applied specific measures of psychological wellbeing. One study (24) included the Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS) (46) which identifies affective and psychological functioning constructs of positive mental wellbeing. Another study (34) used the Flourishing Scale (47), which measures eudaimonic wellbeing and includes feelings of engagement, purpose and meaning in life. Eudaimonic wellbeing focuses on meaning and self-realization and defines well-being in terms of the degree to which a person is fully functioning as their authentic self (48). This study also measured daily affect through ratings of negative and positive affect states (in the form of adjectives) based on the circumplex model of emotion (49). While another study (30) explored psychological wellbeing using a shortened 3-item version of the Flourishing Scale (47). This was supplemented with measures of behaviours related to flourishing using the first item of the Curiousity and Exploration inventory (50), followed with a second item that measured creativity and a third that measured perceived motivation. These scores were combined to form an index of daily flourishing behaviours. Finally, one study (36) used The Quality of Life Index Generic Version-III (51) to measure quality of life in terms of satisfaction with life.

Symptoms of depression

One study (32) (quality score=73%) reported that eating the recommended amount of vegetables per day failed to prospectively predict the incidence of depression symptoms six years later. However, fruit consumption was significantly associated with reduced odds of symptoms in women who ate >2 portions of fruit a day, compared to those who consumed fewer. These findings do not support the hypothesis that vegetable consumption has a superior influence on mental health, nevertheless, they do support the notion that F&V exert different effects on mental health.

On the contrary, the RCT study (30) (quality score=82%) showed that a fourteen-day intervention involving the provision of mostly fruit (carrots, apples, kiwi-fruit/oranges) did not reduce symptoms of depression or anxiety relative to the control group. Even though daily reported F&V intake was significantly higher compared to the participants' baseline and the control group. Reductions in symptoms of depression associated with fruit intake may only be observed over a much longer period of time such as six years, as observed in the longitudinal study (32). Precise timescales, frequencies or quantities of vegetable

consumption may be required to observe the benefits on symptoms of depression but this cannot be explored without further data.

The dietary patterns study including a 'cooked vegetables' pattern (33) (quality score=82%) showed that after adjusting for sociodemographic and lifestyle factors, only the 'Mediterranean-style' dietary pattern was found to result in lower odds of reporting symptoms of depression by 17% three years later. Participants in the highest intake quintile of the 'Mediterranean-style' pattern were less likely to report subsequent symptoms of depression by more than a third (odds ratio 0.63, 95% confidence interval 0.47-0.85) compared with participants in the lowest quintile of intake. This study did not lend support for vegetables having a superior effect on psychological health; neither did it support an effect for fruit intake, as the 'cooked-vegetable' and 'fruit' dietary patterns were nonsignificant. Nonetheless, a 'Mediterranean-style' pattern was characterised by regular intake of garlic, peppers, mushrooms, salad greens, pasta and red wine, so vegetables may have contributed to the effects found. A further study (36) (quality score= 60%) found a significant reduction in symptoms of depression after the implementation of a vegetable-based diet for six weeks. However, participants attended weekly group meetings for support and encouragement and this social interaction may have confounded the results.

A longitudinal study (31) (quality score=70%) reported that combined greater F&V consumption during a data collection time point in 2002-2008 was associated with lower risk of depression at the next data collection time point two years later in 2004-2011. The significance of the association persisted when adjusted for covariates such as age, gender, socioeconomic status, education, previous time point depression scores and history of depression. However, the inclusion of confounding lifestyle factors of obesity, smoking status and social support in the model reduced the association to be nonsignificant. These findings imply that F&V as a combined construct is associated with symptoms of depression, however, health-related behaviours such as obesity and social support mediate the relationship. Habitually consuming F&V may increase positive health behaviours, which consequently contribute to lower symptoms of depression. As this study explored F&V intake as a combined measure, it is not possible to quantify whether there is support for vegetable consumption having a superior influence on symptoms of depression.

Stress and distress

One study (35) (quality score=64%) observed positive changes in stress levels after implementing a twelve-week vegetarian diet. The analysis of self-reported, perceived stress levels at baseline compared to week twelve showed a significant reduction (reduced to 19.57±9.68 points from 22.64±10.73). Concurrently, participants showed improved nutritional-status, demonstrated by significantly improved blood lipid profiles. This study did not quantify daily intake of fruit or vegetables, so effects due to portions of F&V cannot be defined. Furthermore, this study was conducted in Korea and the vegetarian diet implemented involved cultural specific foods, which may limit the transferability to other cultures.

