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Abstract

Little is known about the influence of people's diet on their psychological well-being. This study provides evidence of a link between the consumption of fruit and vegetables and high well-being. In cross-sectional data, happiness and mental health rise in an approximately dose–response way with the number of daily portions of fruit and vegetables. Well-being peaks at approximately 7 portions per day. We document this relationship in three data sets, covering approximately 80,000 randomly selected British individuals, and for seven measures of well-being (life satisfaction, WEMWBS mental well-being, GHQ mental disorders, self-reported health, happiness, nervousness, and feeling low). The pattern is robust to adjustment for a large number of other demographic, social and economic variables. Reverse causality and problems of confounding

	remain possible. We discuss the strengths and weaknesses of our analysis, how government policy-makers might wish to react to it, and what kinds of further research—especially randomized trials—would be valuable.
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Is Psychological Well-Being Linked to the Consumption of Fruit and Vegetables?

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Abstract Little is known about the influence of people's diet on their psychological well-being. This study provides evidence of a link between the consumption of fruit and vegetables and high well-being. In cross-sectional data, happiness and mental health rise in an approximately dose–response way with the number of daily portions of fruit and vegetables. Well-being peaks at approximately 7 portions per day. We document this relationship in three data sets, covering approximately 80,000 randomly selected British individuals, and for seven measures of well-being (life satisfaction, WEMWBS mental well-being, GHQ mental disorders, self-reported health, happiness, nervousness, and feeling low). The pattern is robust to adjustment for a large number of other demographic, social and economic variables. Reverse causality and problems of confounding remain possible. We discuss the strengths and weaknesses of our analysis, how government policy-makers might wish to react to it, and what kinds of further research—especially randomized trials—would be valuable.

Keywords Subjective well-being · Healthy food · GHQ · Diet · Mental health · Depression · Happiness · WEMWBS

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1 Introduction

Thousands of papers have been published on the important topic of what determines people's subjective well-being and psychological health. Little is known, however, about the potential influence of the different kinds of foods that people eat. The well-known review papers of Diener (1994), Diener et al. (1999), Clark et al. (2008) and Dolan et al. (2008), for example, do not mention the role of human diet.

An electronic search on the history of the journal *Social Indicators Research* uncovers only one research article (Farnworth 2009) in which the consumption of fruit and vegetables is mentioned in the Abstract or Key Words. That article is not concerned with potential links to subjective well-being or mental health. Similar searches on the journals *Psychological Medicine* and the *Journal of Health Economics* produce only one article (Capacci and Mazzocchi 2011), and that article is not about the consequences of healthy eating but rather how that might be advertised to the public. In the journal *Social Science and Medicine* there is a larger number of published articles (approximately 30), but almost none deals with connections between well-being and healthy food. One partial exception is the interesting work of Dave and Kelly (2012). However, its focus is on how movements in the business cycle affect both people's consumption of fruit and vegetables and their mental health. Carter et al. (2011) examines the influence of 'food security', rather than the direct consumption of healthy food, upon psychological distress. Recently, a small literature in public health has begun to find results suggestive of some form of correlation between depression and lack of fruit and vegetables (for example, Piqueras et al. 2011; Jacka et al. 2010; Tsai et al. 2012).

One reason why this lacuna in the well-being literature is paradoxical is that so much attention has been paid—in sub-literatures across science and social science—to possible links between physical well-being and human diet. That is reflected in policy. For more than 20 years, western governments have recommended a diet in which people are advised to eat five portions of fruit and vegetables a day. This policy stemmed originally from a proposal in 1988 by the California Department of Health Services. The objective was to reduce the incidence of cancer among Americans who, at that time, were eating fewer than 3 portions a day (Ness and Powles 1997). A 5-a-day policy for physical health has become part of World Health Organization guidelines and been adopted by many nations. To our knowledge, no government has advocated fruit and vegetables as part of a mental-health policy.

Could the nature of food have an important potential role in humans' psychological, and not just bodily, well-being? The background is that there is current interest among governments in the measurement of psychological well-being (an official project is being run, for example, by the UK's Office for National Statistics entitled Measuring Subjective Well-being in the UK, with large-scale data collection currently being undertaken). There is a still-burgeoning statistical literature on the determinants of human happiness and mental well-being (Diener et al. 1999; Easterlin 2003; Graham 2005; Layard 2005; Propper et al. 2005; Shields and Wheatley Price 2005; Blanchflower and Oswald 2008). Nevertheless, with some important exceptions, such as Graham (2008) and Powdthavee (2009), there has been less work on exactly how happiness interacts with health, although it is known that people's physical health conditions enter significantly in well-being equations. There has been particularly little research in the modern well-being literature on the consequences of people's dietary choices (except indirectly as part of research into the effects of obesity).

Journal : Small 11205 | Dispatch : 6-10-2012 | Pages : 17
Article No. : 173 | LE | TYPESET
MS Code : SOCI1728 | CP | DISK

The present study lies at the borders between a number of areas of social science. Its specific focus is the role of fruit-and-vegetable consumption in well-being regression equations. By using recent data, this study provides evidence of a positive association with psychological well-being, and one that often reaches a peak at or above 5 portions a day or more (in many of our equations, at approximately 7–8 portions of fruit and vegetables per day). We explore the nature of this relationship in a number of data sets and for a range of measures of human well-being—life satisfaction, WEMWBS mental well-being, General Health Questionnaire GHQ mental disorders, self-reported health, happiness, nervousness, and feeling low. We show the relationship is robust to controls for a large set of possible confounders. That is important in this setting, because so many 'healthy' attributes, including high levels of education and income, are likely to be correlated with the eating of fruit and vegetables.

