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ORIGINAL PAPER

An apple a day: Protective associations between nutrition and the mental health of immigrants in Canada

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Abstract

Purpose Mental illness represents a major public health burden among Canada's large immigrant population. A burgeoning cross-sectional, longitudinal, and experimental evidence base implicates nutrition in mental health. Healthier diets (e.g., those rich in certain micro-nutrients) may benefit cognitive, social, and emotional functioning through attenuated inflammation and other bio-psychological pathways. The present study examined associations between nutrition and three markers of mental health among immigrants to Canada.

Methods Employing cross-sectional data from immigrant respondents ($n = 37{,}071$) to a nationally representative population-based survey (the Canadian Community Health Survey: CCHS 2011–2014), we modelled associations of daily fruit and vegetable consumption with three mental health outcomes: anxiety and/or mood disorder diagnosis, being distressed (assessed via the 6-item Kessler Psychological Distress Scale), and having good self-rated overall mental health. Multivariable logistic regression analyses were employed, adjusting for various socio-demographic and lifestyle-related variables.

Results Higher consumption of fruit and vegetables demonstrated significant, protective associations with odds of having a mood and/or anxiety disorder, being distressed, and self-rated good mental health. Such patterns of association were similar regardless of ethno-cultural minority status and recency of immigration. Moreover, the protective associations of nutrition and mental health were independent of socio-demographic, health, and lifestyle factors.

Conclusions Results suggested evidence of protective associations between healthy nutritional intake and mental illness among a large-scale sample of immigrants in Canada. Importantly, the protective associations of healthier diets with immigrants' mental health were independent of various markers of healthy lifestyles (e.g., general health status, physical activity, alcohol use). Healthy dietary intake may, therefore, be worth consideration in efforts to prevent mental illness among immigrants.

Keywords Nutrition · Diet · Immigration · Mental health · Canada

Introduction

In recent years, around a quarter of a million individuals have immigrated to Canada annually [1]. In 2016, immigrants comprised 22% of Canada's population (over 7.5 million people) and almost 40% of youth in Canada were foreign-born or had at least one foreign-born parent [2]. The majority of recent newcomers to Canada originate from Asia; China, India, and the Philippines are the commonest source nations [1]. Despite this subpopulation's demographic significance, and recognition of immigration as a determinant of health, epidemiological evidence concerning immigrant populations in Canada (and in many major resettlement nations) is overshadowed by extant evidence for the overall/general population [3].

There is no health without mental health—mental disorders account for almost one-third of years lived with disability globally [4], and approximately one in three residents of Canada suffer a mental illness in their lifetime [5]. Despite some mixed findings in the literature—some of which are partly a product of differential healthcare utilization [6] as well as cultural attitudes/stigma concerning western medical

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care [7]—mental health problems are a major concern for Canada's immigrants. Moreover, immigrants may face specific risk factors, such as ethnic prejudice, social stigma, cultural/language barriers, and acculturation- and migration-related stress, that contribute to poor mental health [8]. Indeed, immigrant mental health is recognized as a major public health issue in Canada [9]. Examining the role of factors (and especially modifiable factors) associated with immigrants' mental health in Canada is thus important.

Nutritional psychiatry

In addition to important pharmacological and psychotherapy advances in the treatment and management of mental illnesses, an emergent literature has garnered focus on non-pharmacological, malleable factors (e.g., physical activity; [10]) that may modify one's likelihood of suffering mental health problems and hence help inform preventive efforts. A convincing evidence base indicates protective influences of healthy, nutritional diets (e.g., those rich in fruits, vegetables, whole grains, with little intake of processed or high-sugar foods) for physical health such as cardiovascular diseases and cancers [11]. Nutrition has a central role in the prevention of (and recovery from) many cardiovascular conditions—an influence that is well-established and accepted in public health [12]. Nutrition may, however, also have a key role in the prevention of *mental* illnesses [13].

Dietary intake affects the functioning of the immune system and antioxidant defence systems, and both systems can affect mental health [14, 15]. Nutritional intake is well-known to impact inflammation—a process that affects mental health [16]. Additionally, nutrition can affect gut microbiota, and inflammation has been linked to mental illness via the gut–brain axis [14]. Accordingly, there is a subfield of psychiatry termed 'nutritional psychiatry' [17] and several studies have examined or advocated for nutrient-based interventions in the management and treatment of mental health conditions, whether as lifestyle changes or as nutraceuticals [18, 19]. In recent decades, growing and convergent findings from observational [20], prospective [21, 22], and experimental research [23, 24], as well as meta-analyses [25, 26], together suggest healthy diets may be implicated in protecting against mental illness.