Another study (31) (quality score=70%) identified that greater F&V consumption at a baseline time point was associated with lower distress scores two years later. This significant association remained when adjusted for age, gender, history of depression, education, socioeconomic status, chronic disease, binge drinking and obesity. However, when social support, smoking and physical activity were added to the model, the association was no longer significant. The findings indicated that social support was strongly associated with distress, depression and poor diet, including low F&V consumption. Thus, social support may also moderate the negative impact of low F&V consumption on psychological health. From the evidence presented, the strength and direct causality of vegetable consumption on stress and distress levels remain unclear.

Psychological wellbeing

Evidence from two micro-longitudinal studies provide some support for the hypothesis that vegetable consumption may be more influential in promoting states of positive psychological wellbeing than fruit. One study showed that when current mood was controlled for, vegetable consumption continued to predict psychological wellbeing, but fruit did not for between-person associations (34) (quality score=60%). Also, the strength of the associations were stronger for vegetable consumption ($r = .174$, $p < .001$) compared with fruit consumption ($r = .085$, $p = .89$). Another study found that both men and women benefitted equally from influences of vegetable consumption on psychological wellbeing, but not for fruit (29) (quality score=55%). Overall, even small increases in F&V consumption were associated

with enhanced psychological wellbeing.

Vegetable consumption also played a stronger role in changes to psychological wellbeing between and within individuals (34). It was found that on days when participants consumed more F&V they reported greater daily eudaimonic wellbeing (social and psychological wellbeing, also referred to as flourishing) and positive affect than on days when they consumed fewer F&V. The wellbeing relationship was within-day as no next-day lagged relationships were found. When daily changes in positive affect were controlled for, vegetable consumption continued to predict increases in daily eudaimonic wellbeing within individuals (fruit also predicted increased wellbeing when holding positive affect constant). Additionally, the consumption of vegetables was associated with lower negative affect, but this was not the case for fruit consumption. In summary, the between-person and within-person associations between vegetables and eudaimonic wellbeing were stronger when compared with fruit.

The other study (29) also applied multi-level modelling analysis to complete repeated daily observations nested within individuals to explore how psychological wellbeing fluctuated as a function of the foods consumed over time. The findings imply that F&V consumption similarly influence psychological wellbeing. On days when individuals consumed 0.15 more portions of vegetables and 0.11 more portions of fruit, they experienced higher positive affect, which included feeling calmer, happier and more energetic. These associations exceeded the adjusted significance threshold of $p < 0.005$. Secondly, lagged analyses revealed that on days when individuals consumed more portions of vegetables or fruit, they reported greater positive affect the next-day (while controlling for current-day fruit/vegetable consumption). However, this lagged finding was not replicated by the aforementioned study (34).

The predictor model findings indicated that for every one serving increase in vegetables or fruit (above the participants' habitual intake), positive affect increased by 0.028 or 0.029 points, respectively (29). From these findings, it was predicted that 5.7 additional daily vegetable portions (or 5.5 fruit portions) above habitual daily intake would produce meaningful increases in daily positive affect (reflecting a small Cohen's *d* effect size of 0.2).

Taking the participants' baseline daily F&V intakes into account (1.7 portions of fruit; 2.5 portions of vegetables), a daily intake of approximately 7-8 combined F&V portions is required for meaningful change to positive affect (alternatively 8.2 total daily servings of vegetables or, 7.2 total servings of fruit). These findings remained regardless of the BMI (Body Mass Index) of participants, however, while both men and women benefitted equally from vegetable consumption, the association for fruit consumption and positive affect (same-day and next-day) was significantly stronger in men than women. Notably, the reverse causality analysis was not significant; that is, positive affect did not predict vegetable (or fruit) intake. However, from the evidence discussed, it is not possible to conclude that the relationship is causal or direct because these studies did not involve experimental manipulation of F&V intake.

RCT studies have begun to address this gap; findings from the fourteen-day RCT study (quality score=82%) indicated that a relatively small increase in F&V consumption is associated with improvements in psychological wellbeing (30). This study showed that after providing young adults with F&V to consume regularly, significant psychological wellbeing gains were observed from consuming +1.2 more F&V portions a day from baseline, or, increasing consumption by 1 portion more than the control group (this study did not delineate separate F&V effects). In regards to effect sizes analysed using variance-explained effect size estimates of the time slopes, the F&V provision condition compared to the control predicted 10.5% of the variance in the growth in flourishing, 8.7% growth in vitality and 18.4% of the growth in flourishing behaviours (motivation, curiosity etc.).