The study employs a variety of measures—they are defined individually in the Appendix—under the umbrella of subjective well-being. This is to make the point that a statistical link with healthy eating appears a rather general one and does not depend on the use of one particular well-being variable.

A limitation of our analysis should be made clear from the beginning. Our data sets are cross-sectional. This implies that, as in some other parts of the well-being literature, we cannot draw firm inferences about causality. It is perhaps natural, nevertheless, to begin with cross-sectional associations. Here these are sufficiently marked, and robust to a plethora of controls for confounding influences, that the associations seem to us potentially of interest to a range of researchers in well-being, and to suggest that it will be valuable to create future longitudinal data sets in which fruit-and-vegetable portions are measured.

2 Methods

Many social-science surveys do not record people's consumption of fruit and vegetables. That is probably one reason why, on this issue, the well-being literature remains small. To try to make progress, we obtained a number of British data sets in which dietary variables have become available.

The data sets used are the Welsh Health Survey of 2007–2010, the Scottish Health Survey of 2008, and the Health Survey of England in 2008. Each is a random sample of the adult population so is representative of the respective nations. Together these samples, which are cross-sectional, provide information on approximately 80,000 randomly selected individuals.

We follow a now-long tradition—surveyed in for example Dolan et al. 2008—in well-being research of estimating regression equations on observational data. In such equations, the dependent variable is a measure of subjective well-being or mental health. Much is known about the kinds of variables that enter statistically significantly in such equations (for example, Blanchflower and Oswald 2004 and Clark et al. 2008). To allow for these possible confounding effects, we incorporate independent variables and estimate equations of the general form:

$$\textit{Psychological well-being} = f(\textit{daily portions of fruit and vegetables consumed}, \textit{age}, \textit{gender}, \textit{education}, \textit{income}, \textit{etc})$$

and we are then interested in the size and level of statistical significance on the variable for fruit and vegetable consumption.

Journal : Small 11205 | Dispatch : 6-10-2012 | Pages : 17
Article No. : 173 | LE | TYPESET
MS Code : SOCI1728 | CP | DISK

The means and standard deviations of the study's dependent variables are given in the Appendix of the paper. A long set of independent variables is included in the regression equations. Because they are standard in the research literature, they are not defined in full each time, and vary slightly from one data set to another, but they include banded dummy variables for variables such as the age of the person and his or her level of education and marital status. Body mass index is represented by the acronym BMI. Income is entered in the regressions in a way that has been normalized (it is so-called equivalized income) for the number of people living in the household. To check robustness, many other personal characteristics are included in the equations.

3 Results from a Range of Well-Being Regression Equations

The first results, given in Table 1, are for a sample of approximately 14,000 individuals from the Scottish Health Surveys of 2008 and 2009. Table 1 reports regression equations—one in each of three columns—in which the dependent variable is a person's life satisfaction on an eleven point integer scale from zero to ten. This estimation method treats the data as cardinal; switching to an ordinal estimator makes no substantive difference. The mean of life satisfaction is 7.6 and its standard deviation is 1.9. The question's wording is given in Appendix.

As independent variables in the fullest life-satisfaction equation of Table 1, we include 7 banded-dummy variables for people's age; 1 gender dummy; 4 dummies for different racial groups; 6 dummies for people's different labour force status, such as unemployed or retired; 5 marital-status dummies; dummy variables for the number of children, whether the person has a long-standing illness, is sexually active, is a non-smoker, is religious; variables for the person's BMI and the log of their income. These variables are known from the literature to enter significantly in well-being equations, so we do not comment in detail on each one.

In its first column, Table 1 provides estimates of the raw unadjusted correlation between life satisfaction and the daily number of portions of fruit and vegetables. A strong positive, and almost monotonic, correlation is evident. Those people who eat 8+ portions a day have a life-satisfaction score approximately 0.9 points higher than those who eat almost no portions (all the fruit-and-vegetable coefficients, in this and later tables, are normalized relative to the base case of eating fewer than 1–2 portions per day). Column 2 of Table 1 then corrects for a range of demographic characteristics: this regression equation incorporates variables for a person's age, gender, and race. There is evidence here of a strong U-shape in age, in accordance with earlier literature (such as Blanchflower and Oswald 2008), and of low levels of life satisfaction among black people. The fruit-and-vegetable gradient, however, is almost unchanged from that in column 1.

In column 3 of Table 1, a larger set of variables are included. These are designed to correct for possible confounding factors. Importantly, because it is to be expected that fruit and vegetable consumption is correlated with many aspects of socioeconomic advantage, we choose to control here (and throughout later tables) for, among others, factors such as:

Disability
Being unemployed
Marital status
Having children
Major illness

Journal : Small 11205 | Dispatch : 6-10-2012 | Pages : 17
Article No. : 173 | LE | TYPESET
MS Code : SOCI1728 | CP | DISK