Although dietary patterns greatly vary across regions and cultures, the bulk of extant nutritional psychiatry literature appears to point to protective associations based on the so-called 'traditional' diets, which are rich in fruits and vegetables but lacking in processed and high-sugar content foods [21]. A 'Western' diet is contrasted to the traditional diet, as it tends to lack fruits or vegetables and is often characterized by higher levels of processed foods. Little work, however, has examined how diet among immigrants to Canada (mostly from non-Western regions) may relate to mental health outcomes. A recent scoping review of diet and immigration in Canada identified 49 articles yet only 1 (a qualitative study) considered associations of diet with migrants' mental health [27]. Moreover, the review's authors advocated for further work to document how immigrants' dietary patterns may implicate mental health.

The present study

In light of Canada's large immigrant population and the burden of mental illness, it is important to examine how a modifiable factor such as nutrition may relate to mental health using large-scale, population-based data representing Canada's foreign-born population. It is also important to assess whether such associations may vary according to two immigrant factors: ethno-cultural minority status (as most minority respondents are likely of non-Western heritage), and time since immigration (a crude marker of exposure to Canadian society, including dietary norms). Therefore, three main research questions guided the present study: How does healthier diet relate to immigrants' mental health?; Does length of time since migration impact associations between nutrition and immigrants' mental health?; Does ethno-cultural minority status differentiate associations between nutrition and immigrants' mental health?

Method

Data source

All data were obtained from the public-use datafiles of the Canadian Community Health Survey (CCHS), a national health survey administered annually via computer-assisted interviews [28, 29]. CCHS data represent ~ 98% of the Canadian populace aged ≥ 12 years; the CCHS excluded institutionalized, full-time Canadian military persons, on-reserve Aboriginal residents, and residents of certain remote regions. Survey interviewers with diverse language competencies were employed to help mitigate language barriers. The combined yearly (2011–14) CCHS administrations comprised 252,391 respondents; each administration yielded a response rate of approximately 87%. Detailed information on the CCHS is available elsewhere [28, 29].

Measures

Nutrition. On the CCHS, respondents indicated how frequently they consumed fruits and vegetables, based on nutrition-related items from the Behavioural Risk Factor Surveillance System [30]. Interviewers preceded these

questions with the statement: "The next questions are about the foods you usually eat or drink. Think about all the foods you eat, both meals and snacks, at home and away from home". Specifically, participants were asked to respond to the following questions (each with a range of 0–20): "Not counting juice, how often do you usually eat fruit?"; "How often do you (usually) eat green salad?"; "How often do you (usually) eat carrots?"; "Not counting carrots, potatoes, or salad, how many servings of other vegetables do you usually eat?". Participants were asked to provide a temporal context to their response as they were prompted: "For example: once a day, three times a week, twice a month". Regardless of the time unit used by the participants (per day, per week etc.), the interviewer categorized the number of times per day each substance (e.g., green salad) was consumed. Additional items asked about juice and potato consumption. Fruit juices often lack several nutritionally beneficial properties of fruit (e.g., fiber), often contain added sugars/sweeteners, and are not—per se—considered central to healthy dietary intake. Potatoes typically have fewer nutritional benefits than other (root) vegetables, and are more likely to be consumed in unhealthy formats (e.g., as potato chips or fries) than other vegetables. Thus, our composite nutritional intake variable was a summation of combined fruit and vegetable consumption (FVC) on a daily basis, excluding potato or fruit juice consumption. We modeled the FVC in terms of quartiles whereby the lowest quartile served as the reference. This approach was chosen as it enabled assessment of a potential dose–response association between diet and mental health, it permitted evaluation of the nature of the relationship (e.g., linear, U-shaped, or otherwise) and quartiles of diet/nutritional intake have been previously used to model nutrition [20, 31].

The CCHS-based measure of FVC has been found to be a useful measure of overall diet quality, since greater daily FVC corresponded to higher scores on more in-depth assessments of diet quality based on a score based on detailed servings-based information regarding the adequacy of one's healthy food intake (including fruits, vegetables, and whole grains) and the moderation of one's unhealthy food intake (including sodium and saturated fats) across 11 components [32]. Relatedly, the daily FVC measure has exhibited expected associations with a range of health outcomes (e.g., positively associated with healthful outcomes) [33].

Mental health. Three variables were employed to represent mental health: mood and/or anxiety disorder diagnosis, distress level, and self-rated overall mental health status. The presence of either disorder was based on responses (yes/no) to the queries: "Do you have an anxiety disorder such as a phobia, obsessive–compulsive disorder or a panic disorder?" and "Do you have a mood disorder such as depression, bipolar disorder, mania or dysthymia?". Before answering, interviewers reminded participants: "Remember, we're interested in conditions diagnosed by a health professional and that are expected to last or have already lasted 6 months or more". Anxiety and mood disorders together represent the commonest classes of disorders for which mental health services are sought in Canada [34]. Information about respondents' use of psychiatric medication was unavailable. Distress level was based on summed score on the 6-item Kessler Psychological Distress Scale (K-6). A cut-point of ≥ 6 was chosen as it has exhibited reasonable levels of both sensitivity (0.88) and specificity (0.84) for 1-month major depression in a general Canadian sample [35]. To assess positive mental health, good self-rated mental health was derived from responses to the item "In general, would you say your mental health is…?". Responses of Excellent, Very Good, or Good were categorized as good mental health while responses of Fair or Poor were categorized as poor mental health. This single-item measure has been supported by prior validity evidence as a useful marker of overall mental well-being [36].

