Lower risk of incident dementia among older adults having 3 servings of vegetables and 2 servings of fruits a day

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Key points:

- Consuming at least 3 servings of vegetables or 2 servings of fruits a day might independently lower risk of dementia in older adults.

- The risk was even lower in those who had consumed at least these amounts of both, suggesting that neither vegetables nor fruits could substitute one another despite they are often viewed as the same

food group.

- Having 3 servings of vegetables and 2 servings of fruits a day in late life might help prevent

  dementia.

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ABSTRACT

Background: dietary modification can potentially reduce dementia risk, but consensus on the amount of vegetables and fruits required for cognitive maintenance is lacking. We examined whether the minimal daily requirement of vegetables and fruits recommended by the World Health Organization (WHO) as part of a healthy diet for prevention of heart diseases and stroke would help older adults prevent dementia.

Methods: in this population-based observational study, we followed the dietary pattern and cognitive status of 17,700 community-living dementia-free older adults for 6 years. In line with the WHO recommendation, we defined the cutoff for adequate intake of vegetables and fruits as at least 3 and 2 servings per day, respectively. The study outcome was incident dementia in 6 years. Dementia was defined by presence of clinical dementia in accordance with the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) or Clinical Dementia Rating of 1 to 3.

Results: multivariable logistic regression showed that the estimated odds ratios for incident dementia were 0.84 (95% confidence interval 0.70–0.99; $P<0.05$) for those consuming at least 3 servings of vegetables per day, 0.83 (0.72–0.95; $P<0.01$) for those consuming at least 2 servings of fruits per day, and 0.70 (0.57–0.87; $P=0.001$) for those consuming at least these amounts of both, after adjusting for age, gender, educational level, hypertension, diabetes, heart diseases, stroke, Parkinson's disease, and depression.

Conclusion: having 3 servings of vegetables and 2 servings of fruits a day might help prevent

dementia in older adults.

INTRODUCTION

Dementia is now a global health concern [1]. In the absence of disease modifying treatment, finding ways to prevent or slow dementia onset is of great clinical and public health importance [2–4]. Dietary modification is one non-pharmacological intervention that can potentially reduce dementia risk [5], as much evidence suggests that people who consume more vegetables have better cognition [6–11]. However, several questions remain unanswered. Although fruits are equally rich in vitamins compared to vegetables and are an important component of a healthy diet [12], their evidence of lowering dementia risk is comparatively less [6, 7, 13]. Moreover, it is uncertain how much vegetables or fruits one should eat to be regarded as having high consumption. Currently, there is no consensus on the recommended daily intake of vegetables and fruits for cognitive maintenance. To better understand how dietary modification can help prevent dementia, it is important to investigate whether vegetables and fruits could independently modify dementia risk and how much of them older adults need to eat every day.

In this study, we examined the amount of vegetable and fruit intake and followed the cognitive status of a large cohort of dementia-free older adults for 6 years. The objective was to investigate whether those consuming at least 3 servings of vegetables and 2 servings of fruits a day, which was in line with the World Health Organization (WHO) recommendation on the minimal daily requirement of vegetables and fruits for prevention of non-communicable diseases such as heart diseases, stroke, and cancer [12], were at a lower risk of incident dementia. The findings could potentially provide some insight into the daily amount of vegetables and fruits required for cognitive maintenance, and might

highlight the importance of consuming adequate amount of not only vegetables but also fruits in

dementia prevention.

METHODS

Study design and participants

The present study shared the same design and cohort as our previous study [14]. In brief, this was

a 6-year observational study of 18,298 local residents who received regular health assessment and

dementia screening at the Elderly Health Centers (EHCs) of the Department of Health of the

Government of Hong Kong between 2005 and 2011. Those who did not have re-assessment since 2008

were traced and offered a follow-up cognitive examination conducted by geriatric psychiatrists either

at the EHCs, at their homes, or by phone in 2011. Inclusion criteria for this study were age 65 years

and older, ethnic Chinese, and dementia-free. Those who lived in cared homes or had history of stroke

or Parkinson's disease were also eligible for this study. Exclusion criteria were having clinical

dementia or scoring below the education-specific cutoff on the Cantonese version of the Mini-Mental

State Examination (C-MMSE) at baseline [15].

Assessment and quantification of vegetable and fruit consumption

All participants were asked during the health assessment to describe their usual daily dietary

pattern in the past one month. Relatives or caregivers were invited to provide collateral information for

those who had difficulty in recalling their dietary habit. The amount of vegetable and fruit intake was

quantified as the number of servings of vegetables and fruits per day, which was estimated by taking

into consideration of the portion size and variety of vegetables and the amount and type of fruits that

the participants usually ate every day, with each serving equivalent to about 80 grams [16]. Please see

Appendix 1 in the supplementary data for some examples of one serving of vegetables or fruits [17].

