Does Eating Fruit and Vegetables Also Reduce the Longitudinal Risk of Depression and Anxiety? A Commentary on 'Lettuce be Happy'

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Redzo Mujcic[a] and Andrew J. Oswald[b*]

[a] *Warwick Business School, University of Warwick, Coventry, CV4 7AL, UK. Email address: r.mujcic@gmail.com*

[b] *Department of Economics and CAGE Centre, University of Warwick, Coventry, CV4 7AL, UK. Telephone 02476 523510. Email address: andrew.oswald@warwick.ac.uk*

[*]*Corresponding author*

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This short article, to be published in Social Science & Medicine, is designed as a complement to the paper:

Lettuce Be Happy: A Longitudinal UK Study on the Relationship between the Fruit and Vegetable Consumption and Well-Being. By Neel Ocean, Peter Howley and Jonathan Ensor. Social Science & Medicine, 2019, forthcoming.

Abstract

This paper provides evidence of a longitudinal connection between current diet and later mental health. We build upon a new research article by Neel Ocean, Peter Howley and Jonathan Ensor (2019, forthcoming), which uses UK data to argue that consumption of fruit and vegetables may be able to improve people's self-assessed GHQ and life-satisfaction scores. We show, in Australian data, that an equivalent result may be true for actual clinical diagnosis of depression and anxiety. We conclude that there appears to be accumulating evidence for the psychological power of fruit and vegetables.

Introduction

Neel Ocean, Peter Howley and Jonathan Ensor (2019, forthcoming) have made an important contribution to the literature on diet and psychological well-being. The authors use a large longitudinal survey from the United Kingdom. Ocean and his colleagues document a statistically robust and positively-sloped relationship between people's consumption of fruit and vegetables and their (i) GHQ mental-health scores and (ii) levels of life satisfaction.

Particularly notably, the authors are able to control for so-called fixed effects. In other words, unlike most previous researchers, they can 'difference out' the unchanging and typically unobservable characteristics of individuals. Ocean et al. examine, in effect, how changes in diet are correlated with changes in mental well-being. This is a key feature of their work. It means that the Ocean et al. results are immune from a famous criticism in this area of research -- namely that deep-down personality or family upbringing might lead people simultaneously to eat in a healthy way and also to have better mental well-being, so that diet is then merely correlated with, but incorrectly gives the appearance of helping to cause, the level of well-being. Hence these authors' analysis goes substantially beyond simple cross-sectional results in UK data such as those in Blanchflower et al. (2011).

As Ocean et al. (2019) also explain, the positively-sloped relationship they establish in UK data is potentially consistent with that found recently in the Australian fixed-effects analysis of Mujcic and Oswald (2016). That seems scientifically encouraging for this field of research. For all researchers in this area, nevertheless, a number of challenges remain.

Here we consider three. First, *governments and medical authorities are often interested in the determinants of major mental ill-health conditions*, such as depression and high levels of anxiety, and not solely in a more typical citizen's level of well-being. Second, *although GHQ and life-satisfaction scores are of considerable value, such scores are inevitably based on self-assessment*. It might be argued that they lack the persuasiveness of an external medical diagnosis. Third, there remains the scientific difficulty that it is hard to establish *which went first in time*: did diet alter and then mental wellbeing followed, or was it reverse causality? Valuable new work by Boehm and colleagues (2018), for example, has found evidence that mentally healthy people tend to maintain a fruit and vegetable diet in future periods. There remains the possibility that the only way to make certain progress in the research area would be, following in the methodological footsteps of work such as Steptoe et al. (2004) and Conner et al. (2017), to construct a giant randomized trial. We think there is much to be said for that, but we are

also conscious of some of the weaknesses as well as the strengths of RCTs, as discussed in Deaton and Cartwright (2018).