Table 1 Life-satisfaction regression equations—Scotland, 2008/2009

1–2 portions fruit and veg	0.2735 (4.58)	0.2689 (4.52)	0.0107 (0.17)
2–3 portions fruit and veg	0.5272 (8.94)	0.5328 (9.05)	0.1315 (2.08)
3–4 portions fruit and veg	0.6406 (10.64)	0.6572 (10.91)	0.2101 (3.21)
4–5 portions fruit and veg	0.7071 (11.19)	0.7298 (11.53)	0.1977 (2.89)
5–6 portions fruit and veg	0.8243 (11.92)	0.8481 (12.24)	0.2264 (2.99)
6–7 portions fruit and veg	0.7576 (9.56)	0.7826 (9.86)	0.1738 (2.04)
7–8 portions fruit and veg	0.8568 (9.10)	0.8830 (9.38)	0.2802 (2.85)
8+ portions fruit and veg	0.8578 (10.06)	0.8960 (10.50)	0.2743 (2.94)
16–24		0.5002 (7.66)	0.4251 (4.73)
25–34		0.2986 (5.13)	0.0178 (0.27)
35–44		0.1098 (2.07)	−0.1212 (2.09)
55–64		0.1664 (3.15)	0.4015 (6.63)
65–74		0.4601 (8.27)	0.7750 (8.74)
75+		0.2582 (4.27)	0.8798 (8.32)
Male		0.0654 (2.05)	−0.0452 (1.20)
Mixed		−0.2698 (0.87)	−0.2167 (0.68)
Asian		−0.2369 (1.72)	−0.2802 (1.68)
Black		−0.8466 (3.01)	−1.0920 (3.40)
Other race		−0.3835 (1.62)	−0.4147 (1.67)
Student			0.1770 (1.54)
Disabled			−1.4861 (16.43)
Unemployed			−0.9089 (−8.02)
Retired			0.0152 (0.21)
Home worker			−0.2238 (3.01)
Other LF status			0.0329 (0.17)
Married			0.3611 (5.74)
Living together			0.2382 (3.28)
Separated			−0.2083 (2.00)
Divorced			−0.1737 (2.01)
Widowed			−0.0741 (0.82)
# kids age 2+			0.0666 (2.57)
# kids age < 2			0.2972 (3.89)
Long standing illness			−0.4368 (11.67)
Sexually active			0.5294 (11.84)
Exercise			0.0087 (4.68)
Non-smoker			0.1945 (5.55)
BMI			−0.0050 (1.53)
Non-religious			−0.1553 (4.22)
Log equivalized income			0.1752 (6.46)
Constant	7.0946 (155.34)	6.8374 (116.20)	5.3943 (16.48)
Adjusted R^2	0.0195	0.0279	0.1898
N	13,938	13,898	9,761

The dependent variable is a 10-point life satisfaction score. This and later dependent variables are explained in the Appendix

Source: Scottish Health Survey, 2008–2009. Equation 3, in the third column, also includes 8 social-class dummy variables, 6 level-of-education dummy variables and 13 region dummy variables. Base categories: age 45–54; <1 portion fruit and vegetables; and employed

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Journal : Small 11205 | Dispatch : 6-10-2012 | Pages : 17
Article No. : 173 | LE | TYPESET
MS Code : SOCI1728 | CP | DISK

Being sexually active
The amount of exercise
Smoking
Body mass index (BMI)
Being religious
Income
Social class
Education
Region.

These variables again enter the study's equations with coefficients that are familiar from the broader well-being literature. The role of region in Scotland's consumption of fruit and vegetables has been studied before, for example by Shelton (2009), although with a primary emphasis on cardiovascular disease.

What emerges in the third column of Table 1 is that even after adjustments a marked fruit-and-vegetable gradient is visible in people's scores for life satisfaction. Those individuals consuming 8+ portions a day have an adjusted life satisfaction score approximately 0.27 points higher (the exact coefficient is 0.2743 with a t statistic, testing against the null of zero, of 2.85) than those who eat almost no fruit and vegetables.

It might be thought that the coefficient of 0.2743 is small. However, its size is best seen in perspective of the whole regression equation. From the coefficients of column 3 of Table 1, we can observe that this corresponds to a larger life-satisfaction increment than being a non-smoker (0.1945), is only a little less than that from being married (0.3611), and in absolute size is more than half the coefficient of having a longstanding illness (−0.4368). Being unemployed, which is known from well-being research to have routinely one of the largest effects in happiness equations, is associated with approximately −0.9 points.

Might there be confounding with the consumption of other foods? Perhaps there is no beneficial effect from eating fruit and vegetables, but rather it is simply that large numbers of portions signal that someone eats less meat and drinks less alcohol, and that meat and alcohol, say, are somehow harmful to well-being. Later we use a further data set to adjust for other dietary factors. That check is not possible in these Scottish data.

Table 2 moves to an equation that uses the new WEMWBS well-being measure. This is closer to a positive well-being score and includes hedonic and eudaimonic perspectives. The constituent parts (such as "I have been feeling optimistic" and "I have been feeling useful") are discussed in Tennant et al. (2007) and the Appendix.

The mean of the dependent variable in Table 2 is 49.8 with a standard deviation of 8.5. Once again, there is a positive association between eating fruit and vegetables and having high mental well-being. In the fully adjusted estimates of column 3 of Table 2, those people who eat 7–8 portions a day have a well-being score approximately 3 points greater than those who eat tiny amounts of fruit and vegetables. In absolute size, this is notably large. It exceeds the coefficient on being unemployed (−2.4302) and is almost half that from being disabled (−6.4178). This intriguing result suggests that further research with WEMWBS measures is desirable.

Table 3 moves to a psychiatric ill-being measure, a General Health Questionnaire GHQ score. This has been widely used in the mental health literature as an indicator of psychological morbidity (Goldberg et al. 1997; Hu et al. 2007). It is scored here on a 36-point scale and has a mean of 10.8 and a standard deviation of 5.0.

