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Longitudinal Associations between Psychological Well-Being and the Consumption of Fruits and Vegetables

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Abstract

Background: Psychological well-being is associated with longevity and reduced risk of disease, but possible mechanisms are understudied. Health behaviors like eating fruits and vegetables may link psychological well-being with better health; however, most evidence is cross-sectional.

Purpose: This study investigated psychological well-being's longitudinal association with fruit and vegetable consumption across as many as seven years.

Methods: Participants were 6,565 older adults from the English Longitudinal Study of Ageing, which includes men and women ages ≥50. Psychological well-being was assessed with 17 items from the Control, Autonomy, Satisfaction, Pleasure (CASP) Scale. Fruit and vegetable consumption was initially assessed during 2006–07 and then approximately every two years through 2012–13. Covariates included sociodemographic factors, health status, and other health behaviors.

Results: Mixed linear models showed that higher baseline levels of psychological well-being were associated with more fruit and vegetable consumption at baseline (β=0.05, 95% confidence interval [CI] 0.02, 0.08) and that fruit and vegetable consumption declined across time (β=-0.01, 95% CI -0.02, -0.004). Psychological well-being interacted significantly with time such that individuals with higher baseline psychological well-being had slower declines in fruit and vegetable consumption (β=0.01, 95% CI 0.01, 0.02). Among individuals who initially met recommendations to consume ≥five servings of fruits and vegetables (N=1,719), higher baseline psychological well-being was associated with 11% reduced risk of falling below recommended levels during follow-up (hazard ratio=0.89, 95% CI 0.83, 0.95).

Conclusions: Findings suggest that psychological well-being may be a precursor to healthy behaviors such as eating a diet rich in fruits and vegetables.

Keywords

Psychological well-being; diet; nutrition; healthy aging; longitudinal; older adults

Acronyms

body mass index (BMI); confidence interval (CI); Control, Autonomy, Satisfaction, Pleasure (CASP); English Longitudinal Study of Ageing (ELSA); hazard ratio (HR); Health Survey for England (HSE); relative risk (RR); standard deviation (SD)

Introduction

Positive psychological well-being – hereafter referred to as psychological well-being – is a multidimensional construct that does not simply reflect the absence of distress, but rather represents the positive feelings, thoughts, and strategies of individuals who function well in their life and evaluate their life favorably (Boehm & Kubzansky, 2012). Key indicators of psychological well-being – such as life satisfaction, purpose in life, and optimism – have been linked with improved health outcomes. For example, methodologically rigorous prospective investigations and systematic reviews indicate that higher levels of well-being are associated with increased longevity and reduced risk of disease (Boehm & Kubzansky, 2012; Chida & Steptoe, 2008). Despite the accumulating evidence in support of psychological well-being's associations with physical health, the underlying mechanisms remain vastly understudied. Empirical evidence (Kubzansky & Thurston, 2007) and theory (Boehm & Kubzansky, 2012; Steptoe, Dockray, & Wardle, 2009) indicate that the health behaviors in which one engages may be possible pathways linking psychological well-being with improved health. That is, psychological well-being may encourage healthy behaviors such as regularly consuming fruits and vegetables or exercising, as well as discourage unhealthy behaviors such as smoking cigarettes. Experiencing high levels of psychological well-being may influence health behaviors by fostering successful goal pursuit (e.g., developing strategies to consume more vegetables in daily life), coping effectively with challenges (e.g., having frozen vegetables on hand when fresh ones are not available), and navigating between immediate desires versus long-term goals (e.g., choosing a side salad rather than French fries to meet one's goal of consuming more vegetables) (DeSteno, 2009; Rasmussen, Wrosch, Scheier, & Carver, 2006).

However, with a few exceptions (Kim, Kubzansky, Soo, & Boehm, 2017), much of the research concerning associations between psychological well-being and health behaviors has been cross-sectional (Boehm, Vie, & Kubzansky, 2012). For example, in one study of 72 undergraduate students, greater levels of happiness were significantly associated with greater consumption of fruits and vegetables (Ding, Mullan, & Xavier, 2014). Moreover, in large national cohorts of adult men and women, happier and more optimistic individuals consumed healthier foods like fruits and vegetables compared with their less happy and optimistic peers (Blanchflower, Oswald, & Stewart-Brown, 2013; Kelloniemi, Ek, & Laitinen, 2005). Although intriguing, such cross-sectional findings cannot establish whether well-being precedes and leads to healthier behavior, or vice versa. Several studies have examined whether eating fruits and vegetables leads to enhanced levels of well-being (e.g., Conner, Brookie, Richardson, & Polak, 2014), but for prevention and intervention purposes, it is critical to determine if psychological well-being precedes and leads to changes in health behaviors (Boehm, et al., 2012). If it does, then interventions that successfully increase psychological well-being (Bolier et al., 2013; Weiss, Westerhof, & Bohlmeijer, 2016) may also translate into improved health behaviors.