In this Commentary, we try to provide a small amount of extra evidence that may help to complement the Ocean et al. results. Using Australian rather than UK data, we ask whether the tenor of the results in Ocean et al. (2019) and Mujcic and Oswald (2016) might extend to a possible role for fruit and vegetables as a factor associated with lower risk of clinical depression itself. There is older and emerging research in this important area -- see Johnson et al. (2017), Liu et al. (2016), Kingsbury et al. (2016), Mihrshahi et al. (2015), Nguyen et al. (2017), Rooney et al. (2013), Steptoe et al. (2004), and White et al. (2013) -- but the evidence at the time of writing remains mixed. Possible theoretical mechanisms are also currently poorly understood (Dinan and Cryan 2013; Young 2007).

Analysis

Here we study a measure of serious mental ill-health. It is available in waves 2007 and 2009 of the same data set as used in Mujcic and Oswald (2016). The Household, Income and Labour Dynamics in Australia (HILDA) Survey is a nationally representative panel survey that began in 2001. The HILDA Survey collects annual longitudinal information from members of Australian households who are at least 15 years of age (see Watson and Wooden 2002). The data are publicly available.

The measure used in this Commentary's analysis is a binary indicator for whether or not the survey respondent has been diagnosed with long-term depression or anxiety by a health-care professional:

> "*Have you ever been told by a doctor or nurse that you have any of the long-term health conditions listed below? Please only include those conditions that have lasted or are likely to last for six months or more: Depression/Anxiety".*

We restrict our analysis to a balanced panel of individual respondents who answered the above question in the two survey waves (n=7,108). Across the survey periods, approximately 17% of respondents indicated they had been diagnosed with such a mental-health condition.

Does someone's diet in 2007 help to predict their chance of depression in 2009? Following only individuals (n=5,949) who were *not* diagnosed with depression/anxiety in the first period (year 2007), Table 1 relates the estimated probability of those same individuals *being* diagnosed with depression/anxiety in the next period (year 2009) to their daily fruit-and-vegetable intake in the previous period, as well as a number of added demographic and socioeconomic covariates including age, education and income levels, and other lifestyle factors. The results in Table 1 could be interpreted from a kind of prospective point of view, as is common in the medical and public-health literatures. The broad

conclusions are consistent with the Ocean et al. (2019) and Mujcic-Oswald (2016) findings (on GHQ, happiness, and life satisfaction).

In Table 1, the probability of being diagnosed with depression/anxiety in the year 2009 is inversely related to the consumption of fruit and vegetables in 2007. This sample is, it should be emphasized, a group of individuals not previously diagnosed.

The estimated marginal effect of -0.004 implies -- as a matter, it should be emphasized, of statistical association -- that individuals who increase their daily intake of fruit and vegetables from, say, 0 to 8 portions a day are on average 3.2 percentage points less likely to experience depression or anxiety within the next 24 months. While in absolute terms such a benefit to a person's mental well-being might seem quite small, that is not the case. To understand this, we need to compare the calculated effect size (-0.032) relative to that of other major life events such as 'becoming unemployed' or 'being divorced'. From Table 1, such an improved diet is predicted to offset slightly less than half of the increased risk of future depression resulting from current unemployment (0.075) and, more so, the entire increased risk following marital divorce or separation (0.035). The implied effect-sizes are quite substantial.

A possible concern here, in the spirit of research such as Boehm et al. (2018), might be that the studied relationship between diet and diagnosed depression runs in both directions. That is, a healthy diet may reduce the risk of future depression or anxiety, but being diagnosed with depression or anxiety today could also lead to lower fruit and vegetable intake in the future. Table 2 probes this possibility. It tests whether fruit and vegetable consumption in the future can be predicted from the rate of depression or anxiety in the current period. There is no decisive evidence in Table 2 for such reverse-causality; although the coefficient has the 'correct' sign, it is small in magnitude, and the estimated effect does not achieve statistical significance at conventional levels (p-value = 0.17).

Conclusion

Consistent with the spirit of Ocean et al. (2019), this Commentary presents evidence that eating fruit and vegetables may help to protect against future risk of clinical depression and anxiety. Our findings should, however, be treated cautiously. As the philosopher David Hume pointed out in the 1700s (in the case of a cock crowing before sunrise), precedence in time does not prove that a variable that moves first causes a variable that moves second; moreover, by the nature of the statistical exercise reported here, we have not adjusted for fixed effects. Nevertheless, temporal precedence in longitudinal data can sometimes offer valuable insights, and, buttressing Ocean et al. (2019), this paper's results do seem to

offer further evidence consistent with the idea that diet can influence a person's psychological health. The power of fruit and vegetables may be greater than has been appreciated.