The blood samples taken before and after the RCT intervention validated self-reported increases in F&V intake through increases in biomarkers (vitamin C and plasma carotenoids). However, the increases in vitamin C and carotenoids for the intervention conditions were well-below saturation levels (52), thus psychological wellbeing improvements could have been larger if a higher consumption of F&V had been achieved. The participants were low F&V consumers who typically consumed less than 3 portions of F&V a day. This daily intake is lower than that of the previous study sample, which identified that meaningful change in wellbeing, requires consumption of 7-8 daily portions of F&V (29). However, the RCT findings show that meaningful change to psychological wellbeing can be achieved through

approximately one portion increase in F&V intake per day. Participants still fell short of the 5+ a day F&V target (53) with F&V intakes of 3.7 portions per day for the F&V intervention condition compared to 2.8 portions for the control condition. More specifically, average daily portions were 2 for vegetables in the F&V condition versus 1.6 in the control, 1.8 for fruit in the F&V condition versus 1.2 for the control (52). However, the influence of F&V was only evaluated as a combined food category.

Another study (36) observed significant improvements in overall quality of life after participants completed a six-week nutrition intervention which included the daily consumption of green vegetables and fruits (a micronutrient-dense, plant-rich diet). However, it is not possible to disentangle the influence of vegetable consumption because participants also reduced their intake of refined/processed foods and animal products. In addition, they received social support through weekly group meetings and were encouraged to take a multivitamin containing B12, iodine, zinc and Vitamin D.

Lifestyle interventions and psychological health

Two studies involving a community-based lifestyle intervention measured F&V consumption as a combined food category, therefore, it was not possible to delineate vegetable consumption effects from fruit effects. Therefore, the hypothesis that vegetable consumption would have a superior influence on psychological health could not be examined. Nonetheless, both studies provide support for the influence of F&V on psychological wellbeing and imply that the effects are robust for positive psychological health outcomes.

The first study (24) (quality score=73%) examined changes in wellbeing associated with a twelve-week community healthy lifestyle programme, aimed at increasing F&V intake and physical activity. This study showed that increased F&V intake, independent from physical activity, explained some of the change in psychological wellbeing post-intervention and three months later. Changes in F&V intake accounted for the greater change in psychological wellbeing when compared with physical activity; a one-portion increase in F&V intake was associated with an increase of 1.26 positive psychological wellbeing units (measured by the WEMWBS). This was a clinically meaningful improvement even after adjusting for age, gender, physical activity and walking.

The second study (23) (quality score=70%) followed the same population over two years and showed that increasing F&V intake to improve diet quality (mediated by community-level projects) was significantly associated with an improvement in psychological wellbeing. This included less nervousness and reduced feelings of being 'down in the dumps'. The improvements were stronger for positive psychological wellbeing, including happiness and peacefulness. Improved self-rated mental health was associated with an increase in daily consumption of F&V, which only reached statistical significance for those with the greatest improvement in their eating behaviour. Therefore, large margins for change to F&V intake may be required to observe improvements in mental health. Together, this evidence suggests that by increasing F&V consumption over a short time period (3 months) or a longer time period (2 years) that associated improvements in psychological wellbeing will be observed.

DISCUSSION

This review identified a growing body of prospective research that has investigated the role of vegetable (and fruit) consumption in psychological health. Overall, beneficial effects of habitual vegetable and fruit consumption have been reported, with more consistent findings shown for psychological wellbeing compared to measures of mental health, including symptoms of depression, stress and distress. The results from the studies that focused on psychological wellbeing suggest that consuming more portions of vegetables is associated with higher positive affect, lower negative affect and greater eudaimonic wellbeing. Also, consuming more portions of F&V combined is associated with increases in psychological wellbeing, such as feelings of flourishing and vitality. There was also evidence to suggest a preferential effect of vegetable consumption compared to fruit for psychological wellbeing. This was shown by stronger, more robust associations and consistent benefits of vegetable consumption for both men and women compared to fruit consumption.

Increased vegetable consumption (independent from fruit or, combined with fruit) was found to have enhancing effects on positive states of psychological wellbeing after brief periods of time (13 to 21 days) and longer term (six or twelve weeks to 2 years). This included influences on eudaimonic wellbeing, feelings of flourishing, vitality, motivation, improved positive and negative affect, increased happiness, feeling more energised, calmer and

increased overall quality of life. Of the three studies that explored fruit and vegetable intake independently, two explored this in relation to psychological wellbeing and both reported that vegetable consumption increased psychological wellbeing (29, 34). Suboptimal intakes of nutrients found in vegetables, such as folate, have been suggested as a plausible mechanism to explain the relationship observed between F&V intake and psychological wellbeing (54). Folate consumption influences L-Methylfolate levels in the brain which modulate the synthesis of monoamine neurotransmitters serotonin, norepinephrine and dopamine (55). These neurotransmitters are robustly associated with mental health and various nutrients can affect these neurotransmitter levels (56). Alternatively, F&V consumption may lead to both the expectancy of psychological benefits and consequent improvements in psychological wellbeing. However, one study in this review found that psychological expectancies did not mediate the significant relationship between F&V and psychological wellbeing (30).