The current study investigated the longitudinal relationship between psychological well-being and the specific health behaviors of fruit and vegetable consumption. Eating a diet low in fruits and vegetables has been identified as a leading risk factor contributing to the global burden of disease (Lim et al., 2012) and increased risk of mortality (Wang et al., 2014). However, few longitudinal studies have examined whether higher levels of psychological well-being increase the likelihood of consuming healthy foods in daily life. Considering the studies to date that have examined this issue, findings suggest that psychological well-being may predict healthy eating behavior. For example, in a large cohort of postmenopausal women, higher baseline optimism levels predicted healthy dietary change one year later among women participating in a diet intervention trial (Hingle et al., 2014). Similarly, another study reported higher initial optimism in adolescents was associated with eating more fruits and vegetables over an average of 19 months of follow-up (Carvajal, 2012).

The present study builds on prior work comprised predominantly of cross-sectional studies or studies with limited follow-up time by considering whether baseline levels of psychological well-being are associated with higher fruit and vegetable consumption in both men and women over the age of 50 and across as many as seven years. Middle to older age was the primary focus because overall health tends to decline with age, and fruit and vegetable consumption tends to decline for people in their seventies (Imamura et al., 2015; Oyebode, Gordon-Dseagu, Walker, & Mindell, 2014). Although consuming healthy food in midlife is related to successful aging, predictors of healthy eating habits are understudied during this time of life (Britton, Shipley, Singh-Manoux, & Marmot, 2008; Samieri et al., 2013). This study sought to test the hypothesis that individuals reporting higher versus lower levels of psychological well-being would not only consume more fruits and vegetables, but would also be less likely to decrease their fruit and vegetable consumption across time. Following prior work in this area (Kelloniemi, et al., 2005), sociodemographic characteristics, baseline health status (including psychological distress), and other health behaviors were included as potential confounders of the hypothesized associations.

Methods

Participants

Data were drawn from the English Longitudinal Study of Ageing (ELSA), a nationally representative ongoing cohort study of the community-dwelling English population aged 50 and older. The sample for ELSA was recruited from households that participated in the Health Survey for England (HSE; an annual national cross-sectional health survey) in 1998, 1999, and 2001 (Steptoe, Breeze, Banks, & Nazroo, 2013). HSE households that contained at least one person 50 years of age or older who consented to be re-contacted in the future were eligible for inclusion in the ELSA sample.

The first ELSA interview (Wave 1) in 2002–03 included 11,391 men and women (Steptoe, et al., 2013). Follow-up interviews occurred in 2004–05 (Wave 2), 2006–07 (Wave 3), 2008–09 (Wave 4), 2010–11 (Wave 5), and 2012–13 (Wave 6); response rates ranged from 73%-82% across the waves (Steptoe, et al., 2013). To ensure that individuals in their early fifties continued to be represented in the ELSA cohort, refreshment samples of these individuals were added in Waves 3, 4, and 6. Participants were asked about their fruit and vegetable intake beginning at Wave 3. Thus, the analytic sample was restricted to individuals who: 1) responded to these questions at least once between Waves 3 and 6, and 2) had complete data on well-being and all other covariates at the Wave 3 baseline (excepting body mass index [BMI]; see below). The final analytic sample was composed of 6,565 individuals (see Figure S1 in Supplemental Material). Those who were included versus excluded from the analytic sample had higher baseline levels of well-being, were younger and more highly educated, earned higher incomes, were more likely to be white and never smokers, were less likely to report chronic conditions, and were more likely to report moderate or vigorous levels of physical activity (all p-values $<.0001$).

ELSA has been approved by various ethics committees, including the London Multicentre Research Ethics Committee. Informed consent has been obtained from all participants.

Assessment of Psychological Well-Being

Psychological well-being was assessed with items from the 19-item Control, Autonomy, Satisfaction, Pleasure (CASP-19) scale during each wave of ELSA. The CASP-19 was theoretically-derived and designed to broadly assess psychological functioning by measuring levels of control, autonomy, self-realization, and pleasure. It was originally created and validated in a sample of 264 older adults from the United Kingdom (Hyde, Wiggins, Higgs, & Blane, 2003). The CASP-19 is a summative scale with each item rated on a four-point scale describing how much each statement applies to a person’s own life (often, sometimes, not often, and never). The CASP-19 has demonstrated good internal consistency and construct validity both in the ELSA cohort and in other samples (Hyde, et al., 2003; Wiggins, Netuveli, Hyde, Higgs, & Blane, 2008). The CASP has sometimes been referred to as a quality of life measure. However, researchers often use the terms *quality of life* and *psychological well-being* interchangeably. Thus, some measures of quality of life actually assess psychological well-being. Moreover, the CASP-19 has many items that are similar to items used in other well-established measures of psychological well-being (Steptoe, Deaton, & Stone, 2015). For example, the item on the CASP “I feel satisfied with the way my life has turned out” is comparable to an item from one of the most widely used measures of subjective well-being, the Satisfaction With Life Scale (Diener, Emmons, Larsen, & Griffin, 1985): “So far I have gotten the important things I want in life.” Reflecting this similarity, the CASP-19 is strongly correlated (r=0.63-0.66) with two separate measures of life satisfaction (Hyde, et al., 2003; Sim, Bartlam, & Bernard, 2011)