Table 1. Predicted probability of being diagnosed with depression/anxiety in year 2009 using information on fruit and vegetable consumption, and covariates, in year 2007. HILDA Survey 2007 (period *t*) and 2009 (period *t+1*). *[Sample of Individuals Never Previously Diagnosed with Depression/Anxiety.]**

Dependent variable: Diagnosed with depression/anxiety $_{t+1}$			
Independent variables:	*β*	*CI*	*p*
Fruit and vegetable portions/day $_t$	-0.0041	[-0.008, -0.001]	.017
Log of household income $_t$	-0.0031	[-0.012, 0.006]	.489
Age $_t$	0.0004	[-0.002, 0.003]	.743
Age-squared/100 $_t$	-0.0005	[-0.003, 0.002]	.729
Male $_t$	-0.0395	[-0.053, -0.026]	.000
Masters or doctorate $_t$	0.0011	[-0.033, 0.035]	.948
Bachelor or honors $_t$	0.0061	[-0.023, 0.035]	.679
Graduate diploma or certificate $_t$	0.0154	[-0.006, 0.037]	.162
Advanced diploma $_t$	0.0200	[-0.003, 0.043]	.094
Professional qualification $_t$	0.0108	[-0.008, 0.030]	.262
Year 12 high school $_t$	-0.0009	[-0.021, 0.019]	.933
Full-time student $_t$	0.0233	[-0.007, 0.054]	.135
Unemployed $_t$	0.0747	[0.029, 0.120]	.001
Not in the labor force $_t$	0.0069	[-0.013, 0.027]	.496
Married $_t$	-0.0108	[-0.031, 0.009]	.294
Separated $_t$	0.0353	[-0.006, 0.077]	.097
Divorced $_t$	0.0343	[0.006, 0.063]	.018
Widowed $_t$	-0.0605	[-0.101, -0.020]	.003
Long-term health condition $_t$	0.0551	[0.037, 0.073]	.000
# children under the age of 4 $_t$	0.0006	[-0.013, 0.014]	.928
# children aged 5-14 $_t$	0.0005	[-0.009, 0.010]	.910
Drink alcohol 2 or 3 days/month $_t$	-0.0067	[-0.025, 0.011]	.464
Drink alcohol 1 or 2 days/week $_t$	-0.0167	[-0.038, 0.004]	.118
Drink alcohol 3 or 4 days/week $_t$	-0.0158	[-0.036, 0.004]	.120
Drink alcohol 5 or 6 days/week $_t$	0.0019	[-0.021, 0.025]	.872
Drink alcohol everyday $_t$	-0.0079	[-0.033, 0.017]	.535
Non-smoker $_t$	-0.0377	[-0.055, -0.020]	.000
Never eat red meat $_t$	0.0449	[0.005, 0.085]	.027
Never eat fish $_t$	0.0095	[-0.012, 0.031]	.390
Eat breakfast regularly $_t$	0.0008	[-0.015, 0.016]	.923
Drink low fat or skim milk $_t$	0.0047	[-0.008, 0.018]	.477
Avoid fatty foods $_t$	-0.0013	[-0.017, 0.014]	.867
BMI $_t$	-0.0001	[-0.001, 0.001]	.921
Exercise regularly $_t$	-0.0022	[-0.015, 0.011]	.742
Constant	0.1411	[0.044, 0.238]	.004
Adjusted R^2		.023	
Number of observations		5,949	

Notes: Linear probability regression-equation model. Dependent variable equals 1 if individual was diagnosed with depression/anxiety in period t+1 (year 2009), 0 otherwise. The sample consists of n=5,949 HILDA Survey respondents who were *not* diagnosed with anxiety/depression in period *t* (year 2007). The mean of the dependent variable is 0.09. The mean daily fruit and vegetable consumption amount is 3.90 portions. Values in square parentheses are 95% confidence intervals (CIs). **Further note*: Increasing the size of the sample, by including all those with a previous diagnosis of depression/anxiety, and including a dummy variable for that, leaves the coefficient estimate on fruit+veg almost the same and significant at 95%.