The cutoff for adequate intake of vegetables and fruits was defined as at least 3 and 2 servings per day,

respectively, with reference to the WHO recommendation of a healthy balanced diet [12] and the

findings of a recent systematic review [13].

Covariables

Participants' demographics (age, sex, and education) and medical and psychiatric history

(hypertension, type 2 diabetes mellitus, hypercholesterolemia, heart diseases, stroke, Parkinson's

disease, body mass index, unintentional weight loss of 10% or more within a year, smoking pattern,

depression, and dementia) were examined during the health assessment. All diseases were verified and

classified by primary care physicians at the EHCs in accordance with the 10th revision of the

International Statistical Classification of Diseases and Related Health Problems (ICD-10) [18].

Identification of dementia cases

Cognitive examinations were performed as in our previous study [14]. In brief, participants

received the C-MMSE and clinical examination by physicians at the EHCs. Those with follow-up

cognitive examination by geriatric psychiatrists received clinical examination, the C-MMSE, and/or

the Clinical Dementia Rating (CDR) [19], depending on whether the interview was conducted

face-to-face or over the phone. The outcome of this study was incident dementia in 6 years. Dementia

was defined by the presence of clinical dementia in accordance with ICD-10 or a CDR of 1 to 3.

Statistical analyses

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) software version 22 (SPSS, Chicago, IL, USA). The number of participants with follow-up in 6 years was expressed as person-years [14]. The χ^2 test was used to compare the proportion of participants having adequate consumption of vegetables, fruits, or both at baseline between those with and without incident dementia. The level of statistical significance was set at P less than 0.05. To ascertain that incident dementia was associated with inadequate consumption at baseline rather than a longitudinal decrease of intake, participants developing dementia at Years 4 to 6 were selected, and the proportion of those with inadequate consumption at baseline was compared with that at Year 3 using the McNemar's test. To investigate if maintenance of adequate consumption of vegetables and/or fruits in late life was associated with lower incidence of dementia, the proportion of participants who continued having the recommended servings 3 years after baseline was compared between those with and without incident dementia at Years 4 to 6. To test if adequate vegetable and/or fruit intake was associated with a lower risk of dementia years later, the proportion of those with adequate consumption at baseline was compared between those with and without incident dementia at Years 4 to 6. Multivariable logistic regression was performed on the same subgroup to test if adequate consumption of vegetables, fruits, or both at baseline was associated with lower dementia incidence at Years 4 to 6, after adjustment for confounding factors with statistical significance of P less than 0.1. The odds ratios were computed to yield point estimates with 95% confidence intervals.

RESULTS

17,700 older adults were included in this study (Figure 1). 14,250 (80.5%) had at least one

cognitive examination since 2008, contributing to a total of 76,624 person-years of follow-up in 6

years. 1,620 (9.2%) participants developed clinical dementia in 6 years.

A larger proportion of participants reported having adequate daily consumption of vegetables,

fruits, or both at baseline in the cognitively stable group than in the incident dementia group (Table 1).

There was no increase in the proportion of participants who had inadequate intake of vegetables and/or

fruit over the first 3 years among those with incident dementia at Years 4 to 6 (see table in Appendix 2

in the supplementary data).

The proportion of participants maintaining adequate fruit intake in the first 3 years was larger in

those who remained dementia-free than in those who developed dementia at Years 4 to 6 (79.4%

versus 73.3%, P=0.04). A similar trend was observed for the association between maintenance of

adequate intake of vegetables or both vegetables and fruits and incidence of dementia, though the

result did not reach statistical significance (see table in Appendix 3 in the supplementary data).

As older people might have already experienced some cognitive impairment and thereby adopted

a relatively less healthy diet before the clinical onset of dementia, the association between vegetable

and fruit consumption and dementia risk was re-examined by excluding those who developed dementia

within 3 years after baseline. Consistent with the above findings, the proportion of participants having

adequate intake of vegetables, fruits, or both at baseline was larger in those who remained

dementia-free than in those who developed dementia at Years 4 to 6 (Table 2).