To limit confounding of the association between psychological well-being and health-related behaviors, two health-related items were removed from the CASP-19 (“My age prevents me from doing the things I would like to” and “My health stops me from doing things I want to do") to create a 17-item scale from Wave 3 that was used in all analyses (Cronbach's alpha=.88). Nearly all participants had complete data on all 17 items (96%), but if 8 or fewer of the 17 items were missing, then missing values were replaced with the mean value of the non-missing items. Analyses considered CASP-17 as both a continuous variable (mean=37.6; standard deviation=7.65; range 4-51) and a categorical one (via tertiles based on the distribution of scores in the analytic sample) to assess the possibility of discontinuous effects (low ≤35, moderate >35 to <42, high ≥42).

Assessment of Fruit and Vegetable Consumption

During Waves 3 and 4, a series of questions assessed each respondent's fruit intake during the previous day by asking questions related to: (1) how much various sized fruits were consumed (handfuls of very small, small, medium, large, and slices of very large fruit), (2) how many tablespoons of various kinds of fruits were consumed (frozen or tinned, dried, or other mainly fruit dishes), and (3) and how many small glasses of fruit juice were consumed. The previous day's vegetable intake was also assessed with a similar series of questions that asked respondents how much salad was consumed (using a cereal bowl as the standard) and how many tablespoons of either vegetables or pulses (legumes) were consumed.

During Waves 5 and 6, however, the questionnaire changed and respondents were asked single questions about their fruit and vegetable intake. For fruit consumption, respondents were asked, "How many portions of fruit – of any kind – do you eat on a typical day? A portion of fruit is an apple or banana, a small bowl of grapes, or three tablespoons of tinned or stewed fruit. If you drink fruit juice, you can count one glass per day, but additional glasses of fruit juice do not count as additional portions." For vegetable consumption, respondents were asked, "How many portions of vegetables – excluding potatoes – do you eat on a typical day? A serving or portion of vegetables means three heaped tablespoons of green or root vegetables such as carrots, parsnips, spinach, small vegetables like peas, baked beans or sweet corn, or a medium bowl of salad (lettuce, tomatoes, etc.)."

To make fruit and vegetable intake more consistent across all waves, answers from Waves 3 and 4 were recoded to create summative variables that represented total daily fruit and vegetable consumption. Answers were recoded to correspond with the instructions from Waves 5 and 6 such that one portion approximates one serving size. For example, one small fruit was coded as being half a portion; further, one medium fruit, half a large fruit, and one slice of a very large fruit were all coded as being one portion each. One bowlful of salad was coded as being one portion. Every three tablespoons of either fruits or vegetables were coded as being one portion. The number of portions of fruits and vegetables reported during each wave were added together to create one overall variable that represented the total number of fruit and vegetable portions (i.e., servings) eaten during one day. Because there were some outliers for the total number of daily fruit and vegetables, this variable was winsorized to reduce skew (i.e., individuals with fruit and vegetable intake greater than the 99^{th} percentile were assigned the value for the 99^{th} percentile) and then standardized (mean=0, standard deviation=1).

Because the items used to assess fruit and vegetable consumption changed during the follow-up period, fruit and vegetable consumption was also considered as a categorical variable where participants were classified as either meeting or not meeting daily recommended servings of fruits and vegetables. Consistent with recommendations from the World Health Organization (World Health Organization & Food and Agriculture Organization of the United Nations, 2003), the U.K. National Health Service recommends consuming five or more servings of fruits and vegetables per day (Naska et al., 2000). As such, this was the cutoff score used for the categorical variable.

Assessment of Covariates

Baseline sociodemographic and health-related variables were self-reported at Wave 3, except for BMI (which was assessed by a nurse at Wave 4). Age was recorded as a continuous variable in years (to preserve confidentiality, ELSA data managers assign all participants over 90 years old the value of 91). Gender was categorized as either men or women (reference); race was categorized as either White (reference) or non-White. Socioeconomic status was assessed by educational attainment (university degree or equivalent, higher education but not university degree, A-level [high school equivalency based on national exam at age 18], O-level [national exam at age 16], or less than O-level [reference]) and total weekly income (used as a continuous variable). Marital status was categorized as either married or not married (reference); employment status was categorized as either currently working or not currently working (reference). The presence of any self-reported doctor-diagnosed cardiovascular diseases (angina, heart attack, congestive heart failure, or stroke) and non-cardiovascular chronic morbidities (chronic lung disease, asthma, arthritis, osteoporosis, cancer/malignant tumor excluding minor skin cancers, Parkinson's disease, Alzheimer's disease, and dementia or other serious memory impairment) was collected during the interviews. A health status measure was then derived to indicate whether each participant had one or more chronic disease versus none (reference). Doctor-diagnosed depression status (depressed or not depressed [reference]), cigarette smoking (current smoker, former smoker, or never smoker [reference]), and physical activity level (sedentary/low [reference] or moderate/vigorous) were also self-reported. Physical activity was assessed by one item that asked participants about the amount of physical activity in their job, as well as three items that asked participants to indicate how often they engaged in vigorous, moderately energetic, and mildly energetic sports or activities. ELSA data managers categorized responses (sedentary, low, moderate, and high levels of activity) to reflect classifications used in the Allied Dunbar Survey of Fitness (UK Activity and Health Research, 1992). BMI (kg/m^2) was clinically assessed during face-to-face nurse visits in Waves 2, 4, and 6; Wave 4 BMI was included in analyses. Because not all participants had BMI assessed during Wave 4, the analytic sample was smaller when BMI was included in statistical models (N=5,008 or N=1,443 depending on the specific analysis).