Table 2. Testing for reverse causality: Predicted fruit and vegetable consumption in year 2009 using information on depression/anxiety, and covariates, in year 2007. HILDA Survey 2007 (period *t*) and 2009 (period *t+1*).

Dependent variable: Fruit and vegetable portions/day $_{t+1}$			
Independent variables:	*β*	*CI*	*p*
Diagnosed with depression/anxiety $_t$	-0.0718	[-0.174, 0.031]	.170
Fruit and vegetable portions/day $_t$	0.5517	[0.532, 0.571]	.000
Log of household income $_t$	0.0279	[-0.022, 0.078]	.276
Age $_t$	0.0219	[0.006, 0.037]	.006
Age-squared/100 $_t$	-0.0102	[-0.026, 0.005]	.202
Male $_t$	-0.1609	[-0.242, -0.080]	.000
Masters or doctorate $_t$	0.1934	[-0.006, 0.393]	.057
Bachelor or honors $_t$	0.2763	[0.108, 0.445]	.001
Graduate diploma or certificate $_t$	0.1842	[0.059, 0.309]	.004
Advanced diploma $_t$	0.1844	[0.049, 0.320]	.008
Professional qualification $_t$	0.1755	[0.067, 0.284]	.002
Year 12 high school $_t$	0.1267	[0.008, 0.245]	.036
Full-time student $_t$	0.2889	[0.110, 0.468]	.002
Unemployed $_t$	0.0234	[-0.227, 0.274]	.854
Not in the labor force $_t$	0.0237	[-0.087, 0.135]	.675
Married $_t$	0.0329	[-0.083, 0.149]	.579
Separated $_t$	-0.1701	[-0.394, 0.054]	.136
Divorced $_t$	-0.0886	[-0.246, 0.069]	.271
Widowed $_t$	-0.1219	[-0.353, 0.109]	.300
Long-term health condition $_t$	0.0325	[-0.065, 0.130]	.516
# children under the age of 4 $_t$	-0.0519	[-0.132, 0.028]	.203
# children aged 5-14 $_t$	-0.0066	[-0.059, 0.046]	.806
Drink alcohol 2 or 3 days/month $_t$	-0.0049	[-0.110, 0.100]	.926
Drink alcohol 1 or 2 days/week $_t$	-0.0189	[-0.141, 0.103]	.762
Drink alcohol 3 or 4 days/week $_t$	0.0160	[-0.099, 0.131]	.785
Drink alcohol 5 or 6 days/week $_t$	0.0428	[-0.094, 0.180]	.540
Drink alcohol everyday $_t$	0.0535	[-0.092, 0.199]	.471
Non-smoker $_t$	0.2463	[0.147, 0.345]	.000
Never eat red meat $_t$	0.1500	[-0.074, 0.373]	.188
Never eat fish $_t$	-0.2079	[-0.332, -0.084]	.001
Eat breakfast regularly $_t$	0.1778	[0.089, 0.267]	.000
Drink low fat or skim milk $_t$	0.0071	[-0.069, 0.083]	.854
Avoid fatty foods $_t$	0.1781	[0.090, 0.266]	.000
BMI $_t$	0.0022	[-0.005, 0.010]	.559
Exercise regularly $_t$	0.2092	[0.134, 0.284]	.000
Constant	0.1617	[-0.399, 0.723]	.572
Adjusted R^2		.418	
Number of observations		7,108	

Notes: Linear regression-equation model. Dependent variable is the daily fruit and vegetable consumption amount [range: 0 to 10] in period t+1 (year 2009). The mean of the dependent variable is 3.88 portions per day. The sample consists of n=7,108 HILDA Survey respondents who answered the '*diagnosed with depression or anxiety*' question in both survey waves (2007 and 2009). The mean of the *diagnosed with depression/anxiety* dummy variable is 0.17. Values in square parentheses are 95% confidence intervals (CIs).

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