One question to consider is whether the magnitude of any observed effects are likely to be dependent upon baseline habitual consumption. This review identified evidence that increased F&V intake coincided with improvements to wellbeing in a clinically meaningful, dose-response manner per portion of F&V consumed. However, the levels of intake required for meaningful changes differed between studies, ranging from 3.7-7/8 portions. The low level of intake required for meaningful change was found in low baseline consumers (no more than 3 combined portions of F&V). This suggests that the margin for change is important; lower baseline intakes may yield stronger enhancing effects. This was also identified in the lifestyle change intervention study (23), where only participants who showed the greatest improvement to their F&V consumption experienced a significant improvement in self-rated mental health across the two year period. Previous research has observed substantial positive improvements in psychological wellbeing within a two year period when F&V consumption were increased from the lowest levels to the highest levels of intake (14). The higher level of F&V intake required for meaningful change are similar to Austalia's and Canada's recommended daily intake of 7+ portions (57, 58). Thus, the findings imply that regularly consuming close to recommended or higher levels of F&V, results in enhanced daily psychological health through subjective psychological wellbeing, and that greater improvements are to be gained when F&V intakes are particularly low.

The evidence to date suggests that a dose-dependent relationship exists between F&V consumption and psychological wellbeing. Previous cross-sectional research has observed this dose-response relationship by assessing how psychological wellbeing differs across different amounts of F&V intake (17, 18, 59, 60). Higher intakes of F&V are associated with increasingly higher positive psychological health scores. For instance, mean positive affect was found to have a positive linear trend with the number of daily servings of F&V (no association was found for negative affect) (59). This association remained statistically significant after the inclusion of demographic, diet and health behaviour variables. A very large increase in F&V (0 portions to 8+ portions) consumption was associated with approximately a 4-point increase (or .57 SD increase) in positive affect (reflecting a medium Cohen's *d* effect size). These findings correspond with the results from this systematic review and it is clear that the margins for increasing consumption are of significance.

The form in which F&V are consumed may influence the effect they have on psychological health. Recently, researchers have begun to compare the associations of raw versus cooked F&V consumption and the findings show that raw F&V consumption predicted reduced depressive symptoms and higher positive mood, life satisfaction, and flourishing (60). However, processed F&V consumption only predicted higher positive mood. In the RCT study identified by this review (30), the participants in the F&V intervention consumed the high quality F&V that they received mostly raw as snacks (approximately 72% of participants). No improvements to psychological wellbeing were observed in the condition that involved text message reminders to increase F&V intakes, despite similar increases to F&V consumption as the provision condition. In this condition, participants reported adding more vegetables to main meals (only approximately 27% of participants consumed raw). This was supported by the blood sample analysis that showed increased plasma carotenoids in the F&V provision condition, but not in the text message reminder condition. In support of this, food preparation has influences on the bioavailability of the micronutrients consumed (61). Hence, when F&V are consumed raw this may influence mental health and psychological wellbeing more strongly. Together these findings may offer some explanation for the mixed results in regards to mental health, as studies do not differentiate between raw or processed consumption. The types and processing of the F&V consumed are also important. To date, research suggests that the most influential raw foods related to improved mental health

include carrots, bananas, dark leafy greens like spinach and citrus fruits (60), and it is plausible that vegetable consumption may exert stronger influences on wellbeing than fruit through specific bioactive compounds (62).

This review highlights the need for future studies that test the consumption of fruit and vegetables separately, in order to explore possible differential effects on psychological health. Research tends to consider F&V as a combined food group as only three studies evaluated the effects of fruit and vegetables independently. However, the results showed that when measured separately, F&V appear to exert differential effects on psychological health. For instance, vegetables may be more strongly associated with psychological wellbeing. There is the need for future research to consider F&V as separate food categories in order to identify the contributions and most potent targets for psychological health. There was also a wide range of measures used to evaluate mental health across the studies, this reinforces the need for future research to use measures consistent with those previously applied. With further appropriate studies, a meta-analysis would be possible and would help to quantify the different effects across studies.