Statistical Analyses

Baseline (Wave 3) characteristics were examined across tertiles of the CASP-17. Mixed linear models then assessed the association between baseline CASP-17 scores and repeated assessments of fruit and vegetable intake over time. CASP-17 was entered into models as either continuous or categorical (tertile) values, and an interaction between CASP-17 and time was included. This analytic approach accounts for correlations among repeated measures across time within each subject, as well as variability between subjects. It also has the ability to handle unequally spaced intervals between observations. Coefficients for these models were estimated using maximum likelihood and a compound symmetry structure was used for the covariance matrix. A set of four models was evaluated. The first model adjusted for age, gender, and race (minimally-adjusted); the second model additionally included income, education status, marital status, and employment status (demographic-adjusted); the third model additionally included health-related confounders of doctor diagnosis of chronic conditions, depression, smoking status, and physical activity; the fourth model added BMI as a final step because analyses including BMI were based on a different analytic sample due to missing data. Given that healthier individuals may have been more likely to contribute data at subsequent waves, these models also used inverse probability weighting to account for missing data and potential bias in the analytic sample (Seaman & White, 2013). Weights were calculated from logistic regression models that included all relevant baseline sociodemographic and health-related variables.

The same set of models was used in Cox proportional hazards regression analyses, modeling the time to consuming less than the recommended amount (i.e., five servings) of fruits and vegetables each day among those individuals who reported consuming recommended amounts (five or more servings) at Wave 3 (N=1,719). The proportional hazards assumptions for the Cox models were met. Generalized Estimating Equations were also used to fit repeated measures logistic regression models (with the Poisson distribution due to the relatively common outcome). These analyses examined the association between baseline CASP-17 and the likelihood of consuming ≥5 versus <5 servings of fruits and vegetables per day in every wave in which individuals had available data. The same set of models described above were used for these logistic regression analyses. Finally, a sensitivity analysis used mixed linear models similar to those described above to test for reverse causality. These models included fruit and vegetable consumption at Wave 3 as the independent variable and repeated assessments of psychological well-being over time (Waves 3 to 6) as dependent variables to examine if initial fruit and vegetable intake was associated with subsequent levels of psychological well-being over time. If initial fruit and vegetable intake influences subsequent levels of psychological well-being, one would expect to see higher initial fruit and vegetable consumption levels associated with maintaining better or less decline in psychological well-being over time.

Results

At this study's baseline, participants were on average 65.0 years old (standard deviation=9.78; range=50-91). In the largest analytic sample, there were 2,926 men and 3,639 women (55.4%); most were white (98.2%). Participants with high versus low psychological well-being at Wave 3 were younger, more likely to be white, more highly educated, more likely to earn higher incomes, less likely to have chronic conditions or be depressed, more likely to avoid cigarette smoking, more likely to engage in moderate or vigorous levels of physical activity, and more likely to have lower Wave 4 BMI (Table 1).

Higher baseline psychological well-being was associated with greater fruit and vegetable consumption at baseline, regardless of which covariates were included in the models (Table 2). Fruit and vegetable consumption tended to decline across the follow-up period (through Wave 6), but levels of decline depended on initial levels of psychological well-being (interaction $p<.05$) whereby individuals with higher baseline psychological well-being had a slower decline in fruit and vegetable consumption across time. Similar findings were evident when looking at psychological well-being tertiles. In the minimally-adjusted model, both moderate (β=0.06, 95% confidence interval [CI]: -0.001–0.13, p=.05) and high (β=0.17, 95% CI: 0.10–0.23, p<.0001) levels of psychological well-being were associated with greater fruit and vegetable consumption, and both interacted with time (moderate well-being*time: β=0.02, 95% CI: 0.007–0.03, p=.003; high well-being*time: β=0.03, 95% CI: 0.02–0.05, p<.0001). Findings were somewhat attenuated in subsequent models, although both moderate (fully-adjusted: β=0.02, 95% CI: 0.004–0.03, p=.01) and high (fully-adjusted: β=0.03, 95% CI: 0.02–0.05, p<.0001) levels of psychological well-being interacted with time in every model, suggesting higher psychological well-being was associated with a slower decline in fruit and vegetable intake during the follow-up period.