Multivariable logistic regression showed that the estimated odds ratios for incident dementia were 0.84 (95% confidence interval 0.70–0.99; $P<0.05$) for adequate consumption of vegetables, 0.83 (0.72–0.95; $P<0.01$) for adequate consumption of fruits, and 0.70 (0.57–0.87; $P=0.001$) for adequate consumption of both, after adjusting for age, gender, educational level, hypertension, diabetes, heart diseases, stroke, Parkinson's disease, and depression.

DISCUSSION

By following the cognitive status of 17,700 dementia-free older adults for 6 years, we found that having less than 3 servings of vegetables or 2 servings of fruits a day might independently increase risk of dementia. More importantly, the risk appeared to be even higher in those who had consumed less than these amounts of both. These findings suggest that not only could vegetables and fruits independently modulate dementia risk, but one could not substitute the other despite they are often viewed as the same food group. Promotion of adequate intake of both vegetables and fruits could be a potential non-pharmacological intervention for dementia prevention in older adults.

Comparison with other studies

The present findings are consistent with previous epidemiological observation that low vegetable intake is associated with cognitive decline [6–8]. Interestingly, the majority of our participants reported having adequate intake of vegetables at baseline. Although it could be argued that this is due to bias in self-reporting, consuming healthy quantities of vegetables every day might be a common practice among our participants as they were relatively health conscious and active. Under-reporting of insufficient vegetable consumption would also tend to underestimate its effect on dementia risk. Moreover, the observed association remained robust after excluding those with suspected cognitive impairment at baseline and those with incident dementia shortly after baseline. Therefore, adequate vegetable intake in late life might indeed prevent or slow dementia onset.

Contrary to the previous studies which found vegetables but not fruits slowing cognitive decline

[6, 7, 13], our study showed that consuming less than 2 servings of fruits a day was associated with a higher risk of dementia, independently of the amount of vegetable intake. Several explanations might account for the difference in findings. First, we followed the participants' cognitive status for a longer period of time. Second, we used a nurse interview instead of a self-administered questionnaire to examine the participants' dietary pattern. Third, we quantified the servings of different types of fruits and vegetables. Another key difference is that the present study sample was made up of Chinese older adults only, whose prevalence of Apolipoprotein E4 (ApoE4) genotype is known to be low [20]. It would be interesting to see if the observed association is also found in older people of other ethnic groups with low ApoE4 prevalence.

Another major finding of this study is that insufficient consumption of both vegetables and fruits was associated with a higher risk of dementia than inadequate intake of either one alone. It could be argued that the observed association is mediated by malnutrition, which is known to impair cognitive function [21]. However, the prevalence of weight loss in our cohort was low, with no significant difference observed between the dementia-free and incident dementia groups. Also, the BMI of our cohort was not low. Therefore, older adults with limited intake of vegetables and fruits might still be at risk of incident dementia in the absence of malnutrition.

Proposed mechanisms of how vegetables and fruits modulate dementia risk

Although we were unable to address how vegetables and fruits independently modulate dementia risk in this study, we speculate that inadequate intake might exacerbate onset of clinical dementia

through various mechanisms. First, vegetables and fruits are rich sources of nutrients, including vitamin B, vitamin E, flavonoids, and beta-carotenoids, which have antioxidant and anti-inflammatory properties. As oxidative stress and inflammation are thought to be involved in the development and progression of dementia [22], with animal studies showing that deficiency of these bioactive compounds could aggravate the dementia pathologies [23–26], not eating enough vegetables or fruits might decrease resilience against the neurodegenerative processes. Second, this vegetable- and fruit-mediated cognitively beneficial effect is likely dependent on the bioavailability of multiple bioactive compounds, rather than a single nutrient. Indeed, taking dietary supplements has not been consistently found to be effective in preventing dementia in older adults [27, 28]. Third, an additive or synergistic interaction might exist between vegetables and fruits [29], as our data showed that the risk of incident dementia was higher in those with inadequate intake of both than of either one alone. With numerous types of nutrients present in different parts of a plant, it is plausible that the cognitive benefit could be best achieved when both vegetables and fruits are consumed. All these potential mechanisms might explain insufficient intake of either vegetables or fruits alone increasing dementia risk.

Limitations and strengths

One major limitation of observational studies of dietary effect on cognition is that the dietary pattern might change during the study period; therefore, it could be argued that the elevated risk of incident dementia is due to a longitudinal decrease of vegetable and/or fruit intake. Nevertheless, we did not find any increase in the proportion of participants with inadequate vegetable or fruit intake over

the years. Interestingly, the association between maintenance of adequate vegetable intake and

dementia prevention did not reach statistical significance. Because most of our participants reported

consuming healthy quantities of vegetables every day, we speculate that while sufficient intake at

baseline might help protect against dementia, the additional cognitive benefit brought by maintenance

of adequate vegetable consumption might be limited by a ceiling effect.