To examine whether patterns of associations between immigrants' diet and mental health varied according to immigration-relevant factors, associations were stratified according to: recency of immigration, and ethno-cultural minority status. In the public CCHS files used for analyses, time since immigration was collapsed into a dichotomous variable indicating: < 10 years (recent immigrant), and ≥ 10 years (long-term immigrant). Minority individuals were those who self-reported as having an ethno-cultural identity that was non-white/Caucasian. Participants were prompted: "People living in Canada come from many different cultural and racial backgrounds. Are you … ?". In the public CCHS files, responses were collapsed into a dichotomous variable – indicating white or (visible) minority ethno-cultural identity. For reference, ~60% of immigrants to Canada in recent decades originated from Asia; China, India, and the Philippines are the three largest source nations for recent migrants to Canada [1].

Covariates. To more accurately estimate associations of nutrition and mental health among immigrants, we adjusted for the following demographic confounders known to relate to mental health and/or nutrition: sex (male, female), age (≤ 19, 20–34, 35–49, ≥ 50 years), marital status (married/common-law, widowed/separated/divorced, never married), household income (CAD $), and number of children in the household (none or at least one child). Educational attainment was not included as a covariate because education may be an inconsistent marker of socio-economic level for immigrants in Canada since immigrant populations in Canada do not necessarily have their educational qualifications recognized. To account for possible health and lifestyle factors that may confound associations, we additionally adjusted for smoking, physical activity, alcohol use, perceived general health, and presence of chronic conditions. Smoking status was categorized as: daily smoker, occasional smoker, and

non-smoker. Physical activity was based on self-reported typical daily hours of energy expended in leisure activities (e.g., playing sports, running) within the preceding 3 months [29]. Specifically, mean daily energy expenditure was estimated according to the duration, frequency, and nature of physical activities reported. Respondents were categorized as Active if their mean daily expenditure was at least 3 kcal/kg, as Moderately Active if their mean daily expenditure was between 1.5 and 2.9 kcal/kg, and as inactive if their expenditure was < 1.5 kcal/kg. For instance, walking for exercise is estimated to expend 3 kcal/kg per hour whereas playing basketball is estimated to expend 6 kcal/kg per hour. Further details on the physical activity index are specified elsewhere [37]. Alcohol use, based on the last 12 months, was categorized as: Regular drinker (drank alcohol once a month or more frequently), occasional drinker (drank alcohol less than once a month), and non-drinker (no alcohol consumed in the last 12 months). Perceived general health was a variable indicating whether respondents self-rated their overall health as excellent, very good, good, fair, or poor (responses were dichotomized as excellent/very good/good, and fair/poor). A composite of chronic conditions was derived to indicate whether a person had Chronic Obstructive Pulmonary Disease (COPD), diabetes, heart disease, and/or cancer.

Analytic approach

Analyses were conducted in SAS 14 [38], using multivariable logistic regression with survey weights applied. Access to and analysis of data was in accordance with the University of British Columbia's clause regarding usage of public datasets [39]. Logistic regression was employed to model associations of FVC with odds of having poor mental health; separate models were estimated for the three outcomes: (1) mood and/or anxiety disorders, (2) distress, and (3) self-rated good mental health. Strata-specific models were performed for each outcome and each immigrant characteristic (white/minority/recent/long-term). Crude and adjusted odds ratios (ORs) were reported; 95% confidence intervals (CIs) were estimated for all ORs.

Results

The sample (n = 37,071) is characterized in Table 1. Approximately 80% of respondents had lived in Canada for at least 10 years while 43% self-identified as belonging to a visible/ethnic minority group. Slightly over half of the respondents were female, almost 60% of respondents were aged 55 or older, and approximately 60% were married or common-law. Most respondents were non-smokers, most did not have a chronic illness, and approximately half were classified as physically active. Daily FVC was classified into quartiles, associated with the following mean frequencies: Q1/lowest = 1.2, Q2 = 2.6, Q3 = 3.9, Q4/highest = 6.7.

Diet-mental health associations stratified by immigrants' ethno-cultural minority status

Results of the unadjusted and adjusted logistic regression analyses, stratified by visible minority status, are displayed in Table 2. For both white and minority immigrants, unadjusted associations suggested evidence of significant protective/inverse associations between higher FVC and having a mood and/or anxiety disorder or showing distress, as well as positive associations between FVC and odds of self-rated good mental health. After adjustment for covariates, associations weakened slightly but generally remained significant. Relative to those of the lowest level (quartile) of FVC, respondents with higher FVC levels had significantly lower odds of Mood and/or Anxiety disorders (aOR range for white respondents: 0.68–0.83; aOR for minority respondents: 0.66).