Among individuals who initially met recommended levels of fruit and vegetable intake (≥ 5 servings per day; N=1,719), each standard deviation increase in baseline psychological well-being level was associated with a 10-12% reduced hazard of falling below recommended levels during follow-up (an average of 4.44 years; Table 3). These findings were robust regardless of which covariates were included in the models. When psychological well-being tertiles were considered, a threshold effect emerged suggesting that high but not moderate levels of psychological well-being were associated with a lower hazard of daily fruit and vegetable consumption below recommended levels. Findings were robust in both the minimally-adjusted (moderate: hazard ratio [HR]=0.91, 95% CI: 0.78–1.05; high: HR=0.72, 95% CI: 0.61–0.85) and the fully-adjusted model (moderate: HR=0.93, 95% CI: 0.79–1.09; high: HR=0.69, 95% CI: 0.57–0.83).

Additional analyses were conducted to evaluate whether psychological well-being was related to meeting recommendations to consume ≥5 servings of fruits and vegetables each day. In each model, higher baseline psychological well-being levels were associated with significantly greater likelihood of meeting recommended levels of fruit and vegetable consumption (Table 4). This association was evident for both moderate (relative risk [RR]=1.16, 95% CI: 1.10-1.21) and high levels of psychological well-being (RR=1.29, 95% CI: 1.23-1.34) in minimally-adjusted models, although the association was attenuated in fully-adjusted models (moderate: RR=1.10, 95% CI: 1.04-1.15; high: RR=1.19, 95% CI: 1.13-1.25).

Findings from linear mixed models considering fruit and vegetable consumption as a potential predictor of subsequent psychological well-being did not provide strong evidence for reverse causality (Table S1 in Supplemental Material). More fruit and vegetable consumption at study baseline was associated with higher levels of well-being at each follow-up wave, and well-being seemed to decrease slightly over time. However, the rate of change in psychological well-being across time did not depend on baseline fruit and vegetable consumption.

Discussion

Higher psychological well-being has been linked to reduced risk of all-cause mortality and cardiovascular disease (Boehm & Kubzansky, 2012; Chida & Steptoe, 2008). This association may be due, in part, to the healthy behaviors (e.g., eating fruits and vegetables) in which satisfied and purposeful individuals are more likely to engage. To date, most studies have considered only the cross-sectional relationship between psychological well-being and health behaviors. In contrast, this study examined the association across many years using longitudinal data with prospective measures of psychological well-being. Findings were robust. A variety of analytic strategies consistently demonstrated that individuals with higher versus lower levels of psychological well-being consumed more fruits and vegetables across time. Moreover, higher psychological well-being was related to slower declines in fruit and vegetable consumption over time and reduced likelihood of failing to consume recommended levels of fruits and vegetables each day. Findings are consistent with previous cross-sectional evidence (Conner, et al., 2014), and also corroborate and extend the limited longitudinal evidence published to date (Carvajal, 2012; Hingle, et al., 2014; Tinker et al., 2007), which was restricted to women or adolescent participants.

Findings can be considered in light of a theoretical model proposing that one way psychological well-being is linked with health and disease is via behavioral processes (other possible pathways include biological processes and an attenuation in stress-related processes; Boehm & Kubzansky, 2012). This demonstration that psychological well-being assessed prior to measuring diet predicts subsequent fruit and vegetable consumption after accounting for a broad range of potential confounders including depression, provides support for the hypothesis that higher psychological well-being contributes to engagement in healthy behaviors. Individuals with greater psychological well-being may be more likely to engage in healthy behaviors than their less happy or distressed peers because aspects of psychological well-being increase capacity for goal persistence, effective coping strategies in the face of challenge, and balancing tradeoffs between short- and long-term goals (DeSteno, 2009; Rasmussen, et al., 2006).

Given evidence to suggest that psychological well-being is modifiable and amenable to intervention (Bolier, et al., 2013; Weiss, et al., 2016), psychological well-being could be a novel target for intervention to promote healthy behavior. In fact, preliminary work has targeted psychological well-being in interventions designed to foster healthy behavior in people diagnosed with chronic disease. These interventions often involve participating in weekly tasks such as writing letters of gratitude to others, re-experiencing happy events from the past, performing kind acts for others, focusing on one's personal strengths, and setting goals for the future. Although early evidence suggests that it may be possible to improve psychological well-being as a result of these interventions, it is less clear whether such strategies translate into healthier behaviors as well (Cohn, Pietrucha, Saslow, Hult, & Moskowitz, 2014; DuBois, Millstein, Celano, Wexler, & Huffman, 2016; Huffman et al., 2017; Huffman, DuBois, Millstein, Celano, & Wexler, 2015). Additional, well-powered interventions with both healthy people and those diagnosed with disease are needed before any firm conclusions can be made regarding psychological well-being's potential role in bringing about behavioral change.