As this review excluded clinical samples it does not report the influence of vegetable intake as an accessible treatment for the management of psychological issues, however, it should be noted that increasing daily vegetable consumption through a 12-week RCT intervention has been shown to have therapeutic impact in a clinically depressed population by effectively reducing symptoms of depression (63). Further RCT studies that explore reductions in mental health symptoms and wellbeing gains in both clinical and non-clinical populations are called for. These should control for a range of health-related variables, for example physical activity and BMI. It is timely to search for wider, affordable and modifiable lifestyle behaviours that improve psychological health.

Conclusion

This review identified that increased F&V consumption has a positive impact on psychological health. The evidence suggests that vegetable consumption may be a more potent target than fruit consumption for enhancing psychological wellbeing and that interventions to increase psychological wellbeing gains should focus on populations where

baseline intake is particularly low. However, it must be noted that these conclusions are drawn from limited data. The effect of F&V consumption on mental health is less clear, hence, further work is required, particularly RCT studies that delineate the effect of fruit and vegetables. Overall, based on the limited evidence to date, vegetable consumption is relevant to psychological health and could contribute to lifestyle medicine as an affordable preventative public health care strategy.

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TABLE 1

Study information by study duration, sample, measures and results

Author, date of publication, country	Aim	Study duration	No. of participants, sex (%), age at recruitment, mean age (SD) and follow-up statistics	Population description	F&V intake measure	Combined or independent measure of F&V intake used	Psychological health assessment measure	Adjustment for confounders	Main findings	Statistical analysis & results	Conclusions
Blank (2007) (23). UK.	To explore the association between change in diet and physical activity rates and self-reported mental and overall health of residents living in deprived English communities.	Two years from 2002 to 2004.	11,377 16 years and older, mean age/ upper limit not reported, or sex % or SD *n*=10,419 during 2004 follow-up.	Participants were from community-based areas participating in the New Deal for Communities (a major government funded community development initiative). Sample included 958 comparator 'stayers'.	The quality of diet was rated from 1-5 based on the portions of F&V consumed per day.	Combined F&V intake, not analysed separately.	SF-36 mental health score. A combined measure of 5 items.	Gender, age, education, tenure (owner occupied), ethnicity, study area of residence (NDC or comparator), workless household 2002, SF-36 mental health score 2002, physical activity score 2002 and diet score 2002.	Improved diet and mental health associations were stronger for the more positive items: calm and peacefulness (adjusted odds ratio=1.36) and happiness (adjusted odds ratio=1.49). Improved diet was also related to reductions in nervousness (adjusted odds ratio=1.15).	Paired comparisons showed that improved self-rated mental health is associated with a better diet in 2004 compared to 2002. A worsening of self-reported mental health is associated with worse diet. These associations only reach statistical significance for those with the greatest improvement in their diet (2.71, p<0.01).	Significant associations were found between 'large' positive behaviour change in diet (increased F&V intake) and mental health.
Conner (2015) (34). New Zealand.	To test whether F&V consumption is related to eudaimonic wellbeing and eudaimonic behaviours.	Thirteen days in 2013.	405 young adults (66.7% female), 17-25 years old, mean age was 19.85 (SD=1.62). *n*=392 (6 dropped out; 7 completed fewer than 7 diary records).	Undergraduate student participants in the 2013 wave of the Daily Life Study, a large interdisciplinary study of health and emotional experiences of young adults.	An online daily survey using questions modified from the New Zealand Nutrition Survey (1997) was used to quantify F&V portions consumed that day (fresh, frozen, or canned vegetables not including juice or chips).	Analysed separately. Number of portions consumed per day were reported independently for F&V.	Daily eudaimonic wellbeing was measured using an adaptation of the Flourishing Scale (2009). Daily affect was measured through ratings of 9 adjectives of positive affect (PA) and 9 adjectives of negative affect (NA).	Gender, previous day wellbeing and previous day food consumption. Weekend effects were controlled in all lagged analyses.	Vegetable consumption predicted increases in daily eudaimonic wellbeing (p<0.001) after controlling for daily changes in PA. On days when participants ate more F&V they reported greater eudaimonic wellbeing and positive affect than on days when they ate less F&V. Consumption of vegetables, but not fruit, was associated with lower negative affect.	Multilevel modelling with a Hierarchical Linear Modelling software program. The model allowed analysis of food consumption and wellbeing covariance within an individual over time, controlling for weekday versus weekend effects. Next-day lagged analyses were conducted for all significant within-person associations between the food and wellbeing measures to test if consumption predicted changes in next-day wellbeing.	F&V additively contributed to positive changes in eudaimonic states, however vegetables played a stronger role. The within-person design shows that wellbeing fluctuated as a function of F&V consumption within the same person over time. It cannot be determined whether F&V caused the day-to-day changes to wellbeing.
Conner (2017) (30). New Zealand.	To test the psychological benefits of a preregistered clinical intervention to increase F&V consumption in young adults.	Fourteen days in 2015.	*n*=171 67% were female; 18-25 years old, mean age was 19.43 (SD=1.45).	Young adults from the undergraduate student population or members of a student employment agency.	Self-reported F&V intake via smart phone surveys. RCT design involving 3 conditions: provision of F&V, text message reminders to increase intake and a voucher to purchase F&V, and a diet as usual control. Fasting blood samples for Vitamin C and carotenoid levels were taken.	Combined measure and provision of F&V (including more fruit, carrots were the vegetables).	Centre for Epidemiologic Studies Depression Scale (CESD;1977), an Anxiety Subscale of the HADS (1983), 3-item measures of negative and positive mood, a 4-item vitality scale, 3-item Flourishing Scale and a psychological expectations survey.	Ethnicity and psychological expectations. Conditions were balanced in terms of gender, age and BMI.	Provision of F&V to consume but not reminders improved psychological wellbeing over the fourteen-day period. Only participants given the two weeks worth of F&V showed improvements in feelings of vitality, flourishing and motivation. Despite relatively small changes in F&V consumption in the provision condition (+1.2 portions from baseline).	ANCOVA with condition as the between-subject variable, time as the within-subject variable. Hierachical Linear growth curves to assess greater improvements in mood and wellbeing over time relative to the control condition. Neither vitamin C and carotenoids nor psychological expectancies mediated the F&V psychological benefits of consumption.	The effects of the intervention were prominent across measures of psychological wellbeing but not ill-being (depression, anxiety or negative mood).