Odds of having distress were significantly lower for immigrants with higher FVC, for both white immigrants (aOR range 0.71–0.74) and minority immigrants (aOR: 0.77). Concerning the positive mental health variable, odds of reporting good mental health were between 19–23% higher for white immigrants who had higher FVC relative to those with the lowest level of FVC. Similarly, a positive association between FVC and the odds of reporting good mental health was observed among minority immigrant respondents (aOR: 1.26). Generally, the pattern of associations was similar for white and minority respondents in terms of the protective associations between higher FVC and odds of having adverse mental health across the three mental health outcomes.

Diet-mental health associations stratified by recency of immigration

When considering time since immigration (Table 3), unadjusted analyses suggested protective associations of higher FVC with mental health and these patterns generally remained following adjustment for covariates. Significant protective associations were observed between higher FVC and lower odds of having an anxiety and/or mood disorder for both recent (aOR range 0.52–0.72) and long-term immigrants (aOR range 0.74–0.83). Whereas no significant association between FVC and the odds of being distressed was evident among recent immigrants, evidence of significant protective associations between higher FVC was present for long-term immigrants (aOR range 0.73–0.81). Similarly, higher FVC demonstrated no evidence of significant associations with higher odds of reporting good mental health for recent immigrants

Table 1 Analytic sample of immigrant respondents to the 2011–2014 Canadian Community Health Survey

	Overall ($n = 37,071$)	Mental health status		
		Mood and/or Anxiety disorder ($n = 3157$)	Distress ($n = 1288$)	Good self-rated mental health ($n = 33,689$)
	n (%)	%	%	%
Recency of migration				
Recent (< 10 years)	6883 (19.7)	10.3	22.7	20.6
Long-term (≥ 10 years)	28,122 (80.3)	89.7	77.3	79.4
Racial background				
White	21,069 (57.4)	70.6	50.5	43.2
Minority	15,643 (42.6)	29.4	49.5	56.8
Sex				
Male	16,640 (44.9)	35.9	39.4	44.6
Female	20,431 (55.1)	64.1	60.6	55.4
Age				
12–19 years	2334 (6.3)	3.8	8.9	6.6
20–34 years	3382 (9.1)	6.6	12.7	9.5
35–54 years	9801 (26.4)	21.3	31.2	27.4
≥ 55 years	21,554 (58.1)	68.4	47.2	56.5
Marital status				
Married or common-law	21,650 (58.6)	49.7	46.2	59.0
Divorced, separated or widowed	7786 (21.1)	30.4	24.1	20.7
Never married	7521 (20.4)	20.0	29.7	20.2
Household Income				
Under $20,000	4128 (11.2)	18.8	20.9	10.4
$20,000–$39,999	9122 (24.6)	27.9	25.2	24.0
$40,000–$59,999	7376 (19.9)	19.4	12.9	19.9
$60,000–$79,999	5330 (14.4)	11.7	20.9	14.7
≥ $80,000	11,078 (29.9)	22.3	20.9	31.0
Children in the household				
No	29,180 (78.7)	86.4	75.5	77.9
Yes	7891 (21.3)	13.7	24.5	22.1
Chronic illnesses				
None	35,954 (97.0)	95.5	95.5	97.4
At least one chronic illness	1103 (3.0)	4.5	4.5	2.6
Physical Activity				
Active	9736 (27.2)	22.5	19.5	24.3
Moderately active	8603 (24.0)	20.7	20.6	27.8
Inactive	17,506 (48.8)	56.8	59.9	48.0
Smoking status				
Daily smoker	3158 (8.5)	17.0	15.2	8.2
Occasional smoker	1221 (3.3)	4.1	5.8	3.4
Non-smoker	32,678 (88.2)	79.0	78.9	88.5
Perceived overall health				
Excellent/very good/good	31,828 (85.9)	36.1	69.5	89.5
Fair/poor	5243 (14.1)	64.9	30.5	10.5
Alcohol use status				
Regular drinker	18,319 (49.7)	47.8	44.5	50.6
Occasional drinker	6299 (17.1)	17.8	18.7	17.1
Non-drinker (no alcohol use in last 12 months)	12,267 (33.3)	34.4	36.9	32.6

Good self-rated mental health = self-perceived mental health rated as excellent, very good, or good (rather than fair or poor)

Table 2 Odds ratios (95% confidence intervals) relating diet and immigrants' mental health, stratified by minority status