In each column of Table 3, there is again a fruit-and-vegetable gradient. In this case, mental health runs fairly flat once a person reaches 5 or more fruit and vegetable portions

Journal : Small 11205 | Dispatch : 6-10-2012 | Pages : 17
Article No. : 173 | LE | TYPESET
MS Code : SOCI1728 | CP | DISK

Table 2 Well-being regression equations (WEMWBS measure)—Scotland, 2008/2009

1–2 portions fruit and veg	1.4959 (5.30)	1.5005 (5.33)	0.9325 (3.14)
2–3 portions fruit and veg	2.7988 (10.03)	2.8405 (10.18)	1.3958 (4.71)
3–4 portions fruit and veg	3.3428 (11.77)	3.3961 (11.95)	1.5513 (5.06)
4–5 portions fruit and veg	3.6087 (12.11)	3.6772 (12.31)	1.7527 (5.46)
5–6 portions fruit and veg	4.3548 (13.38)	4.4074 (13.50)	2.2156 (6.26)
6–7 portions fruit and veg	4.3878 (11.82)	4.4434 (11.95)	1.9799 (4.99)
7–8 portions fruit and veg	5.0435 (11.56)	5.0459 (11.55)	3.0272 (6.62)
8+ portions fruit and veg	5.3713 (13.57)	5.3553 (13.52)	2.4416 (5.63)
16–24		1.1266 (3.71)	0.7737 (1.86)
25–34		0.5433 (2.01)	−0.3234 (1.04)
35–44		0.4765 (1.94)	−0.2591 (0.96)
55–64		0.7040 (2.86)	1.8415 (6.54)
65–74		1.5851 (6.07)	3.1320 (7.58)
75+		−0.5655 (1.93)	2.1010 (4.24)
Male		0.4977 (3.33)	−0.0059 (0.03)
Mixed		0.1356 (0.10)	0.3521 (0.24)
Asian		0.9885 (1.50)	1.1099 (1.43)
Black		0.1393 (0.10)	−0.5405 (0.37)
Other race		0.1909 (0.17)	−0.4467 (0.38)
Student			0.0770 (0.14)
Disabled			−6.4178 (15.24)
Unemployed			−2.4302 (4.59)
Retired			−0.0096 (0.03)
Home worker			−0.8578 (2.46)
Other LF status			2.2840 (2.50)
Married			0.6202 (2.12)
Living together			0.6193 (1.84)
Separated			−0.5815 (1.19)
Divorced			−0.4959 (1.23)
Widowed			−0.6714 (1.58)
# kids age 2+			−0.1104 (0.92)
# kids age <2			−0.6315 (1.78)
Long standing illness			−1.9021 (10.91)
Sexually active			2.5330 (12.18)
Exercise hours			0.0755 (8.73)
Non-smoker			0.6271 (3.84)
BMI			−0.0029 (0.19)
Non-religious			−0.6021 (3.52)
Log equivalized income			0.5461 (4.29)
Constant	46.9420 (216.67)	46.1228 (167.34)	41.8787 (27.35)
Adjusted R^2	0.0304	0.0357	0.1673
N	12,667	12,661	9,559

Source: Scottish Health Survey, 2008–2009. Equation 3 also includes 8 social-class dummy variables, 6 level-of-education dummy variables and 13 region dummy variables. Base categories: age 45–54; <1 portion fruit and vegetables; and employed

t statistics are given in parentheses

Journal : Small 11205 | Dispatch : 6-10-2012 | Pages : 17
Article No. : 173 | LE | TYPESET
MS Code : SOCI1728 | CP | DISK

Table 3 GHQ Psychological Morbidity Regression Equations—Scotland, 2008/2009

1–2 portions fruit and veg	−0.5927 (3.55)	−0.5726 (3.45)	−0.1602 (0.91)
2–3 portions fruit and veg	−1.0699 (6.47)	−1.0770 (6.54)	−0.3864 (2.19)
3–4 portions fruit and veg	−1.1731 (6.96)	−1.2155 (7.24)	−0.3377 (1.85)
4–5 portions fruit and veg	−1.1739 (6.65)	−1.2354 (7.01)	−0.3876 (2.04)
5–6 portions fruit and veg	−1.6559 (8.58)	−1.7236 (8.96)	−0.6770 (3.22)
6–7 portions fruit and veg	−1.6892 (7.69)	−1.7478 (7.97)	−0.5792 (2.46)
7–8 portions fruit and veg	−1.4662 (5.64)	−1.5447 (5.97)	−0.5801 (2.13)
8+ portions fruit and veg	−1.6961 (7.19)	−1.7734 (7.54)	−0.6394 (2.47)
16–24		−1.1628 (6.46)	−0.5764 (2.32)
25–34		−0.8098 (5.06)	−0.1119 (0.61)
35–44		−0.3741 (2.57)	0.0686 (0.43)
55–64		−0.7147 (4.90)	−1.1497 (6.84)
65–74		−1.3380 (8.67)	−1.7410 (7.07)
75+		−0.9125 (5.29)	−1.8838 (6.37)
Male		−0.9000 (10.17)	−0.7417 (7.07)
Mixed		−0.2124 (0.25)	−0.1558 (0.18)
Asian		0.1001 (0.26)	0.3298 (0.71)
Black		−0.6167 (0.76)	−0.0025 (0.00)
Other race		0.9521 (1.42)	0.9954 (1.43)
Student			0.3042 (0.96)
Disabled			4.6055 (18.24)
Unemployed			2.4640 (7.86)
Retired			−0.0513 (0.25)
Home worker			0.6220 (3.00)
Other Labour Force status			−0.2046 (0.37)
Married			0.1707 (0.98)
Living together			0.3136 (1.56)
Separated			1.2622 (4.36)
Divorced			0.7991 (3.32)
Widowed			1.0274 (4.04)
# kids age2+			0.0122 (0.17)
#kids age <2			−0.0356 (0.17)
Long standing illness			1.4743 (14.19)
Sexually active			−0.9862 (7.95)
Exercise hours per week			−0.0143 (2.78)
Non-smoker			−0.2856 (2.93)
BMI			−0.0026 (0.29)
Non-religious			0.1860 (1.82)
Log equivalized income			−0.3011 (3.99)
Constant	11.8229 (92.22)	12.9271 (79.40)	15.2779 (16.79)
Adjusted R^2	0.0096	0.0247	0.1446
N	12,770	12,763	9,592