TABLE 1 (continued)

Author, date of publication, country	Aim	Study duration	No. of participants, sex (%), age at recruitment, mean age, SD and follow-up statistics	Population description	F&V intake measure	Combined or independent measure of F&V intake	Psychological health assessment measure	Adjustment for confounders	Main findings	Statistical analysis & results	Conclusions
Johnson (2017) (24). UK.	To examine changes in psychological wellbeing associated with a healthy lifestyle programme.	Twelve-week intervention and three months of follow up between April 2011 and April 2012. Data was collected at three time points: baseline, completion at 12 weeks and follow-up.	307 81% were female. All ages were represented from 16 years to 75+ years. 25% completed follow-up three months after the intervention *n*=121.	Community sample in the West Midlands recruited through media publicity, GP referral, posters in the community centres etc.	Self-reported using items 'on a typical day, how much fruit and vegetables do you eat (dried, fresh, frozen, or tinned, one portion is the same as a handful). Responses were predetermined as 0 to 5+ portions.	Combined portions of F&V, not analysed separately.	WEMWBS that covers affective and psychological functioning constructs of wellbeing.	Models adjusted for gender, age, physical activity and walking.	Change in F&V intake (independent from physical activity) explained some, but not all of the change in psychological wellbeing associated with the intervention. F&V intake explained greater variance than physical activity.	Inferential analysis was conducted to identify change in WEMWBS over time, statistical significance and effect size of change.	Healthy lifestyle interventions could improve psychological wellbeing, and improvements can be partly explained by increased F&V intake. Improvements in wellbeing were sustained from completion to the 3-month follow-up.
Kingsbury (2015) (31). Canada.	To examine the associations between F&V consumption and depression across multiple time points and to test the reverse model: the association between depression at each time point and subsequent fruit and vegetable intake.	Every 2 years from 2002/2003 to 2010/2011.	*n*=8,353 47.21% male, 18 years and over, mean age 44.16 (SD=18.41).	Participants were from the National Population Health longitudinal survey.	Daily consumption frequency of fruits, green salad, carrots and other vegetables was assessed using questions from the BRFSS questionnaire**.** Juice and potatoes were not included.	Combined F&V intake, not analysed separately.	Major depression was measured using the Composite International Diagnostic Interview (CIDI-SF). Distress was measured using the Kessler Psychological Distress scale (2002).	Age, gender, history of major depression, education, income, chronic illness, binge drinking/ smoking status, obesity and physical activity.	Greater F&V consumption during a given cycle was associated with lower risk of depression and distress scores at the next cycle (when the model was adjusted for age, gender, history of depression, education, SES, chronic illness).	Generalised estimating equations regression models were used to model the associations between F&V consumption at each cycle and depression status/distress score at the next cycle. When the model for depression was adjusted for obesity, the relationship was no longer significant. When the model for distress scores was adjusted for social support, smoking and physical activity, the relationship was no longer significant.	Using a time-sensitive approach by adjusting for confounders at multiple time points, the relationship between F&V consumption and indicators of mental health were attenuated. Other health-related behaviours may have a more important impact on symptoms of depression than consumption of F&V.
Lee (2016) (35). Korea.	This study explored the effects of switching to a vegetarian diet (rich in F&V) on stress reduction, nutritional status and bowel habits.	Twelve week vegetable-focused diet adopted (April to July 2013).	*n*=14 teachers, 3 male, 11 female, age not reported. The study also included 26 adolescent students but their data was not included in this review.	School-based study.	The school dietician provided vegetable-based meals. The diet included vegetables (25.3%) and fruit (19.5%). Educational sessions were conducted to maintain the vegetable-focused diet habits at home outside of school times.	Self-reported F&V intake was not gathered.	Stress was measured using the Perceived Stress Scale (1983)	None stated.	The stress levels of teachers were substantially reduced to 19.57 (±9.68 points) from 22.64 (±10.73). Blood lipid profiles were significantly improved. The level of vitamin B12 increased significantly.	Paired t-tests were used to analyse the changes to stress levels at week 0 to week 12.	An improvement in stress levels coincided with the adoption of a vegetable-focused diet. Stress levels were significantly reduced after 12 weeks. Nutritional status measured by blood profiles and bowel conditions also improved.