To some extent, it is also likely that the relationship between well-being and fruit and vegetable consumption is bidirectional. The current study explored whether fruit and vegetable consumption led to changes in well-being across time. There was no evidence of this, although these findings stand in contrast to several other studies. For example, a daily diary study of young adults (ages 18-25) tested the bidirectional association between emotions and food consumption and found that fruit and vegetable consumption predicted the next day's positive emotions, but positive emotions did not predict the next day's fruit and vegetable consumption (White, Horwath, & Conner, 2013). The difference in findings between that study and the present one could be due to methodology. For example, the daily diary study was comprised of younger adults, took place across 21 days, and assessed daily feelings whereas the current study included only older adults followed over as many as seven years and assessed an enduring indicator of psychological well-being. Another study with Australian adults examined whether fruit and vegetable intake predicted increases in life satisfaction and happiness across two and four years of follow-up (Mujcic & Oswald, 2016). In that study, even after accounting for initial psychological well-being and other relevant covariates, individuals who increased the number of fruits and vegetables they consumed also showed increased levels of life satisfaction and happiness during the same period (Mujcic & Oswald, 2016). These individuals ranged in age from 15-93; it is possible any effects of higher quality diet are less visible later in life or with older samples. However, given the limited evidence to date, it will be important for future work to investigate the theoretical and temporal sequencing of psychological well-being and food consumption.

Use of the ELSA cohort – older predominantly white adults from England – limits the generalizability of these findings to individuals who are more diverse in age, race, and cultural background. Moreover, the health-related habits of older adults are likely well-established compared with younger adults, so behavior change in younger adults is worth further examination in other cohorts. Another limitation of the current study is how fruit and vegetable consumption was assessed during Waves 3 and 4 – responses may have been restricted because intake during the previous day rather than a typical day was queried. The questions regarding fruit and vegetable consumption then changed starting in Wave 5. Although it cannot be ruled out that declines in fruit and vegetable consumption over time were due to changes in assessment, findings considering whether participants met recommendations to consume five or more servings of fruit and vegetables each day were consistent with those from models that used fruit and vegetable consumption as a continuous variable. That is, all analyses pointed to an association such that higher levels of baseline well-being were associated with a greater likelihood of consuming more fruits and vegetables over time. Although the reported associations were small to moderate in size, even relatively modest associations may have measurable impact at the population level or when effects are compounded across time and contexts (Abelson, 1985; Friedman & Booth-Kewley, 1987). Finally, individuals with higher versus lower psychological well-being may self-report healthier behaviors, which could drive apparent associations. Hence, more varied or objective indicators of food consumption would be useful in future studies.

Strengths of the study include the use of a large and prospective cohort of older people, which allowed examination of changes in fruit and vegetable consumption across multiple years. A variety of analytic methods were used to model the prospective relationship between psychological well-being and diet including inverse probability weighting in mixed models to account for missing data and Cox proportional hazards regression. Each different analysis pointed to a robust association between psychological well-being and fruit and vegetable consumption, even when controlling for sociodemographic and health-related factors. Analyses also considered the likelihood of reverse causality whereby fruit and vegetable consumption preceded psychological well-being, but found no evidence to suggest that diet modified changes in psychological well-being across time.

In sum, this is the first study to show that well-being is prospectively associated with fruit and vegetable consumption during as many as seven years in older adulthood. Given that fruit and vegetable consumption are linked with reduced risk for both all-cause mortality and cardiovascular-related mortality (Wang, et al., 2014), this work highlights one novel lever to pull that might improve diet and ultimately reduce risk for morbidity and mortality – namely, psychological well-being. If future research confirms a positive association between higher well-being and enhanced health behaviors, studies that directly target well-being in an attempt to enhance health behaviors may be warranted.

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Table 1. Covariates by tertiles[a] of baseline (Wave 3) psychological well-being (as assessed by the CASP-17; N=6,565).

	Low Psychological Well-Being N=2,242 (34.2%)	*Moderate Psychological Well-Being* N=1,998 (30.4%)	*High Psychological Well-Being* N=2,325 (35.4%)	p-value[b]
Mean Psychological Well-Being Score at W3 (SD)	29.0 (5.46)	38.7 (1.70)	45.1 (2.33)	
Mean Age at W3 (SD)	65.1 (10.5)	65.5 (9.85)	64.5 (8.98)	0.007
Mean Weekly Income at W3 (SD)	265.0 (187.3)	311.1 (235.8)	361.0 (297.2)	<.0001
Gender				0.871
Men	1002 (44.7%)	881 (44.1%)	1043 (44.9%)	
Women	1240 (55.3%)	1117 (55.9%)	1282 (55.1%)	
Race				0.011
White	2187 (97.6%)	1967 (98.5%)	2294 (98.7%)	
Non-white	55 (2.45%)	31 (1.55%)	31 (1.33%)	
Education at W3				<.0001
University degree	304 (13.6%)	378 (18.9%)	513 (22.1%)	
Higher education, but no degree	295 (13.2%)	324 (16.2%)	405 (17.4%)	
A level	173 (7.72%)	143 (7.16%)	201 (8.65%)	
O level	427 (19.1%)	373 (18.7%)	429 (18.5%)	
Less than O level	1043 (46.5%)	780 (39.0%)	777 (33.4%)	
Employment status at W3				<.0001
Working	706 (31.5%)	739 (37.0%)	876 (37.7%)	
Not working	1536 (68.5%)	1259 (63.0%)	1449 (62.3%)	
Chronic conditions by W3				<.0001
One or more	1529 (68.2%)	1172 (58.7%)	1159 (49.9%)	
None	713 (31.8%)	826 (41.3%)	1166 (50.2%)	
Depression at W3				<.0001
Depressed	349 (15.6%)	128 (6.41%)	88 (3.78%)	
Not depressed	1893 (84.4%)	1870 (93.6%)	2237 (96.2%)	
Smoking status at W3				<.0001
Never	801 (35.7%)	801 (40.1%)	996 (42.8%)	
Former	1042 (46.5%)	948 (47.5%)	1087 (46.8%)	
Current	399 (17.8%)	249 (12.5%)	242 (10.4%)	
Physical Activity Level at W3				<.0001