Source: Scottish Health Survey, 2008–2009. Equation 3 also includes 8 social-class dummy variables, 6 level-of-education dummy variables, and 13 region dummy variables. Base categories: age 45–54; <1 portion fruit and vegetables; and employed

t statistics are given in parentheses

Journal : Small 11205 | Dispatch : 6-10-2012 | Pages : 17
Article No. : 173 | LE | TYPESET
MS Code : SOCI1728 | CP | DISK

per week (at a coefficient in the third column, after full adjustment, of approximately 0.6). The estimated effect is slightly smaller in size, when compared to coefficients on variables such as unemployment (4.6055), than in equations with the earlier well-being measures.

The final set of regressions using Scottish data is in Table 4. Here, for completeness, the dependent variable is self-reported health (*How is your health in general? Would you say it was Very Good, Good, Fair, Bad, or Very Bad*). Its mean is 4.0 and its standard deviation is 0.96. In column 2 of Table 4, where there is a limited set of controls for confounding influences, those who eat large amounts of fruit and vegetables have a better self-reported health score than other people by a substantial amount, namely, by approximately one half a point out of a possible five. Column 3 of Table 4 adjusts for the other possible confounders. Now self-reported health reaches its maximum at 7–8 portions of fruit and vegetables a day. Its coefficient is rather lower at 0.1650, with a t statistic of 3.84, but again an approximately monotonic relationship exists.

4 Controlling for Meat, Fish and Alcohol Consumption

People who are healthy in one kind of behaviour are likely to be healthy in others. A potential criticism of the equations so far is that the data set makes it impossible to control for other dietary factors such as fish- and meat-eating.

To check whether this is a difficulty, Table 5 switches to a different source of data, the 2008 Health Survey of England, in which more information about food intake is available. This HSE provides a sample of approximately 14,000 individuals who report, among other things, both their daily consumption of other foods and their alcohol intake.

Table 5 estimates GHQ mental distress equations for England. The key finding is that the existence of a fruit-and-vegetable gradient in mental well-being is unaffected by the inclusion of variables for the consumption of fish, meat and alcohol. For example, in column 3 of Table 5, those consuming 6–7 portions of fruit and vegetables a week have the best mental health (the coefficient is −0.8576 with a t statistic of 3.56). The meat and fish dummy variables are not as strong in a well-being equation as might have been anticipated. Eating no fish whatsoever, however, is associated with worse mental well-being. We tried various specifications, and all of them left the fruit-and-vegetable gradient essentially unaffected.

As perhaps might be expected, there is a non-linear relationship between mental well-being and the consumption of alcohol. Those who drink on 1–2 days a week have the lowest level of GHQ psychological disorders (in Table 5's final column). There is no statistically significant difference between the GHQ score of a non-drinker and someone who drinks alcohol almost every day.

5 Further Replication Using other Kinds of Well-Being Measures

Table 6 offers evidence from a third source of data. Here the sample is approximately 50,000 men and women who live in Wales, using merged data from the 4 years 2007–2010 of the Welsh Health Survey. Three new dependent variables are employed in Table 6. They are coded from people's answers to: *How much of the time during the past 4 weeks… (1) Have you been happy? (2) Have you been very nervous? (3) Have you felt downhearted and low? - None of the time; a little of the time; some of the time; most of the time; all of*

Journal : Small 11205 | Dispatch : 6-10-2012 | Pages : 17
Article No. : 173 | LE | TYPESET
MS Code : SOCI1728 | CP | DISK

Table 4 Self-reported health regression equations—Scotland, 2008/2009

1–2 portions fruit and veg	0.1344 (4.45)	0.1596 (5.48)	0.0429 (1.55)
2–3 portions fruit and veg	0.2421 (8.12)	0.2929 (10.16)	0.0798 (2.88)
3–4 portions fruit and veg	0.2997 (9.84)	0.3616 (12.28)	0.0954 (3.34)
4–5 portions fruit and veg	0.3460 (10.82)	0.4277 (13.81)	0.0912 (3.05)
5–6 portions fruit and veg	0.4129 (11.80)	0.4923 (14.52)	0.1362 (4.12)
6–7 portions fruit and veg	0.4097 (10.22)	0.4935 (12.71)	0.1042 (2.80)
7–8 portions fruit and veg	0.4934 (10.34)	0.5486 (11.90)	0.1650 (3.84)
8+ portions fruit and veg	0.5103 (11.82)	0.5450 (13.05)	0.1641 (4.02)
16–24		0.3486 (10.91)	−0.0283 (0.72)
25–34		0.2902 (10.18)	0.0224 (0.77)
35–44		0.1791 (6.89)	0.0204 (0.81)
55–64		−0.1682 (6.50)	0.0976 (3.69)
65–74		−0.2755 (10.11)	0.0766 (1.98)
75+		−0.4811 (16.29)	0.0079 (0.17)
Male		0.0128 (0.82)	−0.0404 (2.45)
Mixed		0.0085 (0.06)	0.0160 (0.12)
Asian		−0.1056 (1.57)	−0.1463 (2.00)
Black		0.0423 (0.31)	0.1242 (0.88)
Other race		−0.0481 (0.41)	−0.0921 (0.85)
Student			0.0581 (1.16)
Disabled			−0.9582 (24.25)
Unemployed			−0.1705 (3.44)
Retired			−0.1293 (4.06)
Home worker			−0.1634 (5.02)
Other LF status			−0.0596 (0.69)
Married			−0.0786 (2.86)
Living together			−0.0764 (2.41)
Separated			−0.0923 (2.03)
Divorced			−0.1072 (2.83)
Widowed			0.0040 (0.10)
# kids age 2+			0.0362 (3.19)
# kids age <2			0.1334 (4.00)
Long standing illness			−0.6585 (40.27)
Sexually active			0.1087 (5.56)
Exercise			0.0095 (11.67)
Non-smoker			0.1668 (10.88)
BMI			−0.0131 (9.11)
Non-religious			−0.0370 (2.30)
Log equivalized income			0.0780 (6.59)
Constant	3.7244 (161.24)	3.6954 (128.38)	3.8432 (26.88)
Adjusted R^2	0.0219	0.0944	0.3935
N	13,984	13,940	9,776