TABLE 1 (continued)

Author, date of publication, country	Aim	Study duration	No. of participants, sex (%), age at recruitment, mean age, SD and follow-up statistics	Population description	F&V intake measure	Combined or independent measure of F&V intake	Psychological health assessment measure	Adjustment for confounders	Main findings	Statistical analysis & results	Conclusions
Mihrshahi (2015) (32). Australia.	To evaluate the differential effects of F&V intake in relation to depression and the temporal sequence of the possible association.	Two-three year intervals, over a 6 year period between the years of 2004-2010. Prospective cohort data was used from survey 4 in 2004, survey 5 in 2007 and survey 6 in 2010.	*n*=6,271 Mid-aged women, mean age was 55.45 (SD=1.45). 45-50 years old at baseline.	Mid-aged cohort of women participating in the Australian Longitudinal Study on Women's health (ALSWH).	F&V intake was quantified by the responses to two questions regarding quantity of portions consumed per day.	Number of portions consumed per day were reported and analysed independently for F&V.	Incidence of depression was defined by the presence of symptoms of depression measured by the 10-item CESD Scale (1977) at a survey and the absence of depression at the survey immediately before it. Prevalence of depression was defined as presence of depression at that survey, irrespective of the preceding survey.	BMI, educational attainment, marital status, smoking and alcohol status, physical activity, comorbidities, energy and specific nutrient intake from a FFQ.	Eating the recommended amount of fruit was associated with reduced odds for symptoms of depression. There was no clear effect of eating the recommended amount of vegetables per day on incidence of symptoms of depression. There was a cross-sectional association between vegetable intake and prevalence of symptoms of depression at higher levels of intake (equal to or greater than 5 portions/day).	The association between F&V intake and prevalence of symptoms of depression over three surveys was modelled using logistic regression with generalised estimating equations (GEE) to account for repeated measures. Longitudinal GEE modelling to determine the effects of FV intake on the incidence of depression.	There seems to be a differential effect of fruit and vegetable intake, which may not be additive, with fruit intake being more important than vegetables for symptoms of depression.
Rienks (2013) (33). Australia.	To investigate the association between dietary patterns and prevalence and incidence of symptoms of depression.	Three years from 2001 to 2004. Prospective cohort data was used from survey 3 and survey 4.	*n*=7,588 Sample for longitudinal analysis (no missing data). Mid-aged women aged between 45-50 years at baseline, mean age was 52.5 (SD=1.5).	Mid-aged cohort of women participating in the Australian Longitudinal Study on Women's health (ALSWH).	Dietary intake was assessed at survey 3 using a FFQ developed for use in Australian adults. Participants obtained a score for six dietary patterns, including a 'cooked vegetables' pattern (cauliflower, cabbage, sprouts, broccoli and green beans).	Scores for a fruit dietary pattern and a vegetable dietary pattern were explored independently.	Symptoms of depression were measured using the 10-item CESD scale (1977) at survey 3 and 4.	Energy intake, smoking, physical activity, ability to manage on available income, occupation status, education level, marital status, mean stress score and BMI.	No significant associations were found for the fruit or vegetable dietary pattern. Only an inverse relationship for the 'Mediterranean-style' dietary pattern was found and not attenuated after adjusting for confounders and symptoms of depression at survey 3.	Factor analysis to identify dietary patterns from the FFQ, longitudinal analysis to investigate symptoms of depression at survey 4. Multiple logistic regressions to estimate the association between symptoms of depression at survey 4 and each of the six dietary patterns, while adjusting for other confounders.	The consumption of a 'Mediterranean-style' dietary pattern (garlic, peppers, mushrooms, salad greens, pasta and red wine) by mid-aged women may have a protective influence against the onset of symptoms of depression 3 years later.