Sedentary/Low	853 (38.1%)	493 (24.7%)	401 (17.3%)	
Moderate/High	1389 (62.0%)	1505 (75.3%)	1924 (82.8%)	
Mean BMI (per kg/m^2) at W4 (SD)	28.6 (5.56)	28.2 (5.04)	28.0 (5.22)	0.002
	N=1587	N=1558	N=1863	

[a] CASP-17 scores ≤35 indicated low psychological well-being, >35 or <42 indicated moderate psychological well-being, and ≥42 indicated high psychological well-being.

[b] p-value comes from χ^2 or analysis of variance.

Table 2. Repeated measures analysis modeling change in fruit and vegetable intake over time (Waves 3-6; N=6,565). Values are beta estimates (95% CIs).[a]

	Model 1	Model 2	Model 3	Model 4[b]
Psychological Well-Being (per SD increase)	0.09 (0.07, 0.12)*	0.07 (0.05, 0.10)*	0.05 (0.03, 0.08)*	0.05 (0.02, 0.08)*
Time (years)	-0.01 (-0.01, 0.00)*	-0.01 (-0.01, -0.003)*	-0.01 (-0.02, -0.004)*	-0.01 (-0.02, -0.004)*
Psychological Well-Being*Time interaction	0.01 (0.01, 0.02)*	0.01 (0.01, 0.02)*	0.01 (0.01, 0.02)*	0.01 (0.01, 0.02)*
Age (per year)	0.00 (-0.002, 0.002)	0.003 (0.00, 0.01)*	0.00 (-0.002, 0.004)	0.002 (-0.001, 0.005)
Men	-0.12 (-0.16, -0.09)*	-0.17 (-0.21, -0.13)*	-0.16 (-0.20, -0.12)*	-0.16 (-0.20, -0.11)*
Nonwhite	0.42 (0.27, 0.56)*	0.41 (0.26, 0.55)*	0.42 (0.28, 0.56)*	0.51 (0.34, 0.69)*
Income (per SD)		0.02 (0.003, 0.05)*	0.02 (-0.003, 0.04)†	0.01 (-0.01, 0.03)
Education (reference: <O level)				
University degree		0.20 (0.14, 0.26)*	0.14 (0.08, 0.20)*	0.16 (0.09, 0.22)*
Higher education, but no degree		0.17 (0.11, 0.22)*	0.13 (0.07, 0.18)*	0.12 (0.05, 0.18)*
A level		0.14 (0.06, 0.21)*	0.10 (0.03, 0.18)*	0.11 (0.03, 0.19)*
O level		0.07 (0.02, 0.13)*	0.04 (-0.01, 0.09)	0.04 (-0.02, 0.10)
Married		0.09 (0.05, 0.13)*	0.06 (0.01, 0.10)*	0.04 (-0.01, 0.09)
Employed		-0.03 (-0.08, 0.03)	-0.04 (-0.09, 0.01)	-0.04 (-0.10, 0.01)
Any chronic condition			0.05 (0.01, 0.09)*	0.06 (0.01, 0.10)*
Depressed			0.03 (-0.04, 0.10)	-0.01 (-0.09, 0.07)
Smoking status (reference: never)				
Former			-0.03 (-0.07, 0.01)	-0.04 (-0.08, 0.01)†
Current			-0.32 (-0.38, -0.26)*	-0.31 (-0.38, -0.24)*
Moderate/vigorous physical activity			0.19 (0.15, 0.24)*	0.21 (0.16, 0.26)*
BMI at Wave 4 (per kg/m^2)				0.01 (0.003, 0.01)*

[a] Some beta estimates are very small due to the small range in the dependent variable.
[b] N=5,008 in Model 4.
* $p<0.05$, † $p<0.10$

Table 3. Cox regression modeling time to consuming less than five servings of fruits and vegetables among individuals who consumed recommended levels at the Wave 3 baseline (N=1,719).[a] Values are HR (95% CI).