Source: Scottish Health Survey, 2008–2009. Equation 3 also includes 8 social-class dummy variables, 6 level-of-education dummy variables, and 13 region dummy variables. Base categories: age 45–54; <1 portion fruit and vegetables; and employed

t statistics are given in parentheses

Journal : Small 11205 | Dispatch : 6-10-2012 | Pages : 17
Article No. : 173 | LE | TYPESET
MS Code : SOCI1728 | CP | DISK

Table 5 GHQ psychological morbidity regression equations—England, 2008

1–2 portions fruit and veg	−0.7800 (4.41)	−0.7947 (9.70)	−0.3977 (2.02)
2–3 portions fruit and veg	−1.0267 (5.99)	−0.7838 (4.46)	−0.5674 (2.94)
3–4 portions fruit and veg	−1.1661 (6.81)	−1.0406 (6.09)	−0.5740 (2.94)
4–5 portions fruit and veg	−1.3231 (7.52)	−1.2211 (7.14)	−0.6268 (3.10)
5–6 portions fruit and veg	−1.5454 (8.18)	−1.4173 (8.06)	−0.7943 (3.64)
6–7 portions fruit and veg	−1.4924 (7.11)	−1.6550 (8.77)	−0.8576 (3.56)
7–8 portions fruit and veg	−1.2936 (5.37)	−1.6024 (7.65)	−0.4554 (1.65)
8+ portions fruit and veg	−1.4545 (6.68)	−1.4572 (6.06)	−0.6783 (2.70)
1–4		−1.4901 (9.40)	−1.5041 (6.34)
25–34		−0.7724 (5.25)	−0.6028 (3.46)
35–44		−0.4748 (3.43)	−0.2766 (1.79)
55–64		−0.5632 (4.01)	−0.7860 (4.68)
65–74		−1.0672 (6.99)	−1.5458 (6.36)
75+		−0.5590 (3.45)	−1.4561 (5.16)
Mixed		−1.5607 (7.17)	−0.2399 (0.53)
Asian		0.2641 (0.64)	−0.3374 (1.11)
Black		0.0517 (0.27)	−1.1567 (3.41)
Other race		−0.8193 (2.95)	−0.8880 (1.60)
Male		−0.3770 (0.84)	−0.3748 (3.65)
Current smoker			0.5702 (4.32)
Past smoker			0.1155 (1.07)
Married			−0.5314 (3.34)
Civil partner			2.3068 (1.11)
Separated			1.6532 (4.87)
Divorced			0.6127 (2.66)
Widowed			−0.3719 (1.47)
Living together			0.0429 (0.23)
# days vigorous exercise in week			−0.0442 (9.79)
BMI			0.0388 (4.10)
Unemployed			1.3448 (5.03)
Retired			0.7952 (4.00)
OLF			2.6407 (16.08)
Drink alcohol almost every day			−0.0050 (0.03)
Drink 5 or 6 days/week			−0.1139 (0.52)
Drink 3 or 4 days/week			−0.2000 (1.37)
Drink once or twice/week			−0.3243 (2.72)
No meat			0.1534 (0.83)
No fish			0.4096 (2.55)
Log equivalized income			−0.3966 (5.60)
Constant	11.5932 (82.61)	12.6723 (73.90)	14.8910 (17.03)
Adjusted R^2	0.0064	0.0204	0.0898
N	14,220	14,211	10,320

Source: Health Survey of England, 2008. Equation 3 also includes 7 social-class dummy variables, 7 level-of-education dummy variables, and 8 region dummy variables. Base categories: age 45–54; <1 portion fruit and vegetables; and employed

t statistics are given in parentheses

Journal : Small 11205 | Dispatch : 6-10-2012 | Pages : 17
Article No. : 173 | LE | TYPESET
MS Code : SOCI1728 | CP | DISK

Table 6 Regression equations for happiness, nervousness and 'downhearted and low'—Wales, 2007–2010