Sutliffe (2018) (36). USA,	To determine the impact and effectiveness of a micronutrient-dense, plant-rich dietary intervention on employee wellbeing when administered at the worksite.	Six-week nutrition intervention.	*n*=35 (pilot study) 91.4% female, mean age was 42.57 years old (range: 24-61 years).	University employees with a BMI ≥ 25.	Micronutrient-dense, plant-rich diet (Nutritarian diet) was implemented. This was a vegetable-based diet that emphasized daily consumption of greens, beans and legumes, variety of other vegetables, fresh or frozen fruits, nuts, seeds and wholegrains. Multivitamins were also encouraged.	Self-reported F&V intake was not gathered.	Symptoms of depression were measured using the Beck Depression Inventory-II and The Quality of Life Index Generic Version-III was used to measure quality of life in terms of satisfaction with life.	Dietary compliance, attendance and physical activity were explored in relation to change in outcome variables. To rule out physical activity as a confounder, participants wore an activity tracker during a seven day portion of the intervention.	There was a significant change in overall Quality of Life Index after the intervention. Significant changes were observed in the Health and Psychological subscales. There was a significant change/ reduction in mean depression scores after the intervention. Physical activity was not correlated with changes in the outcome measures.	Paired sample t-tests and a Wilcoxon Signed Ranks test were used to determine significant changes in the outcome measures before and after the intervention.	Improvements in overall wellbeing and mood may be due to the micronutrient-dense, plant-rich diet as well as a subsequent reduction in refined foods and animal products.
White (2013) (29). New Zealand.	To explore the relationships between daily negative and positive affective experiences and food consumption in a naturalistic setting.	Twenty-one consecutive days between April 2008 and August 2009.	*n*=281 55.4% were female; mean age was 19.9 (SD=1.2).	Healthy, young adults from the undergraduate student population.	Internet-based daily diary including five food consumption questions modified from standard questions in the New Zealand Nutrition Survey (1997).	Number of F&V portions consumed per day were reported and analysed independently.	Ratings of 18 adjectives, 9 negative affect adjectives and 9 positive affect adjectives. Averages for each were calculated.	BMI and gender as moderator variables.	On days when individuals experienced higher positive affect, they consumed 0.112 more portions of fruit (p=.002) and 0.147 more portions of vegetables (p<.001). These associations exceeded the adjusted significance threshold of p<0.005.	Multilevel modelling with a Hierarchical Linear Modelling software program to analyse how affect and food consumption co-varied within a given individual over time. Next-day analyses were conducted for all significant affect-eating associations to explore causality.	On days when individuals consumed more portions of fruit and/or vegetables, they reported experiencing greater positive affect the following day, while controlling for current-day intake. Reverse causality was not significant.

Note. SD, Standard deviation; F&V, fruit and vegetables; SF-36, Short Form Health Survey ; NDC, New Deal for Communities, a major government funded community development initiative; PA, positive affect; NA, negative affect; RCT, Randomised Controlled Trial; CESD, Centre for Epidemiologic Studies Depression Scale, BMI, Body Mass Index; HADS, Hospital Anxiety Depression Scale, ANCOVA, Analysis of Covariance; WEMWBS, Warwick-Edinburgh Mental Wellbeing Scale; BRFSS, Behavioral Risk Factor Surveillance System of the USA Centers for Disease Control and Prevention; SES, socioeconomic status; FFQ, Food Frequency Questionnaire.

TABLE 2

Methodological quality of included studies

Study	**Quality rating**	**Score**	**Percentage**
Conner (2017) (30)	High	9/11	82%
Rienks (2013) (33)	High	9/11	82%
Johnson (2017 (24)	High	8/11	73%
Mihrshahi (2015) (32)	High	8/11	73%
Blank (2007) (23)	High	7/10	70%
Kingsbury (2015) (31)	High	7/10	70%
Lee (2016) (35)	Low	7/11	64%
Conner (2015) (34)	Low	6/10	60%
Sutliffe (2018) *(36)*	Low	6/10	60%
White (2013) (29)	Low	6/11	55%