	Model 1	Model 2	Model 3	Model 4[b]
Psychological Well-Being (per SD increase)	0.88 (0.83, 0.94)*	0.90 (0.84, 0.96)*	0.89 (0.83, 0.95)*	0.88 (0.82, 0.95)*
Age (per year)	1.00 (1.00, 1.01)	1.00 (0.99, 1.01)	1.00 (0.99, 1.01)	1.00 (0.99, 1.01)
Men	1.31 (1.16, 1.48)*	1.35 (1.19, 1.53)*	1.35 (1.19, 1.54)*	1.31 (1.14, 1.51)*
Nonwhite	0.70 (0.46, 1.07)†	0.73 (0.48, 1.10)	0.70 (0.46, 1.06)†	0.57 (0.34, 0.97)*
Income (per SD)		0.99 (0.93, 1.06)	1.00 (0.94, 1.06)	0.98 (0.91, 1.05)
Education (reference: <O level)				
University degree		0.84 (0.69, 1.03)†	0.87 (0.71, 1.07)	0.85 (0.68, 1.07)
Higher education, but no degree		0.91 (0.75, 1.09)	0.92 (0.76, 1.11)	0.92 (0.75, 1.13)
A level		0.86 (0.66, 1.11)	0.88 (0.68, 1.14)	0.91 (0.69, 1.20)
O level		1.00 (0.83, 1.20)	1.01 (0.85, 1.21)	1.03 (0.85, 1.25)
Married		0.84 (0.73, 0.96)*	0.85 (0.74, 0.97)*	0.87 (0.75, 1.01)†
Employed		1.11 (0.94, 1.31)	1.09 (0.92, 1.29)	1.06 (0.89, 1.27)
Any chronic condition			0.87 (0.76, 1.00)*	0.84 (0.72, 0.98)*
Depressed			0.85 (0.67, 1.07)	0.85 (0.65, 1.11)
Smoking status (reference: never)				
Former			0.94 (0.82, 1.07)	0.97 (0.84, 1.12)
Current			1.15 (0.94, 1.41)	1.09 (0.86, 1.37)
Moderate/vigorous physical activity			0.83 (0.72, 0.97)*	0.80 (0.67, 0.95)*
BMI at Wave 4 (per kg/m^2)				1.00 (0.98, 1.01)

[a] 49.7% of participants (N=854) reported consuming less than five servings of fruits and vegetables during follow-up.

[b] N=1,443 in Model 4.

* $p<0.05$, † $p<0.10$

Table 4. Repeated measures logistic regression analyses modeling consumption of five or more servings of fruits and vegetables over the follow up period (N=6,565).[a] Values are RR (95% CI).

	Model 1	Model 2	Model 3	Model 4[a]
Psychological Well-Being (per SD increase)	1.13 (1.11, 1.15)*	1.11 (1.09, 1.12)*	1.09 (1.07, 1.12)*	1.09 (1.07, 1.12)*
Time (years)	1.03 (1.02, 1.03)*	1.02 (1.02, 1.03)*	1.02 (1.02, 1.03)*	1.03 (1.02, 1.03)*
Age (per year)	1.00 (1.00, 1.00)	1.00 (1.00, 1.01)*	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)
Men	0.90 (0.87, 0.93)*	0.86 (0.83, 0.89)*	0.87 (0.84, 0.90)*	0.86 (0.83, 0.90)*
Nonwhite	1.23 (1.11, 1.36)*	1.21 (1.09, 1.34)*	1.22 (1.10, 1.36)*	1.30 (1.17, 1.44)*
Income (per SD)		1.02 (1.00, 1.03)*	1.01 (1.00, 1.03)†	1.02 (1.00, 1.03)*
Education (reference: <O level)				
University degree		1.26 (1.20, 1.32)*	1.20 (1.14, 1.26)*	1.21 (1.15, 1.27)*
Higher education, but no degree		1.22 (1.16, 1.28)*	1.18 (1.13, 1.24)*	1.18 (1.12, 1.25)*
A level		1.13 (1.06, 1.21)*	1.10 (1.03, 1.18)*	1.09 (1.02, 1.17)*
O level		1.11 (1.06, 1.17)*	1.08 (1.03, 1.14)*	1.07 (1.02, 1.13)*
Married		1.05 (1.02, 1.10)*	1.03 (0.99, 1.07)	1.02 (0.98, 1.06)
Employed		0.96 (0.92, 1.00) †	0.95 (0.91, 0.99)*	0.94 (0.90, 0.99)*
Any chronic condition			1.13 (1.02, 1.09)*	1.07 (1.03, 1.12)*
Depressed			1.03 (0.97, 1.10)	0.99 (0.93, 1.06)
Smoking status (reference: never)				
Former			0.98 (0.95, 1.01)	0.96 (0.92, 0.99)*
Current			0.74 (0.69, 0.79)*	0.74 (0.69, 0.80)*
Moderate/vigorous physical activity			1.21 (1.15, 1.26)*	1.23 (1.17, 1.29)*
BMI at Wave 4 (per kg/m^2)				1.01 (1.00, 1.01)*

Note: Generalized Estimating Equations fit repeated measures logistic regression models with the Poisson distribution. Effect estimates represent the likelihood of meeting recommended levels of fruit and vegetable consumption in relation to a one standard deviation increase in baseline psychological well-being.

[a] N=5,008 in Model 4