This study has other limitations. Given the nature of the study design, we could not make an

inference about a causal relationship between inadequate vegetable and fruit intake and development

of dementia. The possibility of reverse causation, such as the effect of baseline cognitive capacity on

the choice of diet, and the effect of unmeasured factors, such as duration of dietary habit practicing

prior to this study, could not be completely excluded in this study. Also, care needs to be taken when

applying our findings to the general older population as the participants of this study were relatively

health conscious. Other lifestyle factors might be confounders of the observed association.

Regarding the strengths of this study, we followed a large territory-wide community cohort for a

long period of time. The attrition rate was low, with the majority of participants having a recent

cognitive examination. Also, we quantified in sufficient detail the vegetable and fruit intake at baseline

and at follow-up.

Conclusion

This study presents evidence for inadequate intake of not only vegetables but also fruits being a

potential risk factor for dementia in older adults. It also adds some insight to the daily amount of

vegetables and fruits required for dementia prevention. As a public health promotional strategy, the

need for a balanced diet on cognitive health should be duly emphasized in the older populations.

Future studies should investigate the underlying mechanisms of the observed association.

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Declaration of source of funding

Conflict of interest

None.

Ethical approval

This study was approved by both the Ethics Committee of the Department of Health of the Government of Hong Kong and the Joint Clinical Research Ethics Committee of the Chinese University of Hong Kong and the New Territories East Cluster of the Hospital Authority.

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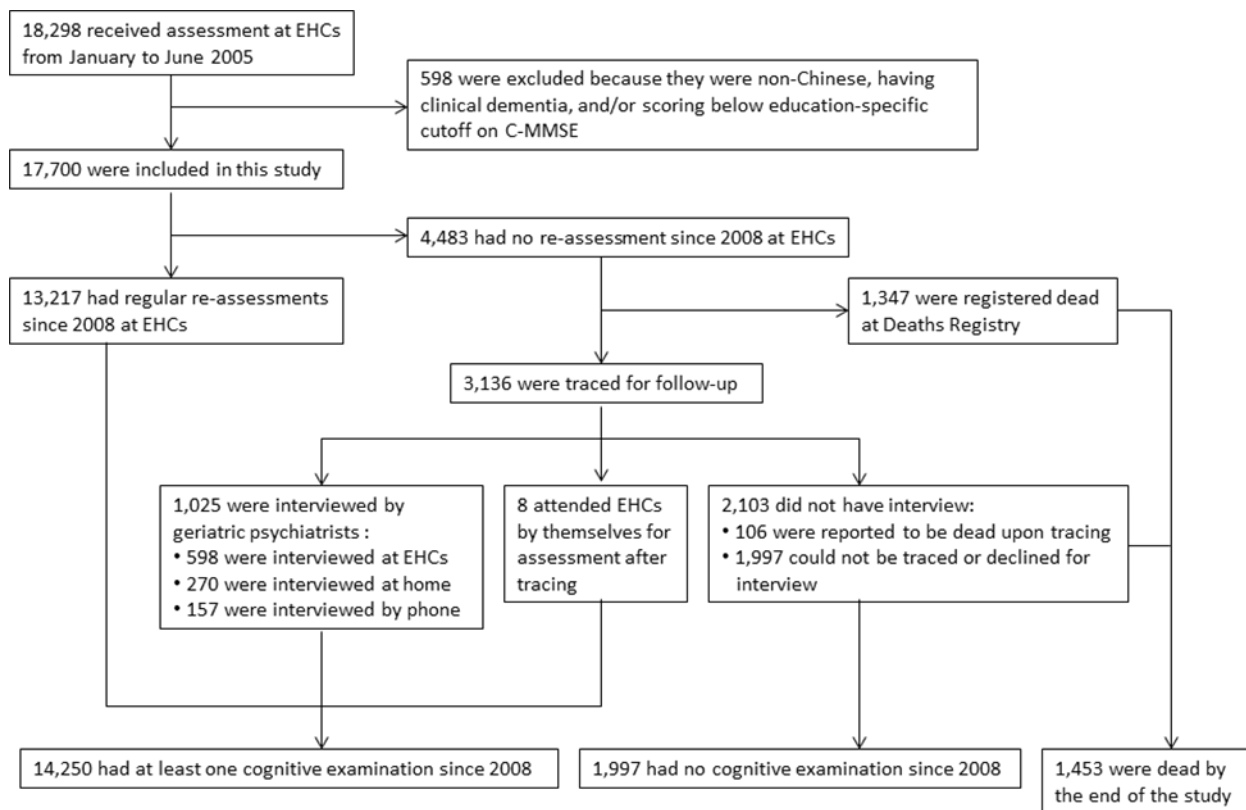
FIGURE AND TABLES

Figure 1. Flow diagram of inclusion and follow-up of participants in this study.

EHCs, Elderly Health Centres; C-MMSE, Cantonese version of the Mini-mental State Examination

Table 1. Comparison of baseline characteristics between participants who remained dementia-free and those who developed dementia in six years.

	Incident dementia		Statistics (P-value)
	No (n=16,080)	Yes (n=1,620)	
Age, years (interquartile range)	74 (71–77)	76 (73–80)	<0.001*
Female, n (%)	10,087 (62.7)	1,166 (72.0)	<0.001†
No schooling received, n (%)	4,151 (25.8)	606 (37.4)	<0.001†
Hypertension, n (%)	10,386 (64.6)	1,137 (70.2)	<0.001†
Diabetes mellitus, n (%)	2,460 (15.3)	286 (17.7)	0.01†
Hypercholesterolemia, n (%)	6,711 (41.7)	689 (42.5)	0.54†
Heart disease, n (%)	1,876 (11.7)	237 (14.6)	<0.001†
Stroke, n (%)	525 (3.3)	98 (6.0)	<0.001†
Parkinson's disease, n (%)	68 (0.4)	13 (0.8)	0.03†
Depression, n (%)	643 (4.0)	102 (6.3)	<0.001†
Body mass index, kg/m^2 (interquartile range)	24.0 (21.8–26.2)	24.0 (21.8–26.3)	0.54*
Weight loss, n (%)	150 (1.2)	20 (1.6)	0.22†
Daily smoking, n (%)	833 (5.2)	76 (4.7)	0.40†
Adequate vegetable intake, n (%)	13,028 (81.0)	1,279 (79.0)	0.04†
Adequate fruit intake, n (%)	8,899 (55.3)	817 (50.4)	<0.001†
Adequate vegetable and fruit intake, n (%)	7,808 (48.6)	718 (44.3)	0.001†

*Mann-Whitney U-test; $^{\dagger}\chi^2$ test

Table 2. Association between adequate vegetable and/or fruit intake at baseline and future risk of incident dementia at Years 4 to 6.

	Incident dementia		Statistics*
	No	Yes	(*P*-value)
	(n=11,838)	(n=880)	
Adequate vegetable intake, n (%)	9,848 (83.2)	700 (79.5)	<0.01
Adequate fruit intake, n (%)	6,796 (57.4)	460 (52.3)	<0.01
Adequate vegetable and fruit intake, n (%)	6,042 (51.0)	407 (46.3)	<0.01

* χ^2 test

Appendix 1

One serving of vegetables was defined as 1/2 bowl of cooked leafy vegetables (e.g. Chinese kale, spinach, and cabbage), 1/2 bowl of cooked gourds, 1/2 bowl of mushrooms, 1/2 bowl of beans or peas, or 1 bowl of raw leafy vegetables (lettuce and purple cabbage).

One serving of fruits was defined as 1 piece of medium-sized fruit (orange, apple, and pear), 2 pieces of small-sized fruit (plum and kiwi), 1/2 piece of large-sized fruit (banana, dragonfruit, and starfruit), 1/2 bowl of mini-sized fruit (grapes, cherries, and strawberries), or 1/2 bowl of cut fruit (papaya and watermelon).

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Appendix 2

Longitudinal changes of proportion of participants who were not eating enough vegetables and/or fruits over the first three years among those with incident dementia at Years 4 to 6 (n=330).

	Baseline	Year 3	Statistics[*] (P-value)
Vegetables, n (%)	65 (19.7)	64 (19.4)	1.00
Fruits, n (%)	139 (42.1)	135 (40.9)	0.77
Vegetables and fruits, n (%)	168 (50.9)	157 (47.6)	0.32

[*]McNemar's test

Appendix 3

Comparison of proportion of participants maintaining adequate vegetable and/or fruit consumption in the first three years between those with and without incident dementia in the following three years.

	Incident dementia		Statistics*
	No	Yes	(*P*-value)
Vegetables, n (%)	5,472 (90.4)	236 (89.1)	0.46
Fruits, n (%)	3,365 (79.4)	140 (73.3)	0.04
Vegetables and fruits, n (%)	2,827 (75.1)	116 (71.6)	0.32

* χ^2 test