Dietary intake and habits of South Asian immigrants living in Western countries

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Previous reviews have indicated that immigration from South Asian to Western countries leads to unhealthy changes in diet; however, these reviews have been limited by the methods used in some included studies. This critical narrative review summarizes findings from original research articles that performed appropriate statistical analyses on diet data obtained using culturally appropriate diet assessment measures. All studies quantitatively compared the diets of South Asian immigrants with those of residents of Western or South Asian countries or with those of South Asian immigrants who had varying periods of time since immigration. Most studies examined total energy and nutrient intake among adults. Total energy intake tended to decrease with increasing duration of residence and immigrant generation, and immigrants consumed less protein and monounsaturated fat compared with Westerners. However, findings for intakes of carbohydrate, total fat, saturated fat, polyunsaturated fat, and micronutrients were mixed. Studies that examine food group intake and include South Asians living in South Asia as a comparison population are needed.

INTRODUCTION

South Asians account for approximately 25% of the world's 7.3 billion individuals.¹ Although the majority of South Asians reside in South Asia (India, Pakistan, Bangladesh, Sri Lanka, Nepal, Bhutan, Afghanistan, or the Maldives), increasingly more South Asians reside in Western countries (North and South America, Western Europe, Australia, and New Zealand). South Asians represent the largest nonwhite ethnic group in the United Kingdom² and Canada,³ constituting approximately 5% of each country's total population, and are among the fastest-growing ethnic groups in the United States⁴ and New Zealand.⁵ While population growth among residents partially explains this rise in prevalence, immigration is also a key factor, as South Asians are one of the 3 largest immigrant groups to the United Kingdom,⁶ Canada,³ the United States,⁷ and New Zealand.⁵

Compared with whites of the same body mass index, South Asians are at increased risk of type 2 diabetes and cardiovascular disease.⁸ Immigration by South Asians to a Western country results in new exposures to food availability and to cultural norms of food preparation methods.⁹ These exposures, along with other lifestyle influences, are thought to encourage changes in dietary habits,¹⁰ leading immigrants to experience excess weight gain that elevates their risk of obesity¹¹ and related chronic diseases.^{12,13} Dietary change following immigration has been identified as a potential modifiable risk factor for obesity and obesity-related disease in this population.¹⁴

Three previous reviews have summarized the diets of South Asian immigrants living in Western countries, but 1 was based on a very small number of studies⁹ and 2 were largely qualitative.^{10,15} Furthermore, the study design and statistical analysis methods used in the

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reviewed studies were not examined to ensure that the effects of known confounders of the associations under study were considered. In addition, none of these reviews critically evaluated the diet methodology to ensure that instruments were culturally appropriate.^{9,10,15}

The purpose of this review is to update and extend previous reviews of diet in South Asians who immigrate to a Western country, with careful attention given to crucial aspects of study methodology. Limitations of relevant studies that failed to conduct appropriate statistical analyses or use culturally relevant diet assessment measures are identified. The findings of only those studies that met the criteria for quality evaluation are then summarized. The aim was to present a critical, rather than systematic, review of the literature.¹⁶

Search process

Details of the literature search process are shown in Figure 1. Briefly, the PubMed and Web of Science databases were searched for studies that examined diet in South Asians following immigration to Western countries. The review was limited to relevant articles published between January 1, 1990, and April 18, 2016. Observational studies and interventions that analyzed baseline data were retained if participants were recruited from the general population and if original diet data was used to quantitatively compare South Asian immigrants with a Western population, with other South Asian immigrants living in the same Western country, or with South Asians living in South Asia. Four publications presented diet data from the same cohort^{17–20}; only the one that analyzed diet data with ethnicity as the main exposure was retained.¹⁷ This process resulted in the identification of 42 articles for further review.

Critical review of statistical analyses

Previous literature has identified age and sex as important confounders of comparisons of diets of recent vs long-term South Asian immigrants^{9,21} and of South Asian immigrants vs Westerners.^{22–24} Given these associations, studies were required to either adjust for or stratify by age and sex in order to be included in the summary of key comparisons. Of the 42 articles, 6 were excluded because no statistical analysis of the diet data was presented. Thirteen were excluded because they reported only crude analyses without adjustment for any covariates. Four additional studies did not adjust for age. Following these exclusions, 19 articles were retained for review of diet assessment methodology.

Critical review of diet assessment methods

Table 1^{17,21–38} shows descriptive information on the 19 studies that were reviewed for diet methodology, arranged by the comparison population. Table 2^{17,21–59} summarizes the development and validation of the diet assessment measures implemented in the remaining 19 relevant articles, organized by the diet methodology used. The following methods were used to collect diet data: (1) food diaries; (2) single 24-hour recalls; (3) food frequency questionnaires (FFQs); and (4) other questionnaires. Different methods were used in each publication except in instances in which the data were from the same study. Three articles by Pomerleau et al.^{24,30,31} used data from the same cohort, 2 of which described intakes of different macronutrients and 1 of which reported intakes in servings and as a percentage of persons meeting dietary recommendations.²⁴ Bharmal et al.,³³ Sarwar et al.,³⁵ and Becerra et al.³⁸ reported similar aspects of diet using overlapping years of data from the same survey and used different comparison groups.

In any study of diet, it is important that strong assessment methodology be used, and for the topic of the present review it was also crucial that the diet data collection method be sensitive to cultural differences in food consumption. Food diaries collect dietary intake data by having participants write down all foods consumed over a prespecified period of time.⁶⁰ There are no restrictions on the types of foods to be recorded,⁶⁰ and thus the method has high utility across cultures. Three studies collected dietary information using either a 7-day^{26,27} or 4-day²³ food diary. The studies that collected data for 7 days required participants to weigh or measure the foods and beverages consumed,^{26,27} and the remaining study instructed participants to estimate or measure the amounts consumed.²³ Information on the development and validation of the food diaries was generally not provided. Sachan and Samuel²³ adapted (in an unspecified manner) a food diary previously developed for pregnant and postpartum adolescents,⁶¹ but no information on validation was given.

Although food diaries are an established method of diet assessment,⁶² the accuracy of information obtained using either a weighed or an estimated food diary in a population of immigrants may be limited by literacy and familiarity with measurement tools and systems.⁶⁰ Anderson et al.,²⁶ Sevak et al.,²⁷ and Sachan and Samuel²³ all addressed this concern by providing participants with written or oral instructions on how to use the diaries and the household measures and food scales, as appropriate. These 3 studies also incorporated follow-up visits or calls (during the recording period or after completion of diet assessment to address participant questions, clarify unclear records, and probe for

Figure 1 Flow diagram of the literature search process.

potentially forgotten foods. Given these measures, all 3 studies were retained in the final summary.

Similar to the food diary, the 24-hour recall usually does not limit the types of foods reported.⁶⁰ This assessment is usually administered by an interviewer, with the interviewer leading the participant through an oral report of all foods eaten in a specified 24-hour period.⁶⁰ Two studies included in the present review used a single 24-hour recall to assess dietary intake.^{17,32} Although multiple days of recall are strongly preferred, the use of a single 24-hour recall is appropriate for the purpose of describing average dietary intake at the group level.⁶⁰ Donin et al.¹⁷ used an interviewer-administered 24-hour recall (that was adapted for children³⁹) and obtained detailed information on ethnic-specific foods.

Interviews were conducted in English, which was the language taught in school to all children who participated in the study.¹⁷ Parackal et al.³² used a computer-assisted 24-hour recall (with verbal assistance in South Asian languages, including Hindi and Punjabi⁴⁰) with a closed list of foods. This list was generated using foods frequently consumed in New Zealand⁴⁰ and could have excluded foods regularly consumed by South Asian immigrants. For that reason, the study of Parackal et al. was excluded,³² but the study of Donin et al. was retained.¹⁷

Seven studies collected dietary data using an FFQ, 5 of which used semiquantitative FFQs^{21,24,29–31} and 2 of which measured intake frequency without indicating the amount consumed.^{25,34} Because FFQs rely on a

Table 1 Description of the 19 studies of diet in South Asian immigrants that met criteria for relevance and statistical analysis

Reference	Comparison population(s)	Western country	Sample size	Percent male	Age (y)	Ethnicity	Country of origin	Immigrant generation
Simmons & Williams (1997) ²⁵	European	UK	304 308	43 52	≈ 54 ≈ 43	European South Asian	–	–
Anderson et al. (2005) ²⁶	European	UK	35 72 35 37	0 0 0 0	28 ≈ 29 31 27	European South Asian 1st-gen South Asian 2nd-gen South Asian	I, P, B	1st/2nd
Sevak et al. (1994) ^{27,a}	European	UK	81 92	100 100	40–64 40–64	European South Asian	I, P, B	–
Stone et al. (2007) ^{22,a}	White European	UK	409 2460	– –	11–15 11–15	European South Asian	–	–
Donin et al. (2010) ^{17,a}	White European	UK	543 558	50 47	9–10 9–10	European South Asian	I, P, B, SL	–
Smith et al. (2012) ^{28,b}	White European	UK	8353 2298 368 349 395 475 351 360	48 ≈ 45 43 46 46 46 47 45	36 ≈ 32 38 33 36 27 33 24	European South Asian 1st-gen Indian 2nd-gen Indian 1st-gen Pakistani 2nd-gen Pakistani 1st-gen Bangladeshi 2nd-gen Bangladeshi	I, P, B	1st/2nd
Ghai et al. (2012) ²⁹	White American	USA	50 425 579	100 100	≈ 58 ≈ 58	American South Asian	I	1st/≥ 2nd
Sachan & Samuel (1999) ^{23,a}	White American Indians living in South Asia	USA India	23 31 27	0 0 0	29–69 26–59 28–69	American South Asians in USA South Asians in South Asia	I	–
Pomerleau et al. (1997) ²⁴	Canadian	Canada	29 458 163	49 –	41 –	Canadian Indian	I	1st
Pomerleau et al. (1998) ³⁰	Canadian	Canada	29 458 163	49 –	41 –	Canadian Indian	I	1st
Pomerleau et al. (1998) ³¹	Canadian	Canada	29 458 163	49 –	41 –	Canadian Indian	I	1st
Parackal et al. (2015) ^{32,b}	NZ European/other Western residence < 10 y ≥ 10 y (ref)	NZ NZ	2728 130 74 54	47 57 50 52	≈ 46 ≈ 39 – –	New Zealander South Asian	I, P, B, SL, N, A	–
Bharmal et al. (2015) ^{33,b}	Western residence 0 to < 5 y residence 5 to < 10 y residence 10 to < 15 y residence ≥ 15 y residence (ref)	USA	1169 144 217 219 589	58 – – – –	40 – – – –	South Asian	I, P, B, SL, N, BH	1st
Talegawkar et al. (2016) ²¹	Western residence 1st tertile 2nd tertile 3rd tertile (ref)	USA	874 298 293 283	53 52 51 56	56 51 54 62	South Asian	I, P, B, SL, N	–
Wandel et al. (2008) ³⁴	Western residence ≤ 10 y residence (ref) > 10 y residence	Norway	629 – –	58 – –	42 – –	South Asian	P, SL	1st
Sarwar et al. (2015) ^{35,b}	Western residence < 15 y residence (ref) > 15 y residence	USA	398 – –	– – –	≈ 39 – –	South Asian	I, P, B, SL ³⁸	1st/≥ 2nd
Lesser et al. (2014) ³⁶	Western residence ≤ 13.8 y (ref) 13.9–21.1 y 21.2–32.1 y ≥ 32.2 y	Canada	121 32 32 32 25	≈ 52 62 59 39 47	≈ 48 46 44 49 53	South Asian	I, P, B, SL, N	1st

(continued)

Table 1 Continued

Reference	Comparison population(s)	Western country	Sample size	Percent male	Age (y)	Ethnicity	Country of origin	Immigrant generation
Chiu et al. (2012) ³⁷	Western residence < 15 y residence (ref) ≥ 15 y residence	Canada	3364 1791 1573	52 50 53	– – –	South Asian	I, P, B, SL	–
Becerra et al. (2014) ^{38,b}	Western residence 1st gen (ref) 2nd gen 3rd gen	USA	1352 1125 208 17	56 – – –	38 – – –	South Asian	I, P, B, SL	1st/2nd/≥ 3rd

Abbreviations and symbols: A, Afghanistan; B, Bangladesh; BH, Bhutan; gen, generation; I, India; N, Nepal; NZ, New Zealand; P, Pakistan; ref, referent group; SL, Sri Lanka; UK, United Kingdom; USA, United States of America; –, information not provided or available; ≈, approximations based on weighted averages of frequencies within given sexes or age ranges.

^aOnly age ranges were provided for each group of interest.

^bSample characteristics based on survey-weighted frequencies.

closed list of foods that may not capture items usually consumed by South Asian immigrants, the quality of studies that use them depends on whether the authors created, adapted, or validated their FFQ for use in a sample of South Asian immigrants.^{60,63,64} Talegawkar et al.²¹ and Wandel et al.³⁴ both adapted existing FFQs to ensure that they appropriately captured the diet of South Asians. They pilot tested previously developed FFQs using South Asians living in Canada²¹ or Norway,³⁴ adding and removing items as needed. Talegawkar et al.²¹ translated the modified FFQ into 2 South Asian languages (Hindi or Urdu),⁴² while Wandel et al.³⁴ provided the modified written FFQ in either English or Norwegian,⁴⁴ with verbal assistance provided in English, Norwegian, Urdu, Punjabi, or Tamil. The original questionnaires were validated for the general population⁶⁵ or for natives of each country,⁴³ but only the FFQ used by Talegawkar et al.²¹ was validated following alteration.⁴¹ Nevertheless, both the Wandel et al.³⁴ and the Talegawkar et al.²¹ studies were retained in the final summary.

The other 5 articles that measured diet using an FFQ were not included in the final summary of results.^{24,25,29–31} Simmons and Williams²⁵ administered the FFQ in participants' native language, but they did not provide information on the development or validation of the measure. Thus, it was unclear whether the FFQ was appropriate for use in a population of South Asian immigrants. Similarly, Ghai et al.²⁹ and Pomerleau et al.^{24,30,31} did not develop or validate their FFQs using a South Asian population or provide the questionnaires in languages commonly spoken by South Asians.^{45,46}

Studies that used instruments that captured focused aspects of diet, rather than overall diet, or that asked about diet-related behaviors such as food preparation were also included in this review. In this context, the necessity for inclusion of culturally appropriate foods is less imperative if assessment of all foods consumed or

all foods in a category (eg, fruits) was not the goal. Wandel et al.³⁴ and Lesser et al.³⁶ used a list of questions with the purpose of assessing changes in intakes of specific foods, food categories, or food habits since immigration, rather than changes in overall diet.^{44,66} Both studies offered the questionnaire in Punjabi,⁴⁷ with Wandel et al.³⁴ providing additional verbal assistance in other South Asian languages. Lesser et al.³⁶ did not adapt the instrument for use in South Asian populations, but Wandel et al.³⁴ modified their questionnaire as previously mentioned, on the basis of a pilot study among South Asians. Both studies were retained in this review, but the discussion of the findings of Lesser et al.³⁶ will be limited to those related to food preparation, given that the authors assessed consumption of entire food categories without adapting the instrument for South Asians.

Smith et al.²⁸ administered an eating habits questionnaire in 5 South Asian languages (Gujarati, Hindi, Punjabi, Urdu, and Bengali) in 1999 and 2004.^{48,49} The 2004 questionnaire was shorter than the 1999 questionnaire and was supplemented with interviewer-administered questions about the previous day's fruit and vegetable consumption.^{48,49} The process used for the development of the eating habits questionnaire was not reported, but prompts and examples included ethnic-specific foods commonly consumed by South Asian populations.^{48,49} Therefore, this study was retained in the summary.

Five other studies that administered questionnaires were not included in the summary of results.^{22,33,35,37,38} Three of these (Bharmal et al.,³³ Sarwar et al.,³⁵ and Becerra et al.³⁸) assessed specific food categories using selected questions from the California Health Interview Survey, but the questionnaire was not developed or validated in South Asians and was not provided in languages commonly spoken by South Asians.^{50–53} Chiu et al.³⁷ used selected questions from the Canadian Community Health Survey, intending to measure usual fruit and vegetable intake. Although the questionnaire was translated into 25 languages, it was not adapted to

Table 2 Diet assessment methods used in the 19 studies of diet in South Asian immigrants that met criteria for relevance and statistical analysis

Reference	Diet assessment measure	Development of assessment measure	Validity of assessment measure	Languages offered
Sevak et al. (1994) ^{27,a}	7-d weighed food diary	Not reported	Not examined	–
Anderson et al. (2005) ²⁶	7-d weighed food diary	Not reported	Not examined	–
Sachan & Samuel (1999) ^{23,a}	4-d food diary	Modified original diary developed for pregnant and postpartum adolescents	Not examined	–
Donin et al. (2010) ¹⁷	Single 24-h recall	Followed recommendations of Nordic Cooperation Group of Dietary Researchers and included elements of the USDA multiple-pass method. Adapted for children. ³⁹	Not examined	Verbal interview in English
Parackal et al. (2015) ^{32,a}	Single 24-h recall	Closed list of foods/beverages based on those regularly consumed in New Zealand ⁴⁰	Not examined	Verbal assistance in English, Maori, Samoan, Tongan, Chinese, Korean, Hindi, and Punjabi ⁴⁰
Talegawkar et al. (2016) ²¹	Study of Health Assessment and Risk in Ethnic groups semiquantitative FFQ	Modified FFQ from Canadian Study of Diet, Lifestyle, and Health using multiple 24-h recalls or single 24-h recall + 4-d diet records from 29 South Asian immigrants ⁴¹	Validated against 7-d food record in 58 South Asian immigrants. Pearson <i>r</i> for macronutrients ranged from 0.45 (grams of protein) to 0.64 (grams of saturated fat) ⁴¹	Written FFQ in English, Hindi, and Urdu ⁴²
Wandel et al. (2008) ³⁴	Modified Oslo Health Study (HUBRO) FFQ and questionnaire on dietary change	Pilot-tested HUBRO FFQ in a group of 130 Pakistani immigrants. Questionnaire on dietary change was then created on the basis of the significance of foods in terms of health benefits and adoption of Norwegian food habits	Original HUBRO FFQ validated for ethnic Norwegians ⁴³ . Details on sample size, comparison method, or statistical results of the validation study were not reported. Validity of questionnaire on dietary change not examined	Written FFQ in English and Norwegian, ⁴⁴ plus verbal assistance in English, Norwegian, Urdu, Punjabi, and Tamil
Simmons & Williams (1997) ²⁵	FFQ	Not reported	Not examined	Written FFQ in native language, plus verbal assistance in native language
Ghai et al. (2012) ²⁹	Women's Health Initiative semiquantitative FFQ	Based on FFQs from the Women's Health Trial, Women's Health Trial Vanguard Study and Full-Scale Studies, Working Well Trial, and the Women's Health Trial Feasibility Study in Minority Populations	Validated for macro- and micronutrient intake against 4-d food records and 4 d of 24-h recalls in 113 white, African American, and other women in the USA. Pearson <i>r</i> for macronutrients ranged from 0.36 (grams of protein) to 0.62 (percent total fat) ⁴⁵	–

(continued)

Table 2 Continued

Reference	Diet assessment measure	Development of assessment measure	Validity of assessment measure	Languages offered
Pomerleau et al. (1997, 1998) ^{24,30,31}	Semiquantitative FFQ	Developed for the Ontario Health Study, with a focus on fat, fiber, and calcium ⁴⁶	Validated against 4-d weighed food records in 147 Canadians. Spearman <i>r</i> for macronutrients ranged from 0.323 (percent protein) to 0.539 (total grams of fat) ⁴⁶	Written FFQ in English, French, Italian, Chinese, and Portuguese
Lesser et al. (2014) ³⁶	Section of comprehensive Multi-Cultural Community Health Assessment Trial questionnaire	Not reported	Not examined	Written questionnaire in English, Punjabi, and Chinese ⁴⁷
Smith et al. (2012) ²⁸	Section of Health Survey for England (1998, 1999, 2003, 2004). Only white comparison population drawn from 1998 and 2003	Not reported	Not examined	Written questionnaire (1999, 2004) and interview (2004) in English, Gujarati, Hindi, Punjabi, Urdu, Bengali, Cantonese, and Mandarin ^{48,49}
Bharmal et al. (2015), ³³ Sarwar et al. (2015), ³⁵ and Becerra et al. (2014) ³⁸	Section of California Health Interview Survey questionnaire (2005, 2007, 2009, 2011)	Developed so that total questionnaire would not exceed 30 min and would cover a wide variety of health-related research topics. Pretested and pilot-tested the English language version each year ^{50–53}	Not examined	Written questionnaire in English, Spanish, Cantonese, Mandarin, ^{50–53} Korean, and Vietnamese
Chiu et al. (2012) ³⁷	Section of Canadian Community Health Survey (2001, 2003, 2005, 2007)	Developed in collaboration with Statistics Canada, other departments, and academic fields. Conducted 2 field tests each year ^{54–57}	Not examined	Written questionnaire in 25 languages, including Punjabi, Tamil, Hindi, and Urdu ^{54–57}
Stone et al. (2007) ²²	Questionnaire of previous day's intake	Modified original questionnaire developed to track changes in diet among schoolchildren ⁵⁸	Validated original questionnaire against 3-d food diaries in 96 adolescents of unknown ethnicity in the UK. Not valid for assessing intake of fibrous foods, positive marker foods, or foods containing altered fat or altered sugar ⁵⁹	—

Abbreviations and symbols: FFQ, food frequency questionnaire; UK, United Kingdom; USA, United States of America; USDA, US Department of Agriculture; —, information not provided or not available.

^aAdditional diet assessment measures used, but results from those measures were either not reported (Sevak et al. [1994]²⁷) or were examined using only crude analyses (Parackal et al. [2015]³²; Sachan and Samuel [1999]²³).

or validated in South Asians.^{54–57} Because these 4 studies aimed to assess intake within entire food/beverage categories without adapting the questionnaire for South Asians, they were excluded. A study by Stone et al.²² was also excluded because the food intake questionnaire used was not developed or modified for South Asian populations and was found to have poor validity in 4 of 7 categories of foods queried.⁵⁹

Of the 19 studies reviewed, only 1 conducted in a child-only sample used a diet assessment measure considered appropriate for use in South Asian immigrant populations.¹⁷ Therefore, the summary was restricted to the remaining 7 studies, all of which were conducted in samples aged 20 years and older, with the exception of the study by Smith et al.,²⁸ which included participants as young as 16 years of age.

SUMMARY OF THE 7 STUDIES THAT USED APPROPRIATE STATISTICAL ANALYSES AND DIET ASSESSMENT METHODS

Seven of the 19 articles reviewed used diet assessment methods deemed sufficient to meet minimum standards.^{21,23,26–28,34,36} Details on the type of data collected, the approach to analysis, and the findings for the 7 studies that met the criteria for statistical analysis and diet assessment are outlined in Table 3,^{21,23,26–28,34,36,44,48,49,65–68} according to the groups compared: South Asian immigrants vs Westerners, long-term vs recent South Asian immigrants, and South Asian immigrants living in Western countries vs South Asians living in South Asia.

When some results in a publication met the criteria and others did not, the summary was restricted to compliant results. For example, summarized results were limited to comparisons of total energy intake and subtypes of fat for Sachan and Samuel²³ and to comparisons of nutrient intake for Talegawkar et al.,²¹ since other analyses in these studies were not adjusted for both age and sex. Similarly, findings for Anderson et al.²⁶ were limited to pairwise comparisons that were clearly delineated as significant or nonsignificant in the text. In the sections below, intakes described in percentages represent intakes as a percentage of total energy^{21,23,27} or food energy.²⁶ Results were considered statistically significant if differences met the criterion of $P < 0.05$.

Studies comparing South Asian immigrant populations with Western populations

Nutrient intake. Four articles showed dietary comparisons between South Asian immigrants and Westerners (Table 3).^{23,26–28} Three of these provided comparisons

of total energy and macronutrient intakes^{23,26,27} and found that intakes of protein^{26,27} and monounsaturated fat^{23,26,27} were significantly lower in South Asian immigrants than in Westerners. Protein intake for South Asian immigrants compared with Europeans was 13.7% vs 15.1%²⁷ and 13.1% (first-generation immigrants) and 13.8% (second-generation immigrants) vs 15.1%.²⁶ Similarly, monounsaturated fat consumption for South Asian immigrants compared with Westerners was 11.9% vs 14.7%,²⁷ 12.4% (second-generation immigrants) vs 13.7%,²⁶ and 13.6 g vs 18.6 g.²³

Although results for intakes of protein and monounsaturated fat were consistent, findings for intakes of total energy,^{23,26,27} carbohydrate,^{26,27} total fat,^{26,27} saturated fat,^{23,27} and polyunsaturated fat^{23,27} were mixed across studies. Two studies found that total energy intake was lower in South Asian immigrants than in Westerners.^{23,27} Sevak et al.²⁷ reported intakes of 9.5 MJ (2269 kcal) vs 10.8 MJ (2580 kcal) in their sample of male Indian, Pakistani, and Bangladeshi immigrants vs Europeans, and Sachan and Samuel²³ reported intakes of 1732 kcal vs 1844 kcal in their sample of female Indian immigrants vs white Americans. The one study that reported a greater energy intake for South Asian immigrants than for Westerners, ie, Anderson et al.,²⁶ also limited the sample to females and, as with Sevak et al.,²⁷ compared Indians, Pakistani, and Bangladeshi immigrants with Europeans.²⁶ However, it differed from the aforementioned studies in that it excluded calories from beverages in the calculation of total energy intake and restricted the sample to first- and second-generation immigrants, finding that first-generation immigrants had a significantly higher energy intake compared with Europeans, at 7950 kJ (1900 kcal) vs 6975 kJ (1667 kcal).²⁶

Carbohydrate,^{26,27} total fat,^{26,27} saturated fat,^{23,27} and polyunsaturated fat^{23,27} intakes were examined in 2 different sets of studies. Only Sevak et al.²⁷ and Sachan and Samuel²³ reported significant differences in intakes of carbohydrate (46.4% vs 40.9%)²⁷ and saturated fat (15 g vs 17 g)²³ for South Asian immigrants compared with Westerners, respectively. Anderson et al.²⁶ and Sevak et al.²⁷ reported significant yet opposite differences in total fat intake of 42.4% (first-generation immigrants) vs 39.1%²⁶ and 36.5% vs 39.2%²⁷ for comparisons of South Asian immigrants with Europeans, respectively. Similarly, results for trends in polyunsaturated fat intake contradicted, with consumption being 8.2% vs 7.0%²⁷ and 7.7 g vs 10.7 g²³ for South Asian immigrants compared with Westerners, respectively.

Examination of micronutrients in these 3 studies showed that South Asian immigrants tended to have lower intakes of micronutrients than Westerners, although results were mixed for vitamin E.^{23,26}

Table 3 Results from the 7 studies that met criteria for relevance, statistical analysis, and diet methodology

Comparison/ reference	Data collected	Method of analysis	Diet outcomes				
			Total energy	Carb	Protein	Fat	Other
South Asian immigrants vs Westerners: examinations of nutrient intake							
Sevak et al. (1994) ^{27,a}	7-d weighed food diaries. Weights of ingredients and cooked food; food description, and portion sizes for dining out	Least-squares regression adjusted for age. Used percent energy for macronutrients	↓	↑	↓	Total ↓ SFA NS MUFA ↓ PUFA ↑	–
Anderson et al. (2005) ^{26,b,c}	7-d weighed food diaries. Weights of cooked food and leftovers; recipe details; menu items when dining out; salt; and dietary supplement use	Multivariate analysis of variance adjusted for age and number of children in household. Used grams and percent energy for macronutrients	↑, 1st gen	NS, 1st/2nd gen (g and %)	↓, 1st/2nd gen (%)	Total ↑, 1st gen SFA – MUFA ↓, 2nd gen (%) PUFA –	↑ Vitamin E density, 1st/2nd gen ↓ Sodium density, 1st/2nd gen ↓ Potassium density, 1st gen
Sachan & Samuel (1999) ^{23,a,b,c}	4-d food diaries (3 weekdays, 1 weekend day). Details not reported	Generalized linear models adjusted for age, education, and/or total energy. Used grams for macronutrients	↓	–	–	Total – SFA ↓ MUFA ↓ PUFA ↓	↓ Vitamin A ↓ Vitamin E
South Asian immigrants vs Westerners: examinations of food group intake or dietary habits							
Smith et al. (2012) ²⁸	Questionnaire of usual eating habits (frequency, type, and amount of foods as well as added fat and salt use); included 20–24 items in 1998–1999 ^{48,67} and 13 items in 2003–2004. ^{49,68} Previous day's fruit and vegetable intake also included (2003–2004)	Logistic regression adjusted for age and sex	–	–	–	–	↓ ≥ 6 times/wk consumption of crisps (chips), chocolate, and biscuits (cookies) ↓ < 1 portion/d fruit consumption (except 2nd-gen Indians) ↓ < 1 portion/d vegetable consumption ↑ ≥ 3 times/wk fried food consumption (1st-/2nd-gen Indians and 1st-gen Pakistanis)

(continued)

Table 3 Continued

Comparison/ reference	Data collected	Method of analysis	Diet outcomes				
			Total energy	Carb	Protein	Fat	Other
Long-term vs recent South Asian immigrants: examinations of nutrient intake Talegawkar et al. (2016) ^{21,c,d}	FFQ containing 102 items from the Study of Health Assessment and Risk in Ethnic groups and 61 unique items that were added after pilot testing. Open-ended frequency responses about intake during previous year, ⁶⁵ with 3 serving sizes per item	Generalized linear models adjusted for age, sex, and total energy. Dunnett's adjustment used for pairwise comparisons of adjusted means. Used grams and percent for macronutrients, except for subtypes of fat (used grams only)	Trends ↓	↓ (g and %)	↓ (g and %)	Total ↑ (g and %) SFA ↑ MUFA – PUFA ↑	Folate ↓ Potassium ↓
			Pairwise ↓, 1st tertile	↓, 1st/2nd tertile (g, 1st/2nd; % 1st)	↓, 1st tertile (g and %)	Total ↑, 1st/2nd tertile (g and %) SFA NS MUFA – PUFA NS	Folate ↓, 1st/2nd tertile Potassium ↓, 1st/2nd tertile Vitamin C ↓, 2nd tertile Vitamin E ↓, 2nd tertile
Long-term vs recent South Asian immigrants: examinations of food group intake or dietary habits Lesser et al. (2014) ^{36,d}	Questionnaire containing 26 items on changes in food preparation, consumption, and nutrition knowledge/awareness since immigration. ⁶⁶ Used 5-point Likert scale of decreased to increased change	Spearman correlation to identify dietary variables associated with length of residence; used these 4 items as dependent variables in ordinal models adjusted for age, sex, education, and BMI	–	–	–	–	↑ Stir frying/barbecuing (13.9–21.1 y since immigration), baking or grilling (13.9–21.1 y since immigration), and microwaving (21.1–32.1 y since immigration)
			–	–	–	–	↑ Consumption of meat NS use of oil, butter, and margarine NS adherence to patterns of foods rich in fat, foods rich in sugar, and mostly Norwegian diet
Wandel et al. (2008) ³⁴	Questionnaire containing 11 items on dietary change with 3 possible responses: increase, decrease, or no change; 43 items retained from HUBRO FFQ plus 12 items that were added or reworded. All items in FFQ asked about usual intake instead of intake during defined time period ⁴⁴	Logistic regression for changes in intake from 4 primary sources of fat and adherence to 3 food-use patterns adjusted for age, sex, country of origin, work status, language, and Norwegian integration index score	–	–	–	–	

(continued)

Table 3 Continued

Comparison/ reference	Data collected	Method of analysis	Diet outcomes				
			Total energy	Carb	Protein	Fat	Other
South Asian immigrants vs South Asians living in South Asia Sachan & Samuel (1999) ^{23,ab,c}	4-d food diaries (3 weekdays, 1 weekend day). Details not reported	Generalized linear models adjusted for age, education, and/or total energy Used grams for macronutrients	↓	–	–	Total – SFA NS MUFA ↑ PUFA ↑	Vitamin A ↓
<p>Abbreviations and symbols: BMI, body mass index; Carb, carbohydrate; gen, generation; MUFA, monounsaturated fatty acid; NS, not significant; PUFA, polyunsaturated fatty acid; SFA, saturated fatty acid; –, information not provided or available; ↓, lower intake among South Asian immigrants vs Westerners, long-term vs recent South Asian immigrants, South Asian immigrants vs South Asians living in South Asia; ↑, higher intake among South Asian immigrants vs Westerners, long-term vs recent South Asian immigrants, South Asian immigrants vs South Asians living in South Asia;</p> <p>^aAdditional diet assessment measures used, but results from those measures were either not reported (Sevak et al. [1994]²⁷) or were examined using only crude analyses (Sachan & Samuel [1999]²³).</p> <p>^bSummarized findings limited to those adjusted for both age and sex (Sachan & Samuel [1999]²³) or to those clearly delineated as significant in the text or tables in the original manuscript (Anderson et al. [2005]²⁶).</p> <p>^cOnly significant findings for micronutrients are shown.</p> <p>^dAdditionally examined intake in terms of foods, but results were examined using only crude analyses (Talegawkar et al. [2016]²¹), or questionnaire was not adapted for use in South Asians (Lesser et al. [2014]³⁶).</p>							

Anderson et al.²⁶ reported more vitamin-E-dense diets among first- and second-generation South Asian immigrant adults than among Europeans (0.9 mg/1000 kJ and 0.8 mg/1000 kJ vs 0.6 mg/1000 kJ, respectively), while Sachan and Samuel²³ reported lower vitamin E intake among South Asian immigrants than among white Americans (2.6 mg vs 4.4 mg). The specific micronutrients that were lower among South Asian immigrants were potassium (280 mg/1000 kJ [first-generation immigrants] vs 360 mg/1000 kJ), sodium (315 mg/1000 kJ [first-generation immigrants] and 320 mg/1000 kJ [second-generation immigrants] vs 385 mg/1000 kJ),²⁶ and vitamin A (618 retinol equivalents [RE] vs 1370 RE).²³

Food group intake or dietary habits. Smith et al.²⁸ compared food groups in the diets of South Asian immigrants and Westerners. They examined frequency of intake and found that, compared with white Europeans, both first- and second-generation South Asian immigrants consumed snacks less frequently and fried and micronutrient-rich foods (ie, fruits and vegetables) more frequently.

Studies comparing South Asian immigrants by time since immigration

Nutrient intake. Talegawkar et al.²¹ examined Indian, Pakistani, Bangladeshi, Sri Lankan, and Nepali immigrants living in the United States and found that length of residence was inversely associated with intakes of total energy, carbohydrate, protein, folate, and potassium and directly associated with intakes of total fat, saturated fat, and polyunsaturated fat. Significant pairwise comparisons tended to be limited to recent vs long-term immigrants, specifically for intakes of total energy (7373 kJ [1762 kcal] vs 6734 kJ [1609 kcal], respectively), carbohydrate (57.4% vs 55.0% or 251 g vs 240 g, respectively), and protein (14.9% vs 14.4% or 62.6 g vs 61.0 g, respectively). For total fat and the aforementioned micronutrients, however, both recent and semi-recent immigrants had significantly different intakes compared with long-term immigrants: 28.3% and 29.1% vs 30.3% or 53.1 g and 54.6 g vs 56.7 g for total fat, respectively; 416 µg and 410 µg vs 388 µg for folate, respectively; and 3664 mg and 3690 mg vs 3554 mg for potassium, respectively.

Food group intake or dietary habits. Lesser et al.³⁶ and Wandel et al.³⁴ analyzed food intake and food preparation methods among first-generation immigrants, with Lesser et al.³⁶ examining immigrants from the same countries described by Talegawkar et al.,²¹ and Wandel et al. narrowing the focus to immigrants from 2 of those

countries (Pakistan and Sri Lanka). Lesser et al.³⁶ found that increasing duration of residence in a Western country was associated with an increased odds of stir frying or barbecuing (odds ratio [OR] = 3.71, $P = 0.024$), baking or grilling (OR = 6.36, $P = 0.002$), and microwaving (OR = 2.75, $P = 0.047$). Wandel et al.³⁴ reported that increasing duration of residence in a Western country was associated only with an increased odds of meat consumption (OR = 1.6, $P < 0.05$). Differences in consumption of butter, margarine, and oil and adherence to select food patterns were not significant.³⁴

Studies comparing South Asian immigrants with South Asians living in South Asia

Of the 7 selected articles, only 1 reported a quantitative analysis comparing South Asians living in a Western country to South Asians living in South Asia (Table 3).²³ Sachan and Samuel²³ found that Asian Indians in the United States had significantly lower intakes of total energy (1732 kcal vs 1976 kcal) and vitamin A (618 RE vs 1191 RE) compared with Indians in India and a higher intake of monounsaturated fats (13.6 g vs 9.2 g) and polyunsaturated fats (7.7 g vs 4.6 g) compared with Indians in India. There was no difference in saturated fat intake between the 2 groups.

CONCLUSION

This critical narrative review of the literature identified 7 studies in adult populations that used sufficiently adjusted statistical analyses and culturally appropriate diet assessment measures to analyze dietary intake among South Asians following immigration to a Western country.^{21,23,26–28,34,36} Many results conflicted across studies, but there were some consistencies. Three studies showed that monounsaturated fat intake was lower in South Asian immigrants than in Westerners.^{23,26,27} One study showed that monounsaturated fat intake was higher in South Asian immigrants than in South Asians living in South Asia.²³ These findings suggest a continuum, with monounsaturated fat intake being lowest in South Asians living in South Asia, highest in Westerners, and intermediate in South Asians living in a Western country. However, Anderson et al.²⁶ found that second-generation, but not first-generation, immigrants had a lower monounsaturated fat intake compared with Westerners, which is not consistent with a hypothesized time trend of increasing monounsaturated fat intake with greater exposure to a Western culture. Findings for protein were also relatively consistent across studies, with 2 studies showing that protein intake was lower in South Asian immigrants than in Westerners.^{26,27}

Talegawkar et al.²¹ reported that increased duration of residence was associated with decreased protein intake, but Anderson et al.²⁶ did not observe a similar decline across generations of immigrants.

Findings for total energy intake were mixed for comparisons of South Asian immigrants and Westerners, and these differences might be attributable to time since immigration. Talegawkar et al.²¹ found that total energy intake decreased as duration of residence in a Western country increased, and thus total energy intake may continue to decrease across immigrant generations. This could explain why Anderson et al.²⁶ observed that first-generation South Asian immigrants had higher energy intakes than Europeans, while the 2 studies with samples of mixed-generation immigrants found that South Asian immigrants had lower energy intakes than Westerners.^{23,27}

Time since immigration does not appear to explain the mixed findings for carbohydrate, total fat, saturated fat, polyunsaturated fat, and micronutrient intakes, but information on the country of origin may help explain the discrepancies in findings. Two of the 7 studies included in this review presented findings by or adjusted for South Asian immigrants' country of origin and found significant differences in dietary intake and habits.^{28,34} One of the 4 studies examining macro- and micronutrient intakes limited the sample to Asian Indians only.²³ The remaining studies used samples with individuals from multiple South Asian countries, which may have resulted in the mixed findings.

It is also possible that other markers of integration into Western culture, besides time since immigration (eg, language fluency or social affiliation), may help explain the mixed findings for the aforementioned macro- and micronutrients. Only 1 of the 7 included studies examined other markers, but it did not assess nutrient intake.³⁴ The authors found that language fluency and degree of cultural integration (examined using an unvalidated 9-point index of integration based on whether immigrants read the host country's [Norway's] newspapers, socialized with ethnic Norwegians, and participated in organizations in Norway) were significantly associated with food preparation methods and food intake following immigration to a Western country.³⁴

An important strength of this critical review was the exclusion of studies on the basis of detailed evaluation of the study design, statistical analyses, and diet methodology. This process resulted in the exclusion of numerous papers, but the criteria applied were considered crucial for the identification of useful information. The intent was to highlight studies that were of high quality and to increase the likelihood that they accurately captured and compared diets of South Asian

immigrants. A weakness is that a critical narrative review, rather than a formal systematic review, was conducted. The databases searched may have missed some relevant articles, and it is always possible some articles may have been misclassified.

Given the large number of South Asian immigrants to Western countries and the relevance of diet to many of the health problems they face, it is important that future studies address the mixed findings and gaps in knowledge uncovered here. New research needs to use well-defined samples, study designs, and analyses that control for confounding by age and sex, and dietary measures that are developed and validated for South Asian immigrants. In addition, more information is needed on variables that have previously been shown to influence diet following immigration. Variables such as duration of residence, immigrant generation, country of origin, socioeconomic status, language, religion, and food restrictions would aid the interpretation and understanding of diet-related choices.^{9,10,69} Future research should aim to examine the intake of food groups as well as the intake of macro- and micronutrients to add context to nutrient intake. Furthermore, future research should examine other markers of integration into Western culture aside from time since immigration and should include South Asians living in South Asia as a comparison population, given the relative lack of information on this contrast. Such research will more fully characterize the dietary intake and habits of South Asian immigrants in Western countries and thus identify specific dietary targets for obesity interventions in South Asian immigrants.

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