Variables	White immigrants ($n=21,069$)						Minority immigrants ($n=15,643$)					
	Mood and/or anxiety		Distress		Good self-rated mental health		Mood and/or anxiety		Distress		Good self-rated mental health	
	uOR	aOR	uOR	aOR	uOR	aOR	uOR	aOR	uOR	aOR	uOR	aOR
Fruit/vegetable intake (ref: Q1/lowest)												
Q2	**0.69** (0.61 0.78)	**0.83** (0.73 0.95)	**0.74** (0.59 0.92)	**0.74** (0.58 0.93)	**1.36** (1.16, 1.59)	1.08 (0.91, 1.28)	**0.55** (0.45 0.67)	**0.66** (0.54,0.82)	0.83 (0.67, 1.03)	0.90 (0.72, 1.12)	**1.34** (1.10,1.62)	1.14 (0.93,1.41)
Q3	**0.56** (0.50, 0.63)	**0.68** (0.60, 0.78)	0.82 (0.67, 1.01)	0.87 (0.70, 1.09)	**1.61** (1.38, 1.88)	**1.19** (1.00, 1.47)	**0.65** (0.54, 0.78)	0.85 (0.70,1.04)	**0.68** (0.54, 0.85)	**0.77** (0.61, 0.97)	**1.33** (1.10,1.60)	1.02 (0.83,1.25)
Q4/highest	**0.60** (0.53, 0.67)	**0.76** (0.66, 0.89)	**0.61** (0.49, 0.76)	**0.71** (0.56, 0.90)	**1.89** (1.61, 2.22)	**1.23** (1.02, 1.47)	**0.73** (0.61, 0.86)	0.95 (0.78,1.16)	**0.68** (0.55, 0.85)	0.82 (0.65, 1.04)	**1.70** (1.40,2.08)	**1.26** (1.01,1.58)

uOR unadjusted odds ratio, *aOR* adjusted odds ratio. Bolding denotes $p<.05$. Analyses were adjusted for sex, age, marital status, physical activity level, chronic illness, household income, perceived health status, children living in household, smoking status, and alcohol use. The n for each strata-specific model varied slightly due to missing data with covariates

Good self-rated mental health = self-perceived mental health rated as Excellent, Very Good, or Good (rather than Fair or Poor)

Table 3 Odds ratios (95% confidence intervals) relating diet and immigrants' mental health, stratified by recency of migration

Variables	Recent immigrants ($n=6,864$)						Long-term immigrants ($n=28,122$)					
	Mood and/or anxiety		Distress		Good self-rated mental health		Mood and/or Anxiety		Distress		Good self-rated mental health	
	uOR	aOR	uOR	aOR	uOR	aOR	uOR	aOR	uOR	aOR	uOR	aOR
Fruit/vegetable intake (ref: Q1/lowest)												
Q2	**0.49** (0.35 0.70)	**0.52** (0.36 0.75)	0.92 (0.66 1.27)	0.98 (0.70 1.37)	1.25 (0.87, 1.78)	1.06 (0.72, 1.57)	**0.68** (0.61 0.76)	**0.83** (0.73 0.93)	**0.75** (0.63 0.90)	**0.77** (0.64 0.93)	**1.32** (1.16,1.51)	1.07 (0.92,1.23)
Q3	**0.68** (0.50, 0.92)	**0.72** (0.52, 1.00)	0.82 (0.59, 1.12)	0.89 (0.64, 1.26)	**1.52** (1.05, 2.21)	1.19 (0.79, 1.79)	**0.59** (0.53, 0.66)	**0.74** (0.66, 0.84)	**0.74** (0.62 0.88)	**0.81** (0.68 0.98)	**1.47** (1.29,1.67)	1.08 (0.93,1.24)
Q4/highest	**0.73** (0.54, 0.98)	0.75 (0.55, 1.03)	0.80 (0.57, 1.12)	0.90 (0.64, 1.26)	**1.57** (1.08, 2.30)	1.16 (0.76, 1.76)	**0.63** (0.57, 0.70)	**0.82** (0.73, 0.93)	**0.61** (0.51 0.73)	**0.73** (0.60 0.88)	**1.83** (1.60,2.10)	**1.22** (1.05,1.42)

uOR unadjusted odds ratio, *aOR* adjusted odds ratio. Bolding denotes $p<.05$. Analyses were adjusted for sex, age, marital status, physical activity level, chronic illness, household income, perceived health status, children living in household, smoking status, and alcohol use. The n for each strata-specific model varied slightly due to missing data with covariates

Good self-rated mental health = self-perceived mental health rated as Excellent, Very Good, or Good (rather than Fair or Poor)

yet FVC related to higher odds of reporting good mental health for long-term immigrants (aOR: 1.22).

Among all significant associations observed across the various immigrant strata, there was little evidence of dose–response trends between FVC and odds of adverse mental health after adjustment for covariates as the point estimates were generally similar in magnitude or else inconsistent in magnitude (increasing in some instances, decreasing in other instances) across the three levels of FVC. Moreover, 95% confidence intervals associated with the point estimates representing levels of FVC often overlapped considerably.

Sensitivity analyses

To examine the robustness of observed protective associations between FVC and mental health, we stratified associations of FVC to the three mental health markers among immigrants according to sex, age, and income (see Appendices). Generally, similar patterns of associations were observed for male, female, younger, older, low-income, and high-income immigrant respondents; higher FVC was associated with lower odds of having a mood and/or anxiety disorder, distress, or reporting good mental health. Across the three mental health outcomes, three exceptions occurred. (1) higher FVC related to higher odds of good self-rated mental health among females but no evidence of association was found for males (we note, however, that the point estimates for males were almost identical to those for females); (2) higher FVC was associated with higher odds of reporting good mental health among lower income (household income < CAD $40,000) (not but among higher income (≥ $40,000) immigrants (significant aORs ranged 1.23–1.53); (3) evidence of significant associations between FVC and good self-rated mental health was found among older aged (but not younger aged) immigrants (significant aORs ranged: 1.17–1:30).

Several additional sets of analyses (results available by request) were performed to examine the sensitivity of findings. When fruit consumption per se and vegetable consumption per se were modelled as exposures, patterns of associations with mental health were comparable to those obtained from using FVC. Also, when an indicator of social support (perceived sense of belonging to community, a factor related to Canadian immigrants' mental health [40]) was controlled for (in addition to all other covariates), a similar pattern of associations remained. We also note that similar patterns of associations were observed when modelling mood disorders and anxiety disorders separately (tables available on request).

Discussion

Understanding malleable factors associated with the mental health of Canada's growing immigrant population is important as such evidence can support programming efforts geared at preventing mental illness specifically, and the burden of disease in general. This study yielded evidence of protective associations between healthier dietary intake and markers of mental health (common mental conditions, psychological distress, and good self-rated mental health) among a population-based sample of immigrants in Canada. Moreover, these associations were independent of diverse demographic, socio-economic, and healthy lifestyle factors—suggesting nutrition's relationship to the mental health outcomes was likely not merely an artifact of a generally healthier lifestyle (e.g., physical activity, smoker status, alcohol use status).

The present findings agreed with those from an expanding body of literature suggesting protective associations between healthier diets and mental health problems [13]. Moreover, observed associations were similar for immigrants who were visible minorities, white, recent, or long-term—suggesting the consistency and coherence of the findings. Recent meta-analyses confirmed evidence of protective relationships of healthier nutrition intake—for which fruits and vegetables form a core component—and various mental health outcomes including: depression [26, 41], bipolar disorder [42], and psychiatric symptoms among persons with schizophrenia [43]. A recent randomized control trial found dietary changes were associated with symptom improvement among adults suffering major depression [23]; similar improvements were observed in an open-label trial of children with attention deficit/hyperactivity disorder following a micro-nutrient treatment [44].

This study offered no consistent evidence of a dose–response association between FVC and any mental health outcome among immigrants. A related cross-sectional study of the general Canadian population also found no evidence indicating a dose–response pattern relating higher FVC to incrementally lower likelihood of common mental disorders and distress [20]. In contrast, a meta-analysis of mostly cohort studies found a pooled association suggestive of a dose–response pattern for healthier nutritional intake and depressive symptoms [41]. Higher adherence to a Mediterranean diet (rich in FVC, whole grains, and fish) was associated with lower likelihood of depression than moderate adherence, and the moderate adherence diet pattern was related to a significantly reduced likelihood of depression relative to those with low or no adherence to the Mediterranean-style diet [41].

A lack of a dose–response relationship may have been due to the cross-sectional nature of the study, or may

have pertained to the limited exposure assessment. FVC denoted counts/frequency of fruits and vegetable consumption without specific information about the portion/serving size. Hence each 'time' a fruit/vegetable was consumed may have represented varying portion sizes—which would undermine accurate assessment of an incrementally increasing dosage of exposure. Moreover, the CCHS lacked specific nutritional information about one's overall diet. Knowledge of which other healthy foods were consumed (foods such as whole grains, nuts), as well as knowledge of consumption of unhealthy foods, would have better characterized the exposure measure beyond solely fruit and vegetable intake, which in turn might have enabled a better quantification of a dose–response relationship. On the other hand, results nevertheless suggested that immigrants in Canada may attain mental health benefits from even consuming fruits and/or vegetables multiple times daily relative to those with a low daily FVC (mean daily FVC in the lowest quartile was 1.2). This pattern was similar to other cross-sectional survey results for the general Canadian populace [20].

Limitations

The cross-sectional nature of the study denied assessment of directionality or causal pathways relating nutritional intake to mental health. In particular, reverse causation may have occurred, whereby poor mental health may have led to poorer nutritional intake. Indeed, numerous studies document worse diets among persons suffering mental illnesses and some persons with mental problems report that consuming unhealthy (e.g., high-sugar) foods as providing relief from their symptoms [45]. One longitudinal study, however, specifically examined whether reverse causation was the driver of associations between nutrition and depression [46]. These authors found counter-intuitive results in that persons who had sought treatment for depression had higher scores on a healthy diet index—while persons who no longer suffered depression at follow-up had higher scores on the healthy diet measure. In support of the claim that nutritional intake leads prospectively to mental health, randomized control trials [23, 24] have documented protective relationships between healthier dietary intake and mental health over time. Considering the extant nutritional psychiatry literature as a whole, it appears that associations between diet and mental health may be bidirectional. Nevertheless, we echo the assertion of Jacka et al. [46] that the bidirectionality of such an association—as with the association of exercise and mental health [10]—does not undermine the value of nutrition in supporting mental health.

Enhanced information about the immigrant respondents (e.g., specific ethno-cultural identity, details on psychological and dietary acculturation) would better contextualize findings. Our sample comprised a relatively small proportion of persons who migrated recently (many had lived in Canada for at least a decade), and hence better representation of how nutrition affects mental health outcomes among recent immigrants to Canada is important. Although minority respondents in the present sample likely originated mostly from non-Western nations (especially Asian nations), considerable variation in mental health outcomes as well nutritional intake exists by cultural background. Greater acculturation/ identification with the host culture is associated with dietary acculturation—a trend of increasingly adopting western diets—while psychological acculturation is known to implicate mental health outcomes for migrants. For instance, immigrants in Canada that report a greater sense of belonging to Canada have greater perceived mental health [47]. The ways in which changes in dietary patterns relate to immigrants' mental health outcomes in Canada is poorly understood [27].

Stigma concerning mental health problems likely led to under-reporting of diagnosed mental disorders. Immigrants, especially from certain regions, are known to under-utilize Canadian healthcare services. For instance, among respondents with suicide ideation, those of a Chinese-background were less likely than white respondents to have accessed mental health services [48]. In Canada, estimates of mood and anxiety disorders based on self-reported diagnoses yielded lower estimates of prevalence (for the general Canadian population) than estimates based on medical administrative records; this gap did, however, narrow from 2003 to 2009, suggesting mental health stigma may be attenuating [34]. Such patterns between self-report and administrative record based mental health prevalence are, however, were not examined for Canada's immigrant population. Despite the probable underestimation of mood and anxiety disorders by immigrant respondents to the CCHS, it is unlikely that such underestimation was systematically related to certain dietary patterns, hence this reporting concern likely had a minimal impact on the main findings.

The self-reported nature of various variables (FVC, smoking, alcohol use, physical activity) may have been subject to reporting biases whereby participants underreported undesirable behaviors and exaggerated socially desirable behaviors such as physical activity and healthy diets. Despite the inclusion of various socio-demographic, health, and lifestyle variables serving as confounders, it is still possible that FVC represented a marker of an overall healthy lifestyle. As a cross-sectional, observational study, it was not possible to isolate the specific effect of FVC on mental health outcomes.

Strengths of the present study

This investigation was the first to document evidence of associations between diet and various indicators of mental health among Canada's foreign-born residents. Data were sourced from a large-scale, population-based survey with a rigorous and well-supported sampling design that is representative of virtually the entire Canadian population. Population-based psychiatric epidemiological evidence concerning Canada's immigrant population is scarce. By including a marker of a mental illness (the widely used K-6 scale) not based on diagnosis by a health provider, an estimate of mental health independent of health service use was represented—which was important given immigrants' underutilization of health services. Considerable validity evidence supports meaningful interpretation of K-6 scores as an indicator of non-specific psychological distress (especially for depressive and anxious symptoms) across diverse subpopulations of participants [49, 50], and thus psychological distress is an important contributor to the disease burden attributed to mental illness. The inclusion of a marker of positive well-being—good self-rated mental health—was a novel contribution, as many prior nutritional psychiatry studies have focused on indicators of mental ill-being (e.g., internalizing conditions [25, 26]). Moreover, the present study identified evidence that a potentially modifiable factor—nutritional intake—matters to immigrants' mental health. Indeed, calls have been made for lifestyle modifications to be more commonplace as a means of supporting mental health [51].

Future directions

A clear future research topic related to the present study could be a more detailed examination of how different subtypes of healthy diets among immigrants impact mental health. As a parallel, a recent analysis of associations between physical activity and mental health identified how different forms and doses of activity (e.g., walking, specific sports, gym/aerobic activities) related to mental health of over 1 million respondents in the United States [10]. It would also be important to consider the role of culture, and dietary acculturation in relationships of diet to mental health since commonly consumed foods vary markedly by cultures. Understanding whether nutritional intake may moderate common mental health risks faced by immigrants (e.g., discrimination, migration-related stress) would be useful. Moreover, understanding how healthy diet relates to the health of specific immigrant groups in terms of their source nation (e.g., those from India, China, or the Philippines) may also be informative given cultural variations in dietary behaviors.

Conclusions

This study employed population-based datasets from a national Canadian health survey to examine evidence of associations between nutritional intake and immigrants' mental health. Higher nutritional quality of immigrants' diet, operationalized as more frequent fruit and vegetable consumption, exhibited significant protective associations with three mental health outcomes. Associations were similar regardless of immigrants' recency of migration or minority status and associations were independent of various socio-demographic, health, and lifestyle factors.

Although additional controlled and prospective studies of immigrant populations are required to complement the present study's results, this study provides evidence of a potentially key preventive role of nutrition for mental health among immigrant residents of Canada. Nutrition may have a salient protective role for supporting the mental health of immigrants in Canada, and public health programming may benefit from educating newcomers to Canada about the importance of consuming fruits and vegetables to both their physical and mental health. Health practitioners may also consider encouraging newcomers to consume fruits and vegetables as a compliment to effective therapies to support their mental health.

Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical considerations The authors declare no conflicts of interest. This study contains secondary data analysis of publicly available data from the Canadian Community Health Survey.

Appendix

See Tables 4, 5, and 6.

Table 4 Adjusted odds ratios (95% confidence intervals) relating diet and immigrants' mental health, stratified by sex

Variables	Mood and/or anxiety distress		Distress		Good self-rated mental health	
	Male	Female	Male	Female	Male	Female
Fruit/vegetable intake (ref: Q1/lowest)						
Q2	0.89 (0.73, 1.03)	**0.74** (0.64, 0.86)	0.85 (0.67, 1.08)	**0.81** (0.65, 1.00)	1.13 (0.93 1.36)	1.06 (0.88 1.28)
Q3	**0.82** (0.68, 0.99)	**0.69** (0.60, 0.79)	0.79 (0.61, 1.03)	0.85 (0.69, 1.04)	1.11 (0.91, 1.35)	1.12(0.93, 1.34)
Q4/highest	0.88 (0.72, 1.07)	**0.77** (0.67, 0.88)	0.80(0.61, 1.06)	**0.75** (0.60, 0.92)	1.21 (0.98, 1.51)	**1.23** (1.03, 1.48)

Bolding denotes $p < .05$. Analyses were adjusted for sex, age, marital status, physical activity level, chronic illness, household income, perceived health status, children living in household, smoking status, alcohol use. The n for each strata-specific model varied slightly due to missing data with covariates

Good self-rated mental health = self-perceived mental health rated as Excellent, Very Good, or Good (rather than Fair or Poor)

Table 5 Adjusted odds ratios (95% confidence intervals) relating diet and immigrants' mental health, stratified by age group

Variables	Mood and/or anxiety distress		Distress		Good self-rated mental health	
	Age < 40 years	Age ≥ 40 years	Age < 40 years	Age ≥ 40 years	Age < 40 years	Age ≥ 40 years
Fruit/vegetable intake (ref: Q1/lowest)						
Q2	**0.76** (0.59, 0.98)	**0.79** (0.69, 0.89)	0.97 (0.76, 1.25)	**0.73** (0.60, 0.90)	1.14 (0.84 1.54)	1.09 (0.94 1.27)
Q3	0.84 (0.66, 1.07)	**0.71** (0.62, 0.80)	0.78 (0.60, 1.02)	0.84 (0.69, 1.03)	0.93 (0.69, 1.24)	**1.17** (1.01, 1.35)
Q4/highest	0.98 (0.78, 1.25)	**0.77** (0.68, 0.87)	**0.76** (0.58, 0.99)	**0.77** (0.62, 0.94)	0.96 (0.71, 1.31)	**1.30** (1.12, 1.52)

Bolding denotes $p < .05$. Analyses were adjusted for sex, marital status, physical activity level, chronic illness, household income, perceived health status, children living in household, smoking status, alcohol use. The n for each strata-specific model varied slightly due to missing data with covariates

Good self-rated mental health = self-perceived mental health rated as Excellent, Very Good, or Good (rather than Fair or Poor)

Table 6 Adjusted odds ratios (95% confidence intervals) relating diet and immigrants' mental health, stratified by income

Variables	Mood and/or anxiety distress		Distress		Good self-rated mental health	
	Lower income (< $40,000)	Higher income (≥ $40,000)	Lower income (< $40,000)	Higher income (≥ $40,000)	Lower income (< $40,000)	Higher income (≥ $40,000)
Fruit/vegetable intake (ref: Q1/lowest)						
Q2	**0.71** (0.61, 0.84)	0.87 (0.74, 1.01)	0.84 (0.67, 1.06)	**0.79** (0.64, 0.99)	1.16 (0.97 1.39)	1.01 (0.83 1.23)
Q3	**0.68** (0.58, 0.80)	**0.80** (0.68, 0.93)	0.88 (0.69, 1.11)	**0.79** (0.64, 0.98)	**1.23** (1.03, 1.47)	0.99(0.81, 1.20)
Q4/highest	**0.69** (0.59, 0.82)	0.93 (0.80, 1.09)	**0.72**(0.55, 0.92)	**0.79** (0.63, 0.98)	**1.53** (1.26, 1.86)	0.99 (0.81, 1.21)

uOR unadjusted odds ratio, *aOR* adjusted odds ratio. Bolding denotes $p < .05$. Analyses were adjusted for sex, age, marital status, physical activity level, chronic illness, perceived health status, children living in household, smoking status, alcohol use. The n for each strata-specific model varied slightly due to missing data with covariates

Good self-rated mental health = self-perceived mental health rated as Excellent, Very Good, or Good (rather than Fair or Poor)

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