	Happy	Nervous	Downhearted/low
1–2 portions fruit and veg	0.0377 (2.16)	−0.0342 (1.86)	−0.0577 (3.02)
2–3 portions fruit and veg	0.0688 (4.07)	−0.0725 (4.06)	−0.1018 (5.52)
3–4 portions fruit and veg	0.1088 (6.55)	−0.1065 (6.07)	−0.1455 (8.01)
4–5 portions fruit and veg	0.1393 (8.32)	−0.1263 (7.14)	−0.1741 (9.52)
5–6 portions fruit and veg	0.1549 (8.89)	−0.1083 (5.89)	−0.1438 (7.55)
6–7 portions fruit and veg	0.1638 (8.74)	−0.0840 (4.24)	−0.1614 (7.88)
7–8 portions fruit and veg	0.1797 (8.71)	−0.1226 (5.63)	−0.1784 (7.91)
8+ portions fruit and veg	0.1716 (9.85)	−0.0487 (2.65)	−0.1303 (6.84)
16–24	0.1360 (7.83)	0.1227 (6.69)	−0.0342 (1.80)
25–34	0.0557 (3.80)	0.1119 (7.22)	0.0436 (2.72)
35–44	0.0046 (0.36)	0.0642 (4.63)	0.0642 (4.47)
55–64	0.1140 (8.55)	−0.1467 (10.41)	−0.1654 (11.34)
65–74	0.2239 (12.73)	−0.2625 (14.10)	−0.2946 (15.31)
75+	0.2307 (11.74)	−0.2649 (12.74)	−0.2978 (13.85)
Male	0.0911 (11.39)	−0.1834 (21.69)	−0.1870 (21.35)
Limiting illness	−0.4254 (41.86)	0.3511 (32.68)	0.4324 (38.89)
# days vigorous exercise	0.0316 (12.88)	−0.0161 (6.21)	−0.0216 (8.05)
Qualification dk/NA	−0.0418 (2.06)	0.0700 (3.24)	0.0437 (1.96)
Other qualification	0.0121 (0.60)	−0.0659 (3.08)	−0.0581 (2.63)
Degree	−0.0119 (0.55)	−0.0360 (1.56)	−0.0725 (3.03)
LF no answer	−0.1316 (4.25)	0.2270 (6.90)	0.1595 (4.69)
School	0.0586 (2.82)	0.2503 (11.39)	0.0401 (1.76)
Government scheme	0.0188 (0.29)	0.1700 (2.51)	0.0817 (1.16)
Unpaid work	−0.1663 (3.55)	0.1664 (3.34)	0.2007 (3.91)
Waiting take up work	−0.1216 (1.81)	0.2967 (4.16)	0.3028 (4.10)
Unemployed	−0.1926 (6.14)	0.2719 (8.21)	0.2847 (8.29)
Temp sick	−0.5525 (8.98)	0.6227 (9.64)	0.7497 (11.11)
Long-term sick	−0.5460 (30.41)	0.7564 (39.80)	0.7284 (37.14)
Retired	−0.0268 (1.82)	0.1159 (7.43)	0.0657 (4.07)
Home worker	−0.0449 (2.89)	0.1215 (7.39)	0.0971 (5.71)
LF other	−0.0660 (2.67)	0.2269 (8.70)	0.1092 (4.04)
BMI	−0.0022 (2.96)	−0.0004 (0.50)	0.0058 (7.02)
SE Wales	0.0400 (4.48)	−0.0487 (5.15)	−0.0490 (5.01)
Mid and West Wales	0.0710 (7.48)	−0.0568 (5.66)	−0.0670 (6.45)
Smokes now	−0.1026 (9.11)	0.0920 (7.73)	0.1365 (11.08)
Smoked ever; not now	−0.0393 (4.30)	0.0238 (2.46)	0.0636 (6.35)
Constant	3.6942 (106.64)	1.7002 (46.37)	1.8650 (49.23)
Adjusted R^2	0.1293	0.1239	0.1424
N	49,972	49,835	49,946

Source: Welsh Health Survey, 2007–2010. All equations also include 3 year-dummy variables, 7 social-class dummy variables, and 4 smoking dummy variables. Base categories: age 45–54; no qualifications; North Wales; <1 portion fruit and vegetables; and employed

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Journal : Small 11205 | Dispatch : 6-10-2012 | Pages : 17
Article No. : 173 | LE | TYPESET
MS Code : SOCI1728 | CP | DISK

the time? Here the means and standard deviations are, for the three well-being measures, as follows:

Happiness	Mean = 3.7, SD = 0.91
Nervous	Mean = 1.7, SD = 0.97
Downhearted and low	Mean = 1.9, SD = 1.01.

Despite the fact that these are different well-being dependent variables from those employed earlier, the three columns of Table 6 reveal a fruit-and-vegetables gradient of the previous kind. Well-being peaks at 7–8 portions for the happiness variable, at 4–5 portions for the nervousness variable, and at 7–8 portions for the downhearted variable.

6 Conclusions

Human beings, like all animals, are fuelled by the food and liquid they consume. Yet the literature on well-being has largely ignored the nature of people's diets.

This study is an examination of the possible connections between healthy eating and human well-being. In each of three data sets, and for seven different measures of mental well-being, we have found evidence for the existence of a positive association between well-being and fruit-and-vegetable consumption. This relationship holds both before and after correction for a large number of possible confounders. Our data sets come from Great Britain and it will be important to check such findings in a wide range of other nations (a start on that is made in US data in Blanchflower and Oswald 2011, Table 2).

This study complements a large literature on, and evidence of a long-known connection between, physical health and the consumption of fruit and vegetables. For well-being researchers, a contribution of the current study is to direct attention towards the potentially important area of variety in food consumption—and especially to the nature of different foods. In retrospect, such a point might appear a natural and even obvious one. Nevertheless, as explained earlier, it has not figured in the tradition of research on subjective well-being stretching back to, for example, the writings of Edward Diener and Richard Easterlin.

The estimated coefficients in our study are substantial. When comparing small and large levels of fruit and vegetable consumption per day, the effect corresponds—for example in the third column of Table 1—to between one quarter and one third of a life-satisfaction point. To put that in perspective, the known (huge) effect of being unemployed corresponds to −0.9 of a life-satisfaction point. Some of our estimated effects are larger.

For policy-makers and researchers, various reactions are possible. One way to respond to this evidence is to argue that the present results act to buttress the importance of the status-quo policy of so-called 5-a-day healthy-eating targets. Our findings are consistent with the need for high levels of fruit-and-vegetable consumption for mental health and not merely for physical health. In some of our regression equations, the coefficients continue to increase up to 7–8 portions a day. In a few they flatten off at, or above, 5 portions a day. In particular instances in our regression-equation tables, it is not possible to reject the null hypothesis that the coefficients in a well-being regression equation are the same between, for example, 5 portions a day and 7 portions a day. More research will be required here. Another potential response, and one that the authors of this study would themselves favour, is to argue that the present study is suggestive, that there are grounds for informing health professionals of the strength of this correlation (with caveats about the lack here of

Journal : Small 11205 | Dispatch : 6-10-2012 | Pages : 17
Article No. : 173 | LE | TYPESET
MS Code : SOCI1728 | CP | DISK

clinching causal evidence), and that the pattern deserves scrutiny in longitudinal data. A further potential reaction, and one consistent with the third, is to argue that there seem grounds here for the funding of randomized trials to explore the consequences for mental health of different levels of fruit-and-vegetable consumption.

Because of the cross-sectional nature of our data, it is sensible to emphasize, first, the need for caution in the interpretation of this study's findings, and, second, the likely desirability in the long-run of randomized controlled trials of different kinds of diets. Our findings can be at best only suggestive of any causal relationship. Nevertheless, the general avenue explored here—that of thinking harder about the types of foods consumed by human beings—appears to be a potentially valuable one for well-being researchers and perhaps also eventually for governments concerned with the ultimate happiness of their citizens. These issues merit future inquiry.

Appendix: Data Description

Scottish Health Survey

	Mean	Standard deviation
Life satisfaction	7.6266	1.8858
Warwick-Edinburgh	49.8446	8.4733
GHQ mental ill-being	10.7911	5.0023
Self-reported health	3.9902	0.9572

One portion of fruit and vegetables is 80 g of any fruit or vegetable as defined by the Department of Health. A portion of fruit includes orange juice.

Life Satisfaction Question

All things considered, how satisfied are you with your life as a whole nowadays?
0—Extremely dissatisfied
1
2
3
4
5
6
7
8
9
10—Extremely satisfied

Self-Reported Health Question

How is your health in general? Would you say it was
5…very good,

Journal : Small 11205 | Dispatch : 6-10-2012 | Pages : 17
Article No. : 173 | LE | TYPESET
MS Code : SOCI1728 | CP | DISK

4 good,
3 fair,
2 bad, or
1 very bad?

Welsh Health Survey 2008

	Mean	Standard deviation
Happiness	3.7181	0.9086
Nervous	1.6889	0.9738
Downhearted and low	1.9329	1.0136

Survey Question

These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past 4 weeks. (1) Have you been happy? (2) Have you been very nervous? (3) Have you felt downhearted and low?—none of the time; a little of the time; some of the time; most of the time; all of the time?

Health Survey of England, 2008

	Mean	Standard deviation
GHQ	10.4975	4.89

GHQ Definition

In the GHQ measure, individuals answer 12 separate mental-distress questions: "Have you lost much sleep over worry?"; "Been able to concentrate on things?"; "Felt you are playing a useful part in things?"; "Felt capable of making decisions about things?"; "Felt constantly under strain?"; "Felt you could not overcome your difficulties?"; "Been able to enjoy your normal day-to-day activities"; "Been able to face up to your problems"; "Been feeling unhappy and depressed?"; "Been losing confidence in yourself?"; "Been thinking of yourself as a worthless person?"; "Been feeling reasonably happy all things considered?". People in the surveys are asked to answer on a scale from 'much more than usual' down to 'much less than usual'.

Portions of fruit and vegetables per day (% of the population)

None	0.054
>0 portion but less than 2	0.171
2 portions or more but less than 3	0.166
3 portions or more but less than 4	0.169
4 portions or more but less than 5	0.139
5 portions or more but less than 6	0.116
6 portions or more but less than 7	0.072
7 portions or more but less than 8	0.043
8 portions or more	0.070

Journal : Small 11205 | Dispatch : 6-10-2012 | Pages : 17
Article No. : 173 | LE | TYPESET
MS Code : SOCI1728 | CP | DISK

Below are some statements about feelings and thoughts.
Please tick the box that best describes your experience of each over the last 2 weeks

STATEMENTS	None of the time	Rarely	Some of the time	Often	All of the time
I've been feeling optimistic about the future	1	2	3	4	5
I've been feeling useful	1	2	3	4	5
I've been feeling relaxed	1	2	3	4	5
I've been feeling interested in other people	1	2	3	4	5
I've had energy to spare	1	2	3	4	5
I've been dealing with problems well	1	2	3	4	5
I've been thinking clearly	1	2	3	4	5
I've been feeling good about myself	1	2	3	4	5
I've been feeling close to other people	1	2	3	4	5
I've been feeling confident	1	2	3	4	5
I've been able to make up my own mind about things	1	2	3	4	5
I've been feeling loved	1	2	3	4	5
I've been interested in new things	1	2	3	4	5
I've been feeling cheerful	1	2	3	4	5

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Journal : Small 11205 | Dispatch : 6-10-2012 | Pages : 17
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