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Is there a healthy migrant effect on cardiovascular health? A narrative review of scientific bibliography

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Abbreviations
AMI: acute myocardial infarction
CVRF: cardiovascular risk factors
HBP: high blood pressure
HME: healthy migrant effect
SDH: social determinant of health
T2DM: type 2 diabetes mellitus

ABSTRACT
International migration is a complex process that impacts population health and is considered a social determinant of health (SDH). A possible health advantage in migrants with respect to natives, called the healthy migrant effect (HME), has been proposed. Currently its evidence is controversial in cardiovascular health. A search was performed in Web of Science and PubMed databases with terms referring to migration, cardiovascular disease, risk factors, and SDH. The search yielded 2933 records, 90 publications were selected: forty-six report evidence for HME (pro, against, mixed or neutral) and 44 describe associated SDH. The HME seems to apply selectively in specific conditions and subgroups according to the analyzed origin and destination. The evidence of associated SDH favors the understanding of these differences; therefore, a broad analysis approach that integrates the various exposures of the migratory process that could influence cardiovascular health is needed.
Keywords: Human migration, Transients and Migrants, Social determinants of health, Healthy migrant effect, Cardiovascular diseases

¿Existe efecto de migrante sano en salud cardiovascular? Revisión narrativa de literatura científica

RESUMEN
La migración internacional es un proceso complejo que impacta la salud poblacional y es considerado un determinante social de la salud (DSS). Se ha expuesto una posible ventaja en salud en migrantes con respecto a nativos, llamada efecto de migrante sano (EMS). Actualmente su evidencia es controversial en salud cardiovascular. Se realizó una búsqueda en Web of Science y PubMed con términos referentes a migración, factores de riesgo, enfermedades cardiovasculares y DSS. La búsqueda arrojó 2933 registros de los cuáles se seleccionaron 90 publicaciones: 46 informan evidencia del EMS (a favor, en contra, mixta o neutros) y 44 describen DSS asociados. El EMS parece ocurrir selectivamente en condiciones específicas y subgrupos según origen y destino analizados. La evidencia de los DSS asociados favorece la comprensión de estas diferencias; por lo tanto, es necesario un enfoque de análisis amplio que integre las diversas exposiciones del proceso migratorio que podrían influir en la salud cardiovascular.
Palabras clave: Migración humana, Migrantes, Determinantes sociales de la salud, Efecto de migrante sano, Enfermedades cardiovasculares

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INTRODUCTION

International migration is a dynamic and complex process of human mobilization that can take place voluntarily or involuntarily, generally promoted by the search for better living conditions[1-3]. It is estimated that there were 272 million international migrants in the world up to December 2019, representing 3.5% of the world's population[4]. There are different migration patterns at global level, where the South-to-North pattern towards developed countries stands out, evidenced by a high concentration of migrants in Europe and North America. There is also a considerable mobility between countries within the same region, from middle-income to high-income countries or between developing countries. This last pattern is the most frequent one in Latin America, known as South-to-South migration[1,4].

The international migration process is neither continuous nor definitive, but is composed of dynamic stages[5]; among which are mainly the pre-migration, transit, destination and return phases[6]. In these stages, differential exposures can arise that influence health and well-being[5], from the social determinants of health (SDH) approach. These exposures correspond to the social conditions in which people develop during their life cycle and migration process. Conditions that may present avoidable unfair systematic differences, capable of producing inequities in health[7].

International migration does not directly represent a risk, but the circumstances in which this process takes place can trigger social and health inequities[8]. That is why international migration is recognized as a SDH[9]. Migrants in an irregular situation, women, children and minorities may face barriers to access social and health protection[10].

There are health problems in international migrants that are of great interest to public health, including chronic non-communicable diseases. The relevance of these diseases arises from the transition from patterns centered on infectious diseases to profiles similar to those of the general population[11]. Among chronic non-communicable diseases, cardiovascular diseases[12] and their risk factors stand out, which produce a high burden of disease and disability worldwide, mainly in adults facing some type of socioeconomic vulnerability[13], refugees or in an irregular administrative situation.

In 2017, an estimate of 422.7 million cases globally and 17.92 million deaths per year due to these causes in the world population[14] was published, and it was considered that by 2030 this could reach 23.6 million deaths per year[15]. This conditions variably affect migrants depending on their origin, destination and time of residence[16,17]. In addition, they may result both from their individual susceptibility and from social and health services access disadvantage facing cumulative SDH exposures, including unhealthy lifestyles[18]. A systematic review of studies in migrants published between 2000-2014 revealed diversity in cardiovascular diseases (CVD) risk. For some groups the risk is similar to that of locals, while in others is higher or even lower[17]. However, a meta-analysis that analyzed causes of mortality by International Classification of Diseases categories found lower mortality due to circulatory causes and type 2 diabetes mellitus (T2DM) in migrants compared to the general population[19]. These results suggest a possible advantage in cardiovascular health that contrasts with the accumulated exposures and risks derived from the migratory process.

The possible health advantage of migrants is called the “healthy migrant effect” (HME), which has better morbidity and mortality indicators compared to the population of the host country[20] or even the country of origin[21]. Among the possible explanatory models, positive selection is proposed, in which the individual considers that he or she possesses the characteristics and resources to undertake migration[22]. This selection can also be made by the destination country with selective entry criteria (requiring health screening or demonstrating a high level of education)[23]. Another model includes habits previously incorporated by migrants, who maintain —for example— healthy lifestyles during migration. In addition, they can improve their health by accessing better structural conditions in the host country, if they manage to integrate and receive social protection[24]. Finally, the protective role of social support and cohesion has been postulated, as they provide positive reinforcement for healthy behaviors and promote wellbeing[25,26]. Likewise, migrants’ interaction in the host society enables a better stress control[27]. However, the HME has also been questioned by authors who argue underregistration of morbidity in migrants, supported by lower access to the health system and the possibility of returning to the country of origin of those with severe diseases. This leads to the so-called fallacy (or bias) of the minor health problems registration in migrants compared to local inhabitants[28,29].

The population of international migrants is heterogeneous and changing over time, with different ex-

posures that could influence changes in the HME[30]. Migrants do not always live in living conditions that favor better cardiovascular health than the native population. Even when, on average, they are in better health state on arrival, the risks that some groups experience during the migration process could result in long-term cardiovascular diseases. To understand the HME in cardiovascular health requires an approach that integrates the various dimensions which shape it. The aim of the current narrative review is to describe the evidence from the last five years on the HME in cardiovascular risk factors (CVRF) and cardiovascular diseases in international migrant population compared with locals, from an integrative approach based on the SDH model.

METHOD

Search strategy

The search was carried out in Web of Science and PubMed databases in April 2020. It was first carried out in a general way to identify HME studies with the terms "migration, behavioral and metabolic CVRF, and cardiovascular diseases". Then, complementary searches were carried out where specific terms for each SDH group were added to the initial equation (strategy detailed in **table 1**). The search was limited to studies published between 2015 and April 2020 in English and Spanish.

Articles selection

After eliminating duplicates, articles selection was started with the reading of titles and abstracts. Those selected, were considered for the reading of the full text. Applied inclusion criteria were:

1. Type of population: Migrants or refugees, regardless of their legal situation, time of residence or generation, older than 18 years old.
2. Type of study: Any type of observational study.
3. Type of measurement: Self-report (surveys, questionnaires, scales, structured interviews), anthropometric measurements, biochemical examinations, electrocardiogram, imaging.
4. Type of results: Presence of the HME in CVRF or cardiovascular diseases.
5. Some component of the SDH model: Demographic (gender, age, ethnicity); socioeconomic (educational level, occupation, income); psychosocial (acculturation, stress, social capital and support) and migration process (country of origin and time of residence).

Data extraction and synthesis

Data were extracted to a Microsoft Excel template and categorized by studies that posit findings for,

Table 1. Search strategy in the literature.

General search equation "migration, behavioral and metabolic CVRF and major CVD".
- #1 "Transients and Migrants" [Mesh] OR "Emigrants and immigrants" [Mesh] OR "Refugees" [Mesh] OR "Migration background" OR "Immigrant background" OR "Migrant" OR "Migrants" OR "Immigrant" OR "Immigrants" OR "Ethnic minority" OR "human migration" [Mesh] OR "emigration and immigration" [Mesh] OR "floating population"
- #2 "cardiovascular risk" OR "metabolic syndrome" [mesh] OR "hypertension" [mesh] OR "Diabetes Mellitus,Type 2" [mesh] OR "obesity" [mesh] OR "overweight" [mesh] OR "dyslipidemia" [mesh] OR "hypercholesterolemia" [mesh] OR "sedentary behaviour" [mesh] OR "alcohol drinking" [mesh] OR "smoking" [mesh]
- #3 "cardiovascular disease" OR "heart failure" [mesh] OR "myocardial ischemia" [mesh] OR "Myocardial infarction" [mesh] OR "coronary disease" [mesh] OR "stroke" [mesh]
Complementary search of social determinants on health (demographic, socioeconomic, psychosocial and of the migratory process) equation.
- #4 "age" OR "gender" OR "women" OR "ethnicity" OR "ethnic"
- #5 "economic status" [mesh] OR "Income" [mesh] OR "remuneration" [mesh] OR "poverty" [mesh] OR "social class" [mesh] OR "socioeconomic factors" [mesh]
- #6 "acculturation" [mesh] OR "cultural assimilation" [mesh] OR "social capital" [mesh] OR "social support" [mesh] OR "social marginalization" [mesh] OR "social discrimination" [mesh] OR "quality of life" [mesh] OR "psychological stress" [mesh]
- #7 "country of origin" OR "nativity" OR "immigrant generation" OR "generation of migration" OR "generational status" OR "duration of residence" OR "length of residence

against, or neutral regarding the HME, and studies reporting each SDH subgroup. For each section they were included:

a) Characteristics of the study (author, year, objective).
b) Characteristics of the population (number of participants, country of origin, ethnicity, age and gender).
c) Source of data, tools and main results.

This information was systematized in a narrative thematic analysis according to the dimensions of interest.

RESULTS

Search results and selected articles

The search yielded 2933 records and 2010 duplicates were eliminated. Thus, the titles and abstracts review was carried out in 923 unique records. At the end of this review, 234 articles that met the inclusion criteria remained, which were subsequently examined in full text, and from which 90 were finally selected for information extraction (**Figure 1**). From this total, 46 were included in the report of the HME and 44 in the description of the associated SDH.

The included studies are cross-sectional and longitudinal (follow-up from one to ten years), whose data sources include questionnaires and population databases. The studies were carried out mainly in North America, Europe, Central America and Oceania. Among these, the destination country with most studies was the United States of America, followed by the Netherlands, Canada and Australia. The origin of the migrants is diverse, coming from all continents, and Asian, Afro-descendant and Hispanic ethnicities were the most represented (the countries of origin are shown in **Figure 2**). Regarding the characteristics of the participants, most report voluntary migration and only two manuscripts include refugees. The gender distribution is similar and the age range goes from 18 to over 75 years old; however, participants are concentrated in the 40 to 60 years old range.

Of the total number of articles included in this review, 17 reported —in general terms— on HME in CVRF and cardiovascular diseases, and 19 were contrary. However, given the variability in health outcomes, a group of ten articles were considered mixed, being in favor of the HME for certain conditions and against for others. In addition, two of these studies (one against and one mixed) also assumed neutral positions in specific conditions (**Table 2**).

Evidence in favor of the HME

Most of the studies in favor of the HME come from North America, where less cardiovascular disease has been observed in Asian[31,32] and Hispanic[31,33] migrants, and those with T2DM[34]. Particularly in South Americans, Cubans and Mexicans lower prevalence of coronary artery disease was registered[35]. While strokes or ictus was less probable in Caribbean Afro-descendants and Africans[36]. The HME has been identified in factors such as high blood pressure (HBP) in

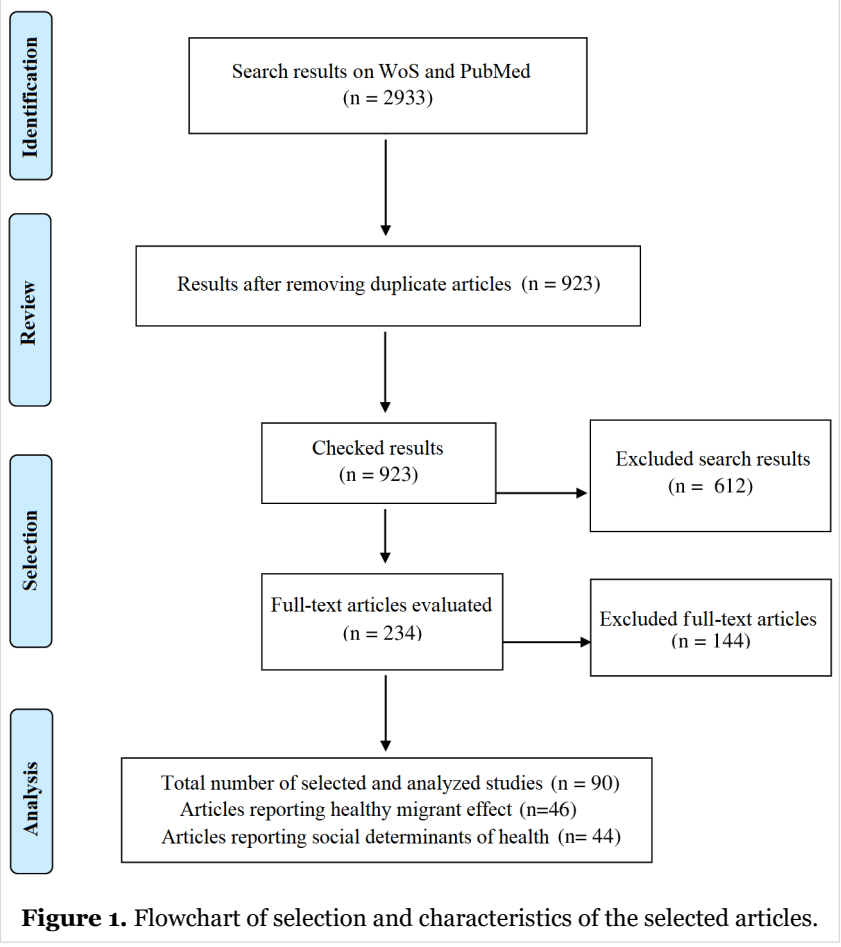

Figure 1. Flowchart of selection and characteristics of the selected articles.

Figure 2. Countries of origin of the international migrants included in the HME evidence.

South Americans[35], Mexicans[37], Africans and Afro-Caribbeans[36,38]. Likewise, T2DM affected a lower proportion to Afro-descendants[38,39], Asians and Europeans, who were also less obese[32,39]. However, one research carried out in Canada and USA suggested that the HME differs according to the country of destination, as only those who resided in Canada had a low prevalence of obesity[40].

In Switzerland, a lower incidence of atrial fibrillation was found in migrants from Iceland, Greece, Italy, Iraq, Turkey, Latin America and Africa[41]. In addition, favorable findings were found for HBP, blood glucose and triglycerides in North Koreans who migrated to South Korea[41,42]. On the other hand, migrants have been recognized as having healthier habits, which could explain the presence of the HME. This is the case of Dominicans living in Puerto Rico[33] and Asians in the USA with low tobacco smoking; as well as lower alcohol consumption in Lebanese compared to local Australians[44]. In addition, there are studies that broaden the understanding of the selection phenomenon by contrasting migrants and the population of the country of origin. From this approach, a lower prevalence of peripheral vascular disease was detected in Ghanaians migrants residing in Europe[45]; while Mexicans living in the USA presented a lower prevalence of metabolic syndrome[46] and tobacco smoking[47].

Evidence against the HME

The evidence contradicting the HME in cardiovascular diseases is located in Europe. In the Netherlands, Indonesian migrants had more heart diseases[48] and Pakistanis had a higher prevalence of acute myocardial infarction (AMI)[49]; similar to the proportion of hospitalizations due to AMI in Asians found in Italy[50]. The literature that informs worse indicators in CVRF covers different regions. In North America, HBP was more common in Afro-descendants[51,52], Asians[52,53] and Hispanics[54]; mainly Dominicans and Puerto Ricans[52]. Likewise, T2DM and tobacco smoking were more prevalent in Hispanics considered acculturated due to language preference[55]. Furthermore, dyslipidemia and obesity were higher in Hispanics[52,54,56] and Afro-descendants[51,52], compared to locals.

On the other hand, in European countries, T2DM was higher in South Asian[57], Pakistani[49], Chinese[58], Surinamese and Turkish[59] migrants. This condition also affected Africans[57,60], to a greater extent, particularly Ghanaians and Moroccans[59]. Russians, Somalis and Kurds were recognized for having elevated blood glucose levels[61]. Meanwhile, Iraqis had earlier onset of T2DM and poor glycemic control, in addition to their obesity[62]. In HBP, the records of Asians [48,52,53,58] and Afro-descendants[63,64] exceeded those of locals, especially Moroccans and Ghanaians[59]. In addition, evidence of obesity[49,59], dyslipidemia[58], sedentariness[57] and tobacco smoking[63] in Afro-descendants and Asians contrasts with the HME. This profile in Asians is similar to that found in Oceania, where T2DM[65] and tobacco smoking were more common in South Asians and Asian-Europeans, respectively[66].

Mixed evidence of the HME

The literature that gathers mixed evidence of the HME is distributed in several regions. In North Amer-

Table 2. Recent evidence of the healthy migrant effect in cardiovascular risk of international migrants.

EVIDENCE IN FAVOR OF THE HEALTHY MIGRANT EFFECT			
Author (year)	**Comparison country**	**Country/region/migrants origin ethnicity**	**Condition in favor of the HME**
Hayfron-Benjamin (2020)[45]	Ghana (non-migrants)	Ghana (migrants in Europe)	Peripheral artery disease
Sharifi (2019)[32]	Canada	Asia Asia and Europe	Coronary artery disease and HBP T2DM and obesity
Song (2018)[42]	South Korea	North Korea	Blood pressure, glucose and triglycerides levels
Garcia (2018)[35]	USA	South Americans, Mexicans and Cubans South Americans	Coronary artery disease HBP
Tamez (2018)[33]	Puerto Rico	Dominican Republic	CVD, tobacco smoking
Commodore-Mensah (2018)[38]	USA	Afro descendants, Caribbean and Africa	HBP and T2DM
El Masri (2017)[44]	Australia	Lebanon	Alcohol consumption, sedentariness
Lu (2017)[40]	USA and Canada	Mexico, South America, Central America, Europe, Africa, Middle East, Southeast Asia, East Asia,	Obesity
Wändell (2017)[41]	Sweden	Island, Greek, Italy, Iraq, Turkey, Africa and Latin America	Atrial fibrillation
Bacon (2017)[37]	USA	Mexico	HBP
Wirth (2017)[36]	USA	Afro descendants, Caribbean and Africa	Ictus and HBP
Fleischer (2017)[47]	Mexico (non-migrants)	Mexico (in USA)	Tobacco smoking
Lê-Scherban (2016)[31]	USA	(Cardiovascular event, Hispanics, Chinese)	(Cardiovascular event, Hispanics, Chinese)
Ford (2016)[39]	USA	Africa, Caribbean Asia, Europe	T2DM Obesity
Kuerban (2016)[43]	USA	Asia	Tobacco smoking
Beltrán-Sánchez (2016)[46]	Mexico (no migrants)	Mexico (migrants in USA)	Blood pressure, metabolic syndrome
Okrainec (2015)[34]	Canada	Latin America, Mexico, Caribbean, Asia, Europe, Africa, USA	CVD
EVIDENCE AGAINST OF THE HEALTHY MIGRANT EFFECT			
Author (year)	**Comparison country**	**Country/region/migrants origin ethnicity**	**Condition against HME**
Fedeli (2018)[50]	Italy	Asia	AMI
Fedeli (2018)[64]	Italy	Africa	Ictus, heart failure and HBP
Raza (2017)[49]	Netherlands	Pakistan	AMI, T2DM and obesity
Jin (2017)[66]	Australia	Mixed Chinese ethnicity	Tobacco smoking
Snijder (2017)[59,60]	Netherlands	Africa	T2DM
Skogberg (2017)[61]	Finland	Russia, Somali, Kurdistan Kurdistan	Glucose levels and metabolic syndrome, dyslipidemia
Cohn (2017)[56]	USA	Hispanics	Dyslipidemia
Modesti (2017)[58]	Italy	China	HBP, dyslipidemia and T2DM
Minneboo (2017)[57]	Netherlands	South of Asia, Suriname, Ghana, Turkey and Morocco. South of Asia, Suriname	Physical inactivity T2DM
Snijder (2017)[59,60]	Netherlands	Suriname, Ghana, Turkey and Morocco Morocco, Ghana, Turkey	T2DM HBP

		Ghana and Turkey	Obesity
Marshall (2016)[51]	USA	Cambodia	HBP and dyslipidemia
Essilfie (2016)[54]	USA	Hispanics	Dyslipidemia and HBP
Yi (2016)[53]	USA	South of Asia	HBP
Agyemang (2015)[63]	Netherlands	Ghana Africa, Asia, Turkey	HBP Tobacco smoking
Gupta (2015)[65]	Australia	South of Asia	T2DM
Nokes (2015)[55]	USA	Hispanics	T2DM and tobacco smoking
Bennet (2015)[62]	Sweden	Iraq	T2DM and obesity
de Back (2015)[48]	Netherlands	Mol Islands (Indonesia)	HBP (women), heart disease
MIXED EVIDENCE OF THE HEALTHY MIGRANT EFFECT			
Author (year)	**Comparison country**	**Country/region/migrants origin ethnicity**	**Condition in favor of the HME**	**Country/region/migrantes origin ethnicity**	**Condition against HME**
Di Giuseppe (2019)[69]	Canada	Eastern Asia	Heart failure	Afro-descendant, South of Asia	T2DM and HBP
				Latin America	Obesity
Cainzos-Achirica (2019)[71]	Spain	Latin America, Asia, Africa	Atrial fibrillation, dyslipidemia, obesity, tobacco smoking	South of Asia	DM2
				Africa, South of Asia	HBP, obesity
				South of Asia	coronary artery disease, heart failure, dyslipidemia, obesity
Fang (2018)[67]	USA	Latin America, Asia, Africa	Coronary artery disease, tobacco smoking	South of Asia, Africa	T2DM
		Europe, Asia, Africa, Latin America	Ictus		
		Eastern Asia, Europe	T2DM		
		Asia, Europe	Obesity		
Etchi (2019)[73]	Finland	Somalia, Kurdistan	HBP	Somalia, Kurdistan	T2DM
Parackal (2017)[75]	New Zeland	China China, India	Tobacco and alcohol consumption	Asia India	Physical inactivity, obesity
Rabanal (2017)[72]	Norway	South of Asia	Tobacco smoking	South of Asia	Dyslipidemia
Lee (2016)[76]	Korea	China	Cholesterol, metabolic syndrome, risk of CVD	China	T2DM, HBP
Tu (2015)[68]	Canada	Asia, Eastern Europe, Latin America	Ictus, AMI	South of Asia	HBP
		Afro descendants	HBP		
		Asia, Europe Afro descendants	Tobacco smoking		
Guo (2015)[74]	Australia	Europe and Asia	CVD	European	Tobacco smoking
		Asia	Tobacco smoking and obesity	Southeast of Asia	HBP, T2DM, dyslipidemia

Van Oeffelen (2015)[70]	Netherlands	Morocco	AMI	Indonesia, South of Asia, Turkey	AMI
NEUTRAL EVIDENCE OF THE HEALTHY MIGRANT EFFECT					
Author (year)	**Comparison country**	**Country/region/migrants origin ethnicity**	**Neutral condition**		
de Back (2015)[48]	Netherlands	Mol Islands (Indonesia)	Ictus, heart failure and HBP		
Guo (2015)[74]	Australia	Northeast Asia	T2DM		

AMI, acute myocardial infarction; CVD, cardiovascular disease; HBP, high blood pressure; T2DM, type 2 diabetes mellitus.

ica, one study revealed lower prevalence of coronary artery disease, stroke, and tobacco smoking in Asians, Africans, and Latin Americans. In addition, Europeans and East Asians were recognized due to lower figures of obesity and T2DM. However, for these diseases the HME was not present in South Asians and Afrodescendants[67]. Other studies have found similar results for stroke, AMI[68] and heart failure[69] in Latin Americans, Asians, Europeans and Afro-descendants. This is added to lower tobacco smoking in Afro-descendants, and HBP in Asians and Europeans[68]. However, migrants from Eastern Europe and Western Asia presented more tobacco smoking[68], while Latin Americans stood out for their obesity[69]; and South Asians and Afro-descendants for their T2DM and HBP[68,69].

In Europe, the advantage in cardiovascular diseases was shown in Africans[70,71], Latin Americans and Asians[71]; although, particularly, the HME was not fulfilled for AMI in Turks, Indonesians and South Asians[70]. These last also were more affected by coronary artery disease and heart failure[71]. Regarding CVRF, the advantage was evidenced for dyslipidemia, obesity and tobacco smoking in Latin Americans, Africans and Asians[71]; among these, South Asians exhibited less tobacco smoking[72]. In contrast, these studies report disadvantages in South Asian[71], Somali and Kurdish migrants[73] for T2DM. Likewise, it was identified evidence against dyslipidemia, HBP and obesity in South Asians[72]and Afro-descendants[71].

In Oceania, the HME was found for cardiovascular diseases in Europeans and Asians[74]. In addition, these last registered less proportion of obesity, as well as of tobacco smoking alcohol consumption[74,75]. The evidence against the HME was described for sedentariness and obesity in Asians[75], specifically from India[75]. Migrants from Southeast Asia exhibited a higher prevalence of HBP, T2DM and dyslipidemia; while Europeans surpassed the smoking habits of the locals[74]. The only mixed study in Asia described the advantage of Chinese migrants in terms of cholesterol levels, metabolic syndrome and cardiovascular disease risk compared to native Koreans. However, HBP and T2DM were more prevalent in these migrants, suggesting the simultaneous presence of protection and risk in the same population[76].

Neutral evidence of the HME

The studies containing neutral findings also describe mixed evidence or against the effect. The study that showed mixed cardiovascular indicators in Asians and Europeans also revealed a neutral position for T2DM in Northeast Asian migrants[74]. In addition, there are authors who report contrary results for cardiovascular diseases and HBP in Indonesian women, although in men the evidence is neutral[48]. Generally speaking, the recent literature suggests variability of the HME and reinforces the lack of consensus. The effect applies selectively for certain cardiovascular diseases and CVRF, as well as in specific subgroups, depending on the studied origin and destination.

Influence of the SDH on cardiovascular diseases and CVRF

A. Demographic determinants

In the literature variations of the HME are found according to gender, age and ethnicity. Asian and Afrodescendant women, for example, have experienced disadvantages in heart failure, stroke[64,71], HBP[48] and dyslipidemia[64]; whereas men suffer in greater proportion from ischemic heart disease[48-50,64], HBP[52,54,63,64,68], T2DM[58,60,64-67,69,71] and obesity[52,75]; mainly Asians, Afro-descendants and Hispanics. In some men these diseases appear early, like AMI in persons under 55 years old[70]. There is evidence that migrants in this age range[71] and even between 31 and 40 years old[60], have higher rates of HBP and T2DM. Similar to dyslipidemia, which occurrence has been demonstrated among persons under 45[54] and 60[56] years old.

With respect to risk habits, European, African and

Asian men stood out for their tobacco smoking[63,66,74] and sedentariness[66,74,75]. In some cases, after adjustment for demographic variables, the apparent HME in cardiovascular diseases disappears[67,69]. This suggests that the differences between migrants and locals can be explained by biological and identity factors of the individual.

B. Socioeconomic determinants

The HME can be modified by components of the socioeconomic status. For example, this effect on cardiovascular diseases disappears in migrants with a lower level of education[34]; meanwhile, the prevalence of atrial fibrillation tends to increase with this level of education[77]. Regarding the influence of income, the risk of heart failure associated with residing in low-income neighborhoods has been reported[69,78]. Furthermore, there is a positive correlation between income level and mortality due to cardiovascular diseases[56]; while intermediate income is associated with structural and functional cardiac alterations[79].

For CVRF, an inverse correlation has been found with annual income[80], mainly low income; which is associated with obesity, dyslipidemia, metabolic syndrome[81] and HBP[53]. In contrast, a higher income generates protection against HBP[38] and T2DM[39]. In relation to occupational status, unemployment is associated with chronic non-communicable diseases[82] and metabolic syndrome[61]; likewise, the type of employment influences the risk, particularly of HBP[83]. On the other hand, in case of low educational level or income there is a greater diagnosis associated to T2DM[38,84,85]. Generally a low socioeconomic status is associated to the increase of cardiometabolic risk[86,87].

C. Psychosocial determinants

Migrants who adopt separation as an attitude of acculturation (limited interest in their culture of origin) present more T2DM, dyslipidemia, overweight, and sedentariness[88,89]; and those considered acculturated, due to their interaction with the host society, present cardiac alterations[79,90], HBP[90,91], obesity, and tobacco smoking[55]. In turn, discrimination favors the appearance of obesity, dyslipidemia, metabolic syndrome[92], T2DM[86,93] and unhealthy habits[93,94]. In addition, the number of discriminatory experiences increases the risk[94,95]; while chronic stress is associated with CVRF[85,87,96,97]. Psychosocial resources generate protection for metabolic factors[87,98-100] and sedentariness[101]; however, the imbalance of these resources is associated with cardiovascular diseases, through ties with extended family[80], migrant concentration in the neighborhood[56] and functional social support[102].

D. Migratory determinants

Recent literature describes the detection of cardiovascular diseases and CVRF in migrants from Central American and Caribbean countries[35,40,52,67,77,103-106], Asia[48,58,62,68,70,76,83,107-109], Africa[51,57,59,61,63,70,73,110-113] and Europe[61,108,114] (**Table 3**). These studies report variations possibly related to the biological and social diversity of the country. For its part, length of residence has been associated with unfavorable indicators of cardiovascular diseases[31], sedentariness[74,113], obesity, atherosclerosis[89] and tobacco smoking[74,113]. Several articles expose risk of HBP, obesity[111] and sedentariness after five[115] and ten years of residence[104,116-118]. Residence for more than ten years in the host country increases the incidence of AMI and stroke[68] and the probability of T2DM[104]; whereas residence for more than 15 years more than doubles the probability of T2DM and HBP[119].

DISCUSSION

The findings of this research come mostly from developed countries, reflecting the South-North migratory pattern. There are few studies related to the HME involving intraregional migration, as well as specific literature on South-South migration and recent migration phenomena in Latin America. The heterogeneity of the evidence on the HME makes it difficult to reach a consensus that supports its existence in cardiovascular diseases and CVRF.

This set of results shows the diversity and complexity of the relationship between international migration and cardiovascular health. The literature in favor of the HME shows wide variability in the conditions in which it takes place and highlights the country and region of origin and ethnicity as possible relevant dimensions. The place of destination also seems to play a differentiating role, since it could determine certain particular exposures.

With respect to explanatory models, the selected articles support the presence of healthy habits in migrant groups, which are preserved during the migratory process. A possible selection process is also discussed, as migrants tend to be healthier than their non-migrant compatriots. However, a slightly higher amount of studies refers results against the HME.

Table 3. Evidence of risk factors and cardiovascular diseases in international migrants per country of origin.

Morbid condition	Country of origin	Author (year)
Cardiovascular disease	Puerto Rico	Linares (2019)[77], Lu (2017)[40]
	Dominican Republic	Linares (2019)[77]
	Mexico	Fang (2018)[67]
	Haiti	Sirutis (2019)[103]
	Ghana	Minneboo (2017)[57]
	Iraq, Afganistan	Tu (2015)[68]
	Indonesia	de Back (2015)[48], Van Oeffelen (2015)[70]
	Morocco, Suriname	Van Oeffelen (2015)[70]
Type 2 diabetes mellitus	Syria	Hani (2019)[107]
	Kurdistan, Somalia	Etchi (2019)[73]
	India, Russia	Commodore-Mensah (2018)[38]
	Ghana, Morocco	Snijder (2017)[60]
	Puerto Rico	Garcia (2018)[35], Lu (2017)[40]
	Mexico	Commodore-Mensah (2016)[98]
	Cambodia	Marshall (2016)[51]
	Ethiopia	Ghobadzadeh (2015)[110]
	Kenya, Liberia	Sewali (2015)[111]
	Iraq	Tu (2015)[68]
High blood pressure	Puerto Rico	Linares (2019)[77], Fei (2017)[52], Lu (2017)[40]
	Syria	Hani (2019)[107]
	Russia	Commodore-Mensah (2018)[38]
	India	Commodore-Mensah (2018)[89], Shah (2015)[83]
	China	Modesti (2017)[58], Lee (2016)[76]
	Ghana	Minneboo (2017)[57], Agyemang (2015)[63], Snijder (2017)[59]
	Morocco	Snijder (2017)[60]
	Romania	Russo (2017)[114]
	Cambodia	Marshall (2016)[51]
	Ethiopia	Ghobadzadeh (2015)[110]
	Kenya, Liberia	Sewali (2015)[111]
	Indonesia	de Back (2015)[48]
Dyslipidemia	Syria	Hani (2019)[107]
	India	Savadatti (2019)[109]
	China	Modesti (2017)[58], Lee (2016)[76]
	Morocco, Turkey	Minneboo (2017)[57]
	Salvador, Honduras, Guatemala	Gill (2017)[105]
Overweight/ obesity	Cambodia	Marshall (2016)[51]
	India	Savadatti (2019)[109], Shah (2015)[83]
	Russia	Commodore-Mensah (2018)[89,108]
	Nigeria	Obisesan (2017)[112]
	Puerto Rico	Fei (2017)[52]
	Salvador, Honduras, Guatemala	Gill (2017)[105]
	Cuba	Affuso (2016)[106]
	Mexico	Commodore-Mensah (2016)[98,104]
	Iraq	Bennet (2015)[62]
	Liberia	Sewali (2015)[111]
Metabolic syndrome	India	Savadatti (2019)[109]
	Salvador, Honduras, Guatemala	Gill (2017)[105]
	Kurdistan, Somalia, Russia	Skogberg (2017)[61]
Tobacco smoking	Puerto Rico	Fei (2017)[52]
	Korea	Patterson (2016)[113]
	Turkey	Agyemang (2015)[63]

	Bangladesh	Shah (2015)[83]
Alcohol consumption	Nigeria	Obisesan (2017)[112]
Physical inactivity	Nigeria	Obisesan (2017)[112]
	Korea	Patterson (2016)[113]

Among these, Asians and Afro-descendants stand out for their higher proportion of CVRF and metabolic risk factors, which supports the importance of hereditary factors and lifestyles, depending on the culture of origin. Likewise, behavioral CVRF are presented that contradict the theoretical arguments of the HME, in the sense that during the migratory process they acquire less healthy patterns[120].

The mixed evidence is less present and reinforces the absence of concluding findings that support an advantage in migrants. These differences show how the HME applies selectively to some conditions and subgroups of the group, with variations according to the countries of origin and destination analyzed. Therefore, the debate is not only focused on better global health indicators, but also on specific causes and determinants of origin, transit and destination. These can determine differential risks for cardiovascular diseases in migrants respect to the locals. This analysis favors the detection of the particular needs of migrants in the host country and the SDH approach as an integrative approach that broadens the understanding of migration and cardiovascular diseases by incorporating into these relationships levels of individual, family, community, and health system determination, as well as social and structural aspects of the migratory process.

The variability of the results can emerge due to the influence of the SDH[121]. Demographic determinants predispose to distinctive physiological processes and cultural practices[122-124], while socioeconomic determinants are integrated as mediators in the choice of habits[125], access to services and living conditions[126,127]. Psychosocial resources, for their part, favor the HME, although their imbalance is associated with cardiovascular diseases and mortality[128,129]. In addition, the process of interaction with the host society[130] facilitates the adoption of behavioral CVRF[120]. Taken together, these determinants are framed in the migratory process, with baseline[131] and acquired exposures that could dissolve the HME[29].

This review evidences, for the first time, