The impact of migration on body weight: a review

O impacto da migração no peso corporal: uma revisão

El impacto de la migración sobre el peso corporal: una revisión

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Abstract

Immigrants may be more vulnerable to obesity as a result of the immigration process. The aim of this article is to summarize current knowledge about the impact of immigration on body mass index (BMI). A systematic review was performed in accordance with PRISMA guidelines through a database search of scientific articles (last updated in August 2014). Thirty-nine articles were included and assessed. Results varied according to ethnic background, country of origin and host country. A consistent positive association between BMI and time since immigration was found among Hispanic, European and African immigrants. Less than half of the studies observed a positive association among Asian immigrants. The quality of the majority of the studies assessed was poor, reflecting a need to improve methodology and concept definition. Immigration appears to have a deteriorative effect on BMI. Underlying causes may include changes in nutrition and physical activity, psychological and social factors, and genetic susceptibility and these aspects should be included as moderator variables in future studies.

Emigration and Immigration; Acculturation; Obesity

Resumo

A obesidade pode ser uma das características mais alteráveis no processo de migração. Pretendeu-se resumir a informação sobre o impacto da migração no índice de massa corporal (IMC). Realizou-se uma revisão sistemática da literatura de acordo com as diretrizes PRISMA, por meio de pesquisa eletrônica (última atualização em agosto de 2014). Foram incluídos e avaliados qualitativamente 39 artigos. A associação entre migração e evolução de IMC varia de acordo com o grupo étnico e países de origem/acolhimento. Imigrantes hispânicos, europeus e africanos apresentam relação consistente e positiva entre IMC e tempo de migração. Os imigrantes asiáticos apresentam associação positiva em menos da metade dos estudos. No geral, a qualidade dos estudos é fraca e há necessidade de melhorar conceitos e métodos. Parece existir um efeito deteriorativo da migração no IMC. Alterações nutricionais, de atividade física, fatores psicossociais e suscetibilidade genética podem ser motivos subjacentes a incluir como variáveis moderadoras em estudos futuros.

Migração Internacional; Aculturação; Obesidade

Introduction

There is a growing interest in the association between immigration and food consumption. Food and beverages play a key role in maintaining social and cultural connections among immigrants. Over time, food consumption among immigrants tends to change due to acculturation and lack of availability of typical food products from their home country [1,2,3].

An association has been observed between dietary acculturation and immigrant integration into the host country and a deterioration of diet among immigrants [4]. Immigration often leads to changes in the quality of food consumed and cooking methods. Immigrants are susceptible to a rapid change in emphasis towards convenience foods, such as snacks and sweets, while the consumption of staple foods like rice and corn remains unchanged over longer periods of time [5]. Studies show that the factors that affect eating habits among immigrants include food availability, income, beliefs relating to food, religion and "food laws", and the generation and age of immigrants [5].

Dietary acculturation does not always have negative results. In a study of Moroccan immigrants carried out in Spain, food choices were more varied and nutritionally-dense among of the most acculturated immigrants [6]. The authors also concluded that recent immigrants with poor fluency in Spanish may have difficulties in accessing a large variety of foods.

Other studies suggest that the initial health status of immigrants is better than that of the population of the host country. This phenomenon is known as the "healthy immigrant effect" [7]. However, this effect often disappears as length of residence increases [7,8]. On the other hand, comparative studies show that after immigration the risk of diseases associated with obesity, such as cardiovascular disease, diabetes, and cancer, may change over time [7]. Susceptibility to obesity [defined as body mass index (BMI) $\geq$ 30 kg/m²] [9] increases with immigration and length of residence in the host country. Evidence from studies carried out in the United States suggests that recent immigrants generally have a lower BMI than the American population. However, BMI tends to increase as the length of residence in the host country increases, progressively converging towards the levels of the American population [7]. The same phenomenon has been observed by studies in Canada, Australia and Europe [8].

Studies of this phenomenon in other countries are scarce. Four of the five systematic reviews of this issue concentrate exclusively on obesity among the US immigrant population. Misra & Ganda [10] analyzed this issue from a global perspective. However, the study was published in 2007 and lacks a qualitative assessment of the papers included. The present article is the result of an updated systematic review of studies to analyze the association between length of time since immigration and body weight among first generation immigrants.

The review was worldwide, including countries for which data was available, and focused on two approaches to research which address the links between immigration, acculturation and weight gain among first generation immigrants. The first uses length of residence in the host country as a proxy measure of acculturation. Although a very common approach, the validity of this assumption has yet to be fully demonstrated in the literature [9]. The second area of research compares immigrants living in the host country with their counterparts living in their home country.

Methods

A systematic review was conducted in accordance with PRISMA guidelines [11] through a search of published studies contained in the PubMed, JSTOR and EBSCO databases, with no publication date restrictions. The search was conducted initially on July 27th 2011 and updated on August 8th 2014. The following combined keywords were used as alternatives in order to obtain as many studies as possible: "immigrant"; "migrant", "foreign-born"; "country of birth", "country of origin"; "region of birth", "region of origin"; "BMI", "body mass index"; "overweight", "obesity"; "body weight" and "duration", "length of stay"; "time"; "acculturation".

The titles and abstracts of the identified papers were independently screened by the first two authors who arrived at a consensus on eligibility and content. The full texts of potentially relevant papers were assessed for eligibility based on the following criteria: (i) papers must describe original work; (ii) studies include adults born in foreign countries (first generation immigrants) and respective specific data about the variables of interest; (iii) measure of overweight or BMI (or change in these variables) is a key/endpoint variable – whether self-reported or not; (iv) studies include length of residence in the host country or amount of time spent in the host country as a key/independent variable; (v) studies include data that allows comparison of immigrants groups and nonimmigrant counterparts from the immigrant's country of origin; (vi) full texts are in English, Spanish or Portuguese. Studies that

focused only on children or teenagers, regardless of whether they were first generation immigrants, were excluded. Generally this group is not entirely independent in their food and leisure physical activity choices, and choice of where to live, and therefore the factors that influence the variables in this group are different to those influencing adult immigrants.

Data was extracted into a standardized matrix that included the title of the article, name of the scientific journal and publication, host country, population and comparison groups (if applicable), main outcome (BMI, overweight/obesity, change in BMI), statistical analysis, covariates used, and main results.

The first two authors independently appraised the quality of the evidence produced by studies focussing on the impact of immigration on obesity based on the following criteria: (a) recruitment strategy; (b) sample size; (c) whether participation rate was reported; (d) participation rate; (e) well defined eligibility criteria; and (f) overall adequacy of methods. The results for each criteria were used to generate a final score, ranging from 0 (low relevance) to 7 (high relevance).

Results

The study selection process is shown in Figure 1. A total of 39 articles from an initial list of 365 citations were considered eligible for this review. These articles were published between 2000 and 2014 and based on studies in the following countries: the United States (25), Canada (4), the Netherlands (1), Spain (1), Italy (1), Israel (1), France (1), Norway (2), Luxembourg (1), Sweden (1) and the United Kingdom (1).

Sample sizes varied between 53 [12] and 478,276 individuals [13]. Table 1 shows that a number of papers included in this review did not include relevant details about methodology, particularly sampling and recruitment techniques and participation rates, thus compromising the quality of the evidence.

Length of residence in the host country as a determinant of increases in BMI

Significant disparities were observed between immigrant sub-groups with regard to the association between length of time since immigration and BMI [13]. Results are therefore presented by immigrant group (Table 2) showing the results for specific countries of origin where available. Some studies therefore appear more than once. We show the most prevalent religion among immigrants and first language based on the region

Figure 1

PRISMA fluxogram.
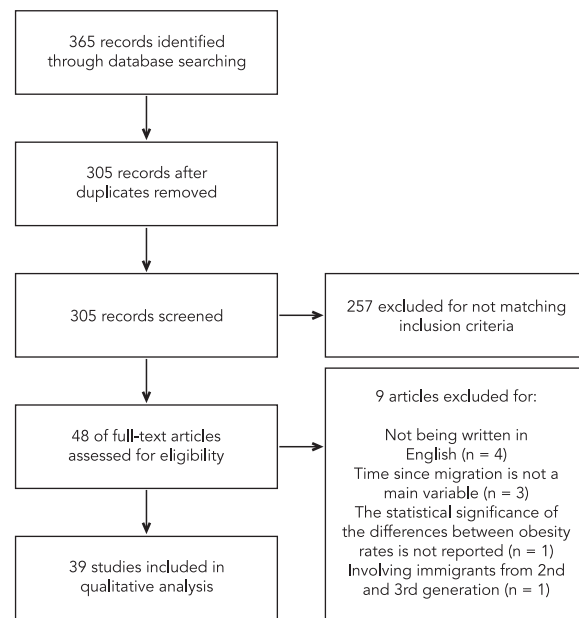
of birth to facilitate the grouping of immigrants and the interpretation of potential acculturation barriers. Four of the studies [12,14,15,16] used only female samples. All but one of the studies [17] sampled only adults. All but one of the studies [18] were cross-sectional. One study consisted of a repeated cross-sectional survey to evaluate changes in the prevalence of obesity among immigrants and US-born individuals [19]. BMI was self-reported in the majority of the studies. Ten of the studies measured weight and height [14,16,18,20,21,22,23,24], while one study measured only height and weight was self-reported [25]. In another study, weight and height were measured but change in BMI (outcome variable) was calculated based on self-reported past weight and height [26]. Only one study reported to have imputed missing data [27]. The variable length of residence in the host country was always defined using an interval scale, generally divided into recent (< 5 years) and long-term (> 15 years). Eleven [13,17,20, 28,29,30,31,32,33,34,35] studies included all immigrant groups resident in the host country. Five studies [17,28,32,36,37] showed the increase in length of residence in the host country but did not stratify the results by immigrant group. Another study [28] presented results by region of origin, concluding

Table 1

Quality assessment of the studies reviewed.

Authors	Host country	Recruitment strategy *	Sample size **	Participation rate (reported or not) ***	Participation rate > 75% ***	Eligibility criteria well defined ***	Overall appreciation of relevance of the article #
Koya & Egede [28]	United States	2	2	1	0	1	↑↑↑
Park et al. [20]	United States	0	2	0	0	1	↑
Gutiérrez-Fisac et al. [32]	Spain	2	2	0	0	1	↑↑
Iversen et al. [26]	Norway	1	2	1	0	1	↑↑
Regev-Tobias et al. [12]	Israel	1	0	0	0	1	↑
Novotny et al. [80]	United States	2	2	0	0	1	↑↑
Lauderdale & Rathouz [39]	United States	2	2	1	1	1	↑↑↑
Dijkshoorn et al. [42]	Netherlands	0	2	1	0	1	↑↑
McDonald & Kennedy [30]	Canada	2	2	0	0	1	↑↑
Goel et al. [34]	United States	2	2	1	0	1	↑↑↑
Roshania et al. [17]	United States	2	2	0	0	1	↑↑
Fu & Vanlandingham [21]	United States	2	1	1	0	1	↑↑
Yeh et al. [63]	United States	1	2	0	0	1	↑↑
Barcenas et al. [38]	United States	0	2	1	1	1	↑↑
Sanchez-Vaznaugh et al. [81]	United States	2	2	0	0	1	↑↑
Lindström & Sundquist [49]	Sweden	2	2	1	0	1	↑↑↑
Albrecht et al. [18]	United States	0	2	0	0	1	↑
Choi et al. [41]	United States	1	0	1	0	1	↑
Tremblay et al. [33]	Canada	0	2	1	1	1	↑↑
Fuentes-Afflick & Hessol [25]	United States	0	0	1	1	1	↑
Wolin et al. [14]	United States	0	1	0	0	1	↑
Toselli et al. [53]	Italy	0	0	0	0	1	↑
Dey & Lucas [82]	United States	2	0	0	0	1	↑
Kaplan et al. [83]	United States	2	2	1	0	1	↑↑↑
Oza-Frank & Narayan [31]	United States	2	2	0	0	1	↑↑
Sanchez-Vaznaugh et al. [29]	United States	2	2	0	0	1	↑↑
Cairney & Ostbye [36]	Canada	2	2	0	0	1	↑↑
Miller et al. [16]	United States	0	0	0	0	1	↑
Chiu et al. [35]	Canada	2	2	1	0	1	↑↑↑
Creighton et al. [27]	United States	2	2	1	1	1	↑↑↑
Ullmann et al. [84]	United States	2	1	0	0	1	↑↑
Martin-Fernandez et al. [37]	France	2	2	1	0	1	↑↑↑
Gele & Mbalilaki [23]	Norway	0	0	0	0	1	↑
Barhmal et al. [40]	United States	2	2	1	1	1	↑↑↑
Riosmena et al. [85]	United States	2	2	0	0	1	↑↑
Parikh et al. [86]	United States	1	1	1	0	1	↑↑
Garduño-Diaz & Khokhar [24]	United Kingdom	0	0	0	0	1	↑
Park et al. [19]	United States	2	2	0	0	1	↑↑
Bhatnagar et al. [45]	United Kingdom	0	1	1	1	1	↑↑
Mahajan & Bermingham [43]	Australia	0	0	0	0	1	↑
Tennakoon et al. [46]	Norway	2	2	1	0	1	↑↑↑
Kouris-Blazos et al. [50]	Australia	2	0	1	1	1	↑↑
Zahid et al. [44]	Norway	2	2	1	0	1	↑↑↑

* 0: non-randomized/convenience sampling; 1: randomized sampling (not national-based); 2: randomized sampling (national-based);

** 0: < 385 cases; 1: 385-1,000 cases; 2: > 1,000 cases;

*** 0: Criteria not met (e.g. participation rate not reported, participation rate < 75% and eligibility criteria not well defined); 1: Criteria met (e.g. participation rate reported, participation rate > 75% and eligibility criteria well defined);

Computed as the sum of scores given to each of the five indicators (previous columns). This overall sum was subsequently recoded into in the following categories: ↑ Poor (less than 4 points); ↑↑ Acceptable (4 to 5 points); ↑↑↑ Good (> 5 points).

Table 2

Effect of length of residence on body mass index/overweight prevalence, by immigrant group.

Immigrant group	Sample size	Host country	Country of origin	Official language/s	(Most prevalent) religion/s	Reference	Association with BMI/ overweight prevalence
Hispanics	7,503	United States	Mexico	Spanish	Roman Catholicism	Barcenas et al. [38]	↑
	313	United States	Central and South America, Mexico	Spanish and Portuguese	Roman Catholicism	Fuentes-Afflick & Hessol [25]	↑
	32 374	United States	*	*	*	Goel et al. [34]	↑
	174	United States	Puerto Rico women	Spanish	Roman Catholicism	Himmelgreen et al. [15]	↑
	2,420	United States	Mexico, Central and South America or Caribbean	Spanish and Portuguese	Roman Catholicism or Christianity	Kaplan et al. [83]	↑
	33,299	United States	Mexico, Central and South America, Caribbean Islands	Spanish and Portuguese	Roman Catholicism or Christianity	Oza-Frank & Narayan [31]	↑
	13,011	United States	*	*	*	Park et al. [20]	↑
	37,350	United States	Mexico, Central and South America, Puerto Rico	Spanish and Portuguese	Roman Catholicism or Christianity	Sanchez-Vaznaugh et al. [29]	↑
	154,649	United States	*	Spanish and Portuguese	Roman Catholicism	Singh et al. [13]	↑
			Cuba	Spanish	Roman Catholicism		↔
			Mexico	Spanish	Roman Catholicism		↑
			Puerto Rico	Spanish	Roman Catholicism		↔
	388		Mexico	Spanish	Roman Catholicism	Wolin et al. [14]	↑
	126,796	Canada	*	*	*	McDonald & Kennedy [30]	↑
	1,486	United States	Mexico and Non-Mexico	Spanish	Roman Catholicism	Albrecht et al. 18 **	↔
	399	United States	"Mainly Mexican"	Spanish	Roman Catholicism	Ulmann et al. [84]	↑
	1,610	United States	Mexico	Spanish	Roman Catholicism	Creighton et al. [27]	↑
	273,188	United States	*	*	*	Park et al. [19]	↑
	43,042	United States	Mexico	Spanish	Roman Catholicism	Riosmena et al. [85]	↔
Number of mentions finding positive association/Total number of mentions							**15/19**

(continues)

that this variable had a significant effect on the prevalence of cardiovascular risk factors (including overweight) among immigrants. A study by Martin-Fernandez et al. [37] of immigrants living in France found that the association between length of time spent in the host country and BMI/overweight was only evident among older men.

• **Hispanics**

Nineteen mentions of the Hispanic subgroup involving different countries of origin were made in 17 studies, of which 15 showed a positive associa-

tion between length of residence and BMI/rate of overweight 79%). All except one of the studies (from Canada) were from the United States. Sample sizes varied between 32 and 273,188 immigrants.

A cross-sectional population based study carried out by Sanchez-Vaznaugh et al. [29] in California showed that increases in BMI with length of residence and general mean BMI were greatest among Hispanic immigrants. This association varies within the Hispanic subgroup, with Mexican immigrants experiencing the greatest increase in BMI and waist circumference over time [18].

Table 2 (continued)

Immigrant group	Sample size	Host country	Country of origin	Official language/s	(Most prevalent) religion/s	Reference	Association with BMI/ overweight prevalence
Asiatics	37,350	United States	China, Philippines, Korea, Vietnam, Pacific Islands	Chinese, Filipino/English, Korean, Vietnamese, Nauruan/English	Taoism, Roman Catholic, Buddhism, Confucianism	Sanchez-Vaznaugh et al. [29]	↔
	63,030	United States	China, Vietnam, Korea	Chinese, Vietnamese, Korean	Non-religious, Catholic, Buddhism, Confucianism	Wang et al. [87]	↑
	254,153	United States	Japan, China, Philippines, India, Korea, Vietnam	Japanese, Chinese, Filipino/English, Hindi, Korean, Vietnamese	Buddhism, Taoism, Roman Catholic, Hinduism	Lauderdale & Rathouz [39]	↑
	2,537	United States	China	Chinese	Taoism	Yeh et al. [63]	↑
	33,299	United States	Southeast Asia	Vietnamese, Thai, Khmer, ...	Islam, Budhism	Oza-Frank & Narayan [31]	↔
			Central Asia	Russian, Mandarin Chinese	Islam		↑
			Middle East	Arabic, Pearsian, Turkish, Berber, Kurdish	Islam		↔
	802	United States	Chinese	Chinese	Taoism	Albrecht et al. [18] **	↔
	32,374	United States	*	*	*	Goel et al. [34]	↔
	86,687	Canada	China, Philippines, Korea, Japan, Vietnam, Cambodia, Laos, Indonesia	Chinese, Japanese, Korean, Vietnamese	Taoism, Islam, Buddhism	Tremblay et al. [33]	↑
			Iran, Afghanistan	Persian	Islam, Muslim		↔
			India, Pakistan, Sri Lanka	Hindu, English, Urdu, Sinhala	Hinduism, Buddhism, Muslim		↑
	13,011	United States	*	*	*	Park et al. [20]	↔
	154,649	United States	China	Chinese	Budhism	Singh et al. [13]	↔
			Philippines	Filipino, English	Roman Catholic		↔
			India	Hindu	Hinduism		↔
			Other Asian countries and Pacific Islands	*	*		↑
	126,796	Canada	South Asian	Hindu, English, Urdu, Sinhala	Hinduism, Buddhism, Muslim	McDonald & Kennedy [30]	↑
			Southeast Asian	Vietnamese, Thai, Khmer	Islam, Budhism		↑
			West Asia	Persian	Islam, Muslim		↑
			China, Japan, Korea	Chinese, Japanese, Korean	Taoism, Buddhism		↔
	703	United States	Vietnam	Budhism	Vietnamese	Fu & Vanlandingham [21]	↑
	261	United States	Vietnam	Budhism	Vietnamese	Choi et al. [41]	↑
	16,316	Norway	Vietnam	Budhism	Vietnamese	Iversen et al. [26]	↔
			Sri Lanka	Sinhala	Budhism		↑
			Pakistan	English, Urdu	Muslim		↔
			Iran	Persian	Islam		↔
			Turkey	Turkish	Islam		↔

(continues)

Table 2 (continued)

Immigrant group	Sample size	Host country	Country of origin	Official language/s	(Most prevalent) religion/s	Reference	Association with BMI/ overweight prevalence
Asiatics	1,384	Netherlands	Turkey	Turkish	Islam	Dijkshoorn et al. [42]	↔
	3,228	United States	India	Hindu	Hinduism	Bharmal et al. [40]	↔
	163,797	Canada	South Asian	Vietnamese, Thai, Khmer, Hindu, ...	Islam, Budhism, Hinduism	Chiu et al. [35]	↔
			China	Chinese	Budhism		↔
	517	United States	China	Chinese	Budhism	Parikh et al. [86]	↔
	100	United Kingdom	South Asian	Vietnamese, Thai, Khmer, Hindu, ...	Islam, Budhism, Hinduism	Garduño-Diaz & Khokhar [24]	↔ ***
Number of mentions finding positive association/Total number of mentions							**13/34**
Europeans	37,350	United States	*	*	*	Sanchez-Vaznaugh et al. [29]	↓
	33,299	United States	*	*	Christian	Oza-Frank & Narayan [31]	↑
			Russia	Russian	Orthodox Christianity		↑
	126,796	Canada	*	*	*	McDonald & Kennedy [30]	↑
	32,374	United States	*	*	*	Goel et al. [34]	↑
	86,687	Canada	*	*	*	Tremblay et al. [33]	↑
	13,011	United States	*	*	*	Park et al. [20]	↑
	154,649	United States	*	*	*	Singh et al. [13]	↑
	843	Luxembourg	Portugal	Portuguese	Roman Catholic	Alkerwi et al. [22]	↔
	218	United States	Former Soviet Union	Russian	Orthodox Christianity	Miller et al. [16]	↔
	163,797	Canada	*	*	*	Chiu et al. [35]	↑
Number of mentions finding positive association/Total number of mentions							**8/11**
North Africans	1,384	Netherlands	Morocco	Arabic, Berber	Muslim	Dijkshoorn et al. [42]	↑
	339	Italy	Morocco	Arabic, Berber	Muslim	Toselli et al. [53]	↑
Number of mentions finding positive association/Total number of mentions							**2/2**
Sub-Saharian Africans	37,350	United States	*	*	*	Sanchez-Vaznaugh et al. [29]	↑
	33,299	United States	*	*	*	Oza-Frank et al. [31]	↑
	126,796	Canada	*	*	*	McDonald & Kennedy [30]	↑
	32,374	United States	*	*	*	Goel et al. [34]	↔
	13,011	United States	*	*	*	Park et al. [20]	↔
	154,649	United States	*	*	*	Singh et al. [13]	↔
	53	Israel	Ethiopia	Amharic	Christianity	Regev-Tobias et al. [12]	↑
	208	Norway	Somalia	Somali, Arabic	Muslim	Gele & Mbalilaki [23]	↑
	163,797	United States	*	*	*	Chiu et al. [35]	↔
Number of mentions finding positive association/Total number of mentions							**5/9**

* No indication (i.e., not possible to identify, from the original article/reference);

** Albrecht et al. [18] is the only longitudinal study included in this review;

*** There is no indication of the statistical significance of the increased BMI mean in long-term immigrants compared with short-term immigrants.

↑ Significant statistical positive association between the two variables of interest; ↔ No significant association found between the two variables of interest;

↓ Statistical tendency (though not significant) for a negative association between the two variables of interest.

Albretch et al. [18] conducted the only longitudinal study on this matter involving Asian and Hispanic immigrants living in six different regions of the United States. Mean annual changes in BMI were statistically significant among Mexican immigrants, but not in other Hispanic subgroups. However, these changes are not significantly different from those observed among US-born Mexican-Americans.

The findings suggest differences between genders. Barcenas et al. [38] reported that among males BMI was significantly in long-term immigrants (resident for ≥ 15 years) than among short-term immigrants (< 5 years), while among females BMI was significantly higher in all length of residence categories (5 to 9 years; 10 to 14 years; ≥ 15 years) than in the short-term category [32].

• **Asians**

Results were less consistent, showing differences according to region of birth. Sample sizes varied from 261 to 254,153 individuals. Studies covered the following host countries: United States (13), Canada (3), Norway (1), and the Netherlands (1). Of the 34 mentions made of the Asian subgroup (corresponding to 18 different studies about Asian immigrants), 13 (38.2%) found a positive and significant association between length of residence and BMI/rate of overweight. McDonald et al. [30] found that there was little change in weight with increasing length of residence in the host country among Chinese immigrants living in Canada. The only longitudinal study included in this review showed that there was no increase in BMI or waist circumference among Chinese immigrants after a five-year follow-up [1], while three studies [1,13,39] found a low prevalence of overweight in this group. Evidence from two studies [30,31] shows a positive or null association between the two main variables among immigrants from the Middle East and West Asia. While no increase in BMI with increasing length of residence in the host country was shown for Indians living in California [40], BMI and insulin-resistance tends to be greater in this group than in their counterparts living in India [10]. A positive association between increase in BMI and increasing length of residence in the host country was found among Vietnamese immigrants living in United States [21,41] and this group was more likely to be overweight than returnees or counterparts who never left the country [21]. This effect was not confirmed in Norway [26]. Dijkshoorn et al. [42] found a high prevalence of obesity in Turkish immigrants living in the Netherlands, but there was no evidence of an association with length of residence in the host country.

• **Europeans**

Sample sizes varied between 218 and 163,797. Only two studies included the immigrants' country of origin [16,22]. Eleven mentions were made of the European subgroup in 10 different studies, of which eight reported a positive association between the two variables of interest (72.7%).

A cross-sectional population-based study in the United States carried out by Sanchez-Vaznaugh et al. [29] reported that the BMI of immigrants living in the host country for less than 5 years was 1.6% higher than that of immigrants who had been living in the country for 15 years or more. However, the authors also found that the BMI of white immigrants living in United States for 15 years was higher than the BMI of those who had lived in the country for 10 to 14 years. These results contradict the findings of a cross-sectional population-based study carried out in the United States by Oza-Frank et al. [31] which shows that long-term Caucasian immigrants (resident for ≥ 15 years) are three-times more likely to be overweight than recent immigrants (resident for < 5 years) from the same ethnic background. Newly-arrived Caucasian immigrants in Canada are 15% less likely to be overweight but the rate of overweight progressively increases reaching host country levels after around 30 years of residence [30].

• **Africans**

Two studies included North Africans (Moroccans). The host countries were the Netherlands and Italy and sample sizes were 339 and 1,384. Both studies found a significant positive association between the two variables of interest. However, the study in the Netherlands, carried out by Dijkshoorn et al. [42], found that this association was only statistically significant among women (cross-sectional study with data derived from a sample taken from the Amsterdam population register).

The sample sizes of Sub-Saharan African immigrants varied between 208 and 163,797 and covered the following host countries: United States (6), Canada (1), Israel (1); and Norway (1). Nine mentions were made in nine different studies, five of which reported a positive and significant association between length of residence and BMI/rate of overweight (55.6%). Only two studies reported the nationality of immigrants (Ethiopia and Somalia). A significant increase in the rate of overweight with increasing length of residence was found among Somali immigrants living in Oslo (Norway) [23].

Comparison of immigrants with respective home-country residents

Of the six studies found in this category, four were from European countries and two from Australia (Table 3). Sample sizes ranged from 250 [43] to 2,000 [44] and the papers were published between 1995 [45] and 2011 [44]. All samples included both genders. Two studies [43,45] used relatives as controls. Five of the studies [45,46,47,48,49] reported that immigrants had a higher BMI than the control group. A study of Indian immigrants living in Australia [43] showed no significant difference in BMI among men. However, the group living in India had higher waist-hip ratios. Two studies [43,46] showed that the cardiovascular risk profile was better in immigrants than in the control group.

Five out of the six studies included Asian samples. Two studies [43,46] of Indian and Sri Lankan immigrants reported that the cardiovascular risk profile was worse in nonimmigrants, despite the fact that BMI was lower or equal in this group. Mahajan & Bermingham [43] found that the level of abdominal obesity was lower (waist-hip ratio) among Indian immigrants than among men and women living in the country of origin. Tennakoon et al. [46] found that female Sri Lankan immigrants had higher BMI and higher waist circumference, but lower triglyceride and blood pressure levels than women living in Sri Lanka, while Bhatnagar et al. [45] reported worse cardiovascular profiles, higher BMI values, and higher total cholesterol levels among Indians living in England when compared to their counterparts living in India.

Kouris-Blazo et al. [50] reported that the rate of obesity among elderly Greek immigrants living in Australia was higher than among their counterparts in Greece. These immigrants apparently had healthier food habits but a worse health status.

Discussion

The association between length of residence in the host country and increase in BMI seems to vary according to the ethnic background of immigrants. This section therefore takes a more detailed look at the association by ethnic group.

Hispanics

The risk of developing obesity is greater among Hispanic immigrants than among people from other ethnic groups living in the United States [29]. The results of linear regression show a clear increase in mean BMI across generations of Hispanic immigrants [10]. This increase is greater among female immigrants [38], showing that women are more vulnerable to the acculturation process [28].

High rates of prevalence of obesity and type 2 diabetes among Hispanics may be explained by the genetic heritage received from American Indians [10]. Sanchez-Vaznaugh et al. [29] explain that newly-arrived Hispanic immigrants have lower educational attainment and are less likely to speak English, stalling upward social mobility and constraining life choices and opportunities. Furthermore, higher BMI may be due to cumulative exposure to social and physical environments and neighborhoods that lack access

Table 3

Body mass index (BMI) or overweight prevalence comparisons between immigrant and non-immigrant communities, by host country.

Immigrant group	Host country	Year of publication	Reference	Significant differences (immigrant group vs. their counterparts)
Pakistani	Norway	2011	44	Men: immigrants had significantly higher BMI (4.5kg/m² higher in immigrant group); Women: immigrants had significantly higher BMI (3.3kg/m² higher in immigrant group)
Indians	Norway	2011	44	Men: BMI without significant differences between groups; Women: immigrants had significantly higher BMI (2.6kg/m²)
	United Kingdom	2006	47	Men: immigrants had significantly higher BMI (4.9kg/m²); Women: immigrants had significantly higher BMI (5.8kg/m²)
	United Kingdom	1995	45	Men: immigrants had significantly higher BMI (3.9kg/m²); Women: immigrants had significantly higher BMI (4.7kg/m²)
Sri Lankans	Norway	2010	46	Men: immigrants had significantly higher BMI (3.2kg/m²); Women: immigrants had significantly higher BMI (2.1kg/m²)
Greeks	Australia	1996	48	

to nutritious food, promote the consumption of high-density foods and constrain physical activity. This is a relevant aspect considering that Hispanics tend to be from more socioeconomically disadvantaged backgrounds than other migrant groups [20]. The effect of the neighborhood factor can be so significant that some studies recommend it as a better measure of the socioeconomic status of Hispanic immigrants [47].

Cuban and Puerto Rican long-term immigrants living in United States were the only groups where the risk of being overweight did not increase [13]. Albrecht et al. [18] suggest that the impact of acculturation varies within the Hispanic subgroup. However, their study was the only longitudinal study found in our review and found no significant increase in BMI in Hispanic subgroups over a five-year follow up period, except in Mexicans where significant increases in BMI and waist circumference were observed. This increase is not significantly different from the one observed in Mexican-Americans born in the United States. Hispanics of Mexican origin often adopt negative health behaviors and are likely to be influenced by behaviors established in the country of origin. The study sample was relatively small and the cohort was relatively older and healthier and was sampled from selected regions, which may compromise the generalizability of the results. A study carried out by Park et al. [19] revealed that the rate of obesity among Hispanic immigrants in the United States increases with increasing length of residence, but does not reach the levels of the population born in the United States, and, according to Park et al. [19], obesity rates among Hispanic immigrants increase at a slower rate than in the native population. Park et al. [19] highlight the following reasons behind the misleading conclusions about obesity among immigrants: differences in aging between immigrants and the native population, the growing duration of the immigration trend and historical trends in obesity. All studies of Hispanic immigrants were conducted in the United States and Canada. Therefore, there is no evidence to suggest that the same increases in BMI and rates of overweight with increasing length of residence would be experienced by Hispanic immigrants in other host countries.

Asians

The analysis of this group is more challenging since the association between length of residence in the host country and BMI varies greatly according to the region of birth, which was not always described in the papers. Asian immigrants living in the United States seem to be the ethnic group that is least affected by acculturation [17,34]. Researchers have suggested that this may be due to the fact that Asians are more likely to have higher educational attainment than Hispanics and are more likely to live in better neighborhoods, which in turn influences access to nutritious food [29]. The evidence related to Middle East or West Asian immigrants is too scarce to make any firm conclusions. There is a positive association between BMI and rates of overweight with increasing length of residence among Vietnamese immigrants living in the United States, but not among those living in Norway. This suggests that the host country may be an important factor influencing the direction and strength of the association. Furthermore, the BMI of immigrants fluent in Norwegian is lower than in the native population, suggesting that greater acculturation is a protective factor for weight increase in this group [26]. Comparative studies with samples of Asian immigrants showed mixed results. While Mahajan & Bermingham [43] and Tennakoon et al. [46] reported a better cardiovascular risk profile in immigrants living in Sydney (Australia) and Oslo, respectively, Bhatnagar et al. [45] found the opposite in immigrants living in England. The first study had several limitations. The sample was composed of a small number of qualified professionals (n = 125), which may have influenced results. All the same, these differences may indicate a more pronounced change in food habits, caloric intake and, potentially, saturated fat intake in England. Tennakoon et al. [46] conducted their study with Sri Lankan immigrants living in Oslo and, according to the authors, the higher BMI in women living in Sri Lanka may be explained by the lack of availability of specific foods in Norway, where, despite increasing BMI among the native population, cardiovascular diseases have decreased with improvements in diet quality from the last 30 years. However, methodological limitations of this study included a gap of three years between the measurements of each sample group and the use of different methodologies to measure blood pressure, and a low response rate conditioned by educational level.

Europeans

The studies of European immigrants lack information regarding the country of origin, making it difficult to interpret the results. Sanchez-Vaznaugh et al. [29] reported a decrease in BMI with increasing duration of residence of immigrants in the United States which, according to the authors, may be explained by the fact that Caucasian immigrants are often more likely to speak English and to live in better neighbour-

hoods than Hispanic immigrants, which in turn leads to greater access to healthy food and facilitates transition into the host country. In Canada, rates of obesity are more likely to reach the same levels as the native population among Caucasian immigrants than in non-Caucasian immigrants. It has been suggested that ethnic minority immigrants acculturate more slowly than those from educated urban settings with similar physical characteristics (such as skin color) [51]. Also, Caucasian immigrants are more likely to speak English, therefore suggesting that linguistic isolation is not a predictor of BMI [51]. An increase in the proportion immigrants in the neighborhood was associated with lower BMI, suggesting that living in a predominantly immigrant neighborhood is a protective factor for this group [20]. One comparative study reported that obesity rates were higher among Greek immigrants than among their counterparts living in their home country. Greek immigrants living in Australia in the 1980s seemed to be living in a "morbidity-mortality paradox": despite high levels of obesity and physical inactivity, data from the time shows that this population group had the second highest average life expectancy, even greater than that of their counterparts in Greece. This paradox has been explained by the adherence to the traditional Mediterranean diet [52]. However Kouris-Blazo et al. [50] did not confirm this protective effect, possibly due to changes in the original Mediterranean diet or greater exposure to the Australian diet.

North Africans

Studies concerning North African immigrants are scarce but unanimous. Toselli et al. [53] and Dijkshoorn et al. [42] showed an increase in BMI in immigrants living in Italy for over 12 years. These studies also reported a significant increase in stress-related factors and the desire to return home among North Africans living in Italy [53]. Acculturative stress has been observed by other studies and can lead to a lowered mental health status (particularly depression and anxiety) that is a known risk factor for obesity. Moroccan families generally fall into lower income categories because of their level of education and professional training [54], which is often associated with higher rates of obesity [55]. In the Netherlands, macronutrient intake among Turkish and Moroccan immigrants was satisfactory, while micronutrient intake was inadequate, leading to differences in weight and health status [54].

Sub-Saharan Africans

Black immigrants often gain weight during the acculturation process. However, not all the studies observed a significant association between the two variables [20,34]. There was a dramatic increase in rates of overweight with length of residence in the host country among Sub-Saharan African immigrants living in Canada [12,30] and Israel. This ethnic group is also susceptible to diet-related illnesses such as cardiovascular disease, hypertension, diabetes mellitus, obesity, and certain cancers [56]. BMI and obesity and insulin resistance prevalence rates tend to be higher among Africans living in the United States than in those living in their home country despite similar genetic origin, showing that differences in chronic disease prevalence are probably due to environmental factors [10]. Often, newly-arrived African immigrants are malnourished and have health problems [57] which can influence their understanding of food and weight. Studies have shown racial differences on weight misperception. For example, overweight and obese African men are more likely to misperceive their own weight status than men from other ethnic backgrounds [58]. Unhealthy practices in African-American communities have been attributed to limited neighborhood healthy food availability and the high cost of healthy food, black consumer-oriented marketing, food preferences and eating patterns [56]. Cultural eating patterns are considered a barrier to healthy eating [48] and deviation from mainstream dietary guidelines in United States is greatest among African-Americans [59]. Several studies indicate that the connections made with family and community through food are highly valued by African Americans [60]. Dietary changes therefore unavoidably entail cultural loss, and resistance towards following healthy eating guidelines may be seen as a form of resistance to racism or cultural dominance [56].

Immigration involves a number of changes in lifestyle, culture and socioeconomic status (at individual, family, and community level) for both immigrants and host populations. Understanding the links between immigration and health is a major epidemiological and public health challenge. The main goal of this article was to summarise current knowledge regarding the impact of immigration on the evolution of body mass index which is recognized as an important health indicator.

Major methodological differences between the studies reviewed made the direct comparison and interpretation of results very difficult, if not impossible, in some cases. Furthermore, a relatively large proportion of the literature analysed

by this study did not provide sufficient information about methodological aspects, particularly sampling procedures, recoding of data and statistical details. A consensual definition of sample selection criteria for studies involving immigrant groups is important to facilitate a better understanding of results and the interpretation and comparison of findings from different studies.

One of the limitations of our study is the non-inclusion of grey literature. Unpublished master's and doctoral theses and reports are a possible further source of detailed information about this issue.

Stratification of data by gender is also important due to different health behaviors adopted by men and women throughout the immigration process [28]. Women are generally considered more vulnerable to the acculturation process than men and consequently are more susceptible to being overweight than men [8]. It is also important to study morbidity differences according to gender, ethnic background and age [61,62]. Cultural preferences, such as media usage [63], and other indicators are often used to measure acculturation instead of, or in addition to, length of residence in the host country.

Figure 2 shows several variables that may mediate the impact of immigration on health. The process is layered and variables are interdependent.

• **Ecogenetics**: most chronic diseases are a result of the interaction between genetic susceptibility to a particular disease and environmental factors. The data on immigrants suggests that this interaction affects the development of type 2 diabetes [64]. Rapid changes in diet and lifestyle can influence the heritability of different phenotypes, which are dependent on the nutritional environment for their expression [10].

• **Socioeconomic status and psychosocial factors**: immigrants generally come from developing countries or a disadvantaged background. Immigration may lead to greater food availability and/or purchasing power. Employment can also be an important factor, since an employed person has less free time to purchase and prepare local food. Immigrants are more likely to work longer hours and have two or more jobs to support themselves [65]. Members of younger and bigger households are also more likely to choose convenience food, while older households are more likely to maintain traditional meals [66]. Immigrants report that acculturation is often associated with an increase in stress [69,70,71] and stress and stress-related disorders may play an important role in the development of obesity [67,68].

• **Traditions and religion**: African-Caribbean groups consume herbal teas and a specific veg-

etable which they believe relieves hypertension and diabetes. Dietary, cultural and religious norms may also play an important role in shaping eating habits. African-Caribbean subgroups often do not eat animal-based foods because they are seen as "dead food". The Seventh-day Adventists and South Asians also have dietary restrictions according to their specific religious beliefs [5].

• **Cultural adaptation**: an immigrant's status in the country (documented versus undocumented) [72], first language, media preferences, and level of identification with host country culture are important acculturation mediators (and may also be barriers to accessing health services [73]) and are often factors associated with increases in BMI after immigration.

• **Body image, self-perception and beliefs relating to food**: body image is often rooted in the culture of the immigrant's home country. For example, being overweight may be seen as sign of success by some cultures, rather than as a health problem. In Moroccan communities, obesity is perceived as sign of prosperity among women [74,75,76].

• **Nutrition transition**: following migration, ethnic groups alter their eating habits, combining elements of their traditional diet with some of the less healthy aspects of the Western diet. Some studies showed an increase in fat and sugar intake and a decrease in fruit and vegetable consumption after immigration [77], while others observed a decrease in vegetarianism and an increase in the consumption of caffeinated beverages [24]. Food availability and prices are determinants of food choices among immigrants [70], while the factors age and generation are two major determinants of the extent of dietary change [5].

• **Physical inactivity**: physical activity levels are more likely to be lower among immigrant groups than in white or nonimmigrant groups [49]. This may be related to the known influence of socioeconomic factors on physical activity. New immigrants often have lower socioeconomic status and work longer hours than nonimmigrants, which reduces the amount of time available and opportunities to practice physical activity [49]. Nevertheless, some immigrants state being more physically active after immigration [8].

Conclusion

We found only five literature reviews of the effect of immigration on weight gain: four specifically addressed the epidemiology of obesity among immigrants living in the United States, and one, conducted by Misra & Ganda [10] and published

Figure 2

Proposed integrated model.
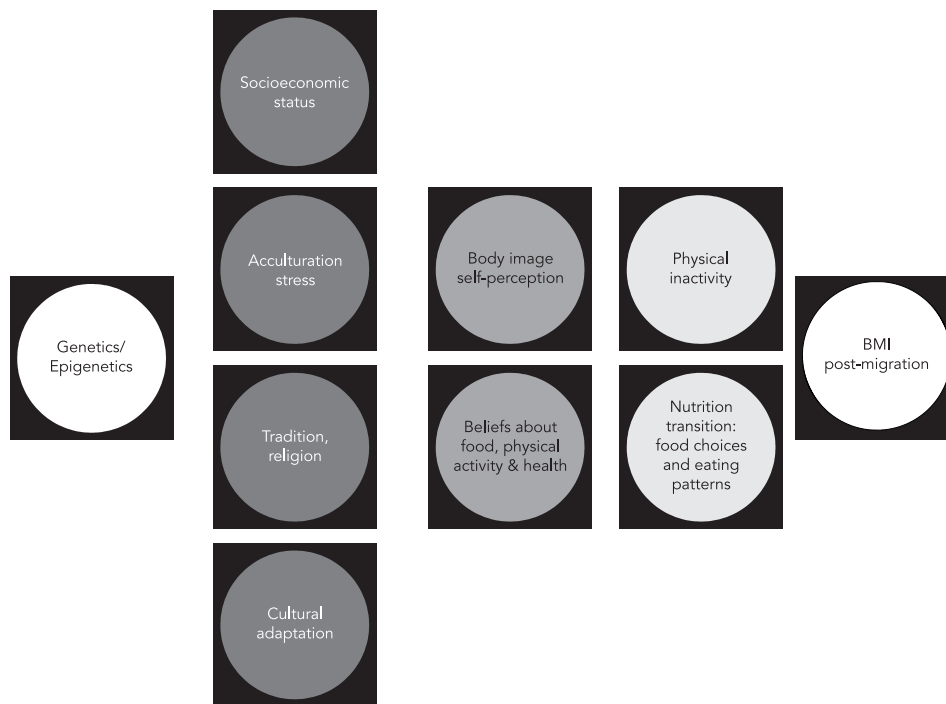
BMI: body mass index.

in 2007, focused on adiposity and diabetes in ethnic groups. The present study aimed to carry out a worldwide review and clearly focus on comparable research in this field in order to provide a qualitative synthesis of current data and an updated perspective on this topic. The flux of immigrants has changed since 2007 and this is an important factor to consider when analysing and interpreting data. Notwithstanding the methodological differences, the most relevant conclusion of these studies is that there is a significant and positive relationship between body weight and length of residence among U.S. immigrants [8]. This association varies according to ethnic background and may be weaker or inexistent among immigrants with a higher level of education [78], and BMI tends to converge towards the levels of the host population at a quicker rate among women immigrants [79].

Studies about the impact of immigration on health present several challenges due to the number of variables involved and constant changes in these factors. First, migrant populations may not comprise a representative sample of their home country's population and may be healthier or unhealthier than their nonimmigrant counterparts [10]. Secondly, the increased influence of the Western food industry is radically affecting the diet of children and teenagers in several underdeveloped countries and therefore the eating habits commonly seen in first generation immigrants may also have been acquired by their nonimmigrant counterparts in their home country [10]. All but one of the studies covered by this review are cross-sectional, making it hard to make causal inferences about the length of residence in the host country and the increase in BMI and prevalence of overweight. This is a significant drawback and therefore further research of this association involving longitudinal studies of immigrants from different ethnic backgrounds is necessary. Nevertheless, some important conclusions can be drawn from these studies. Acculturation, often measured as length of residence in the host country, is an important determinant of the health of immigrants whose effect depends on a number of variables which have major implications for nutrition transition.

Whereas in some countries immigrants have a lower risk of obesity than the home country population (for example the United States), in other countries the risk of obesity among immigrants is apparently greater (for example Sweden). Therefore, the cultural aspects of the host country seem to play a key role in health protection. Despite these differences, the impact of acculturation is often negative and generally the risk of obesity among immigrants increases as length of residence in the host country increases. Furthermore, nonimmigrants tend to have a lower mean BMI than their counterparts who decided to immigrate. Understanding the culture, beliefs and traditions of the country of origin, as well as food acculturation, may be the key to a better understanding and preventing the negative impacts of this process.

Resumen

La obesidad puede ser una de las características más variables en el proceso de migración. En este estudio se pretendieron actualizar los conocimientos acerca de la relación entre migración e índice de masa corporal (IMC). Además, se procedió a una revisión sistemática de la literatura, de acuerdo con las directrices PRISMA, por búsqueda electrónica (actualizada en agosto de 2014). Se incluyeron 39 artículos y se analizaron cualitativamente. Los resultados variaron según el grupo étnico, el país de origen y acogida. Los inmigrantes hispanos, africanos y europeos mostraron una relación consistente y positiva entre el IMC y el tiempo de migración. Los inmigrantes asiáticos mostraron una asociación positiva en menos de la mitad de los estudios. Puede haber un efecto negativo de la migración sobre el IMC. Cambios nutricionales y de actividad física, factores psicosociales y la susceptibilidad genética pueden ser razones subyacentes que deben ser incluidas como variables moderadoras en estudios futuros.

Migración Internacional; Aculturación; Obesidad

Contributors

All authors made an equal contribution to the production of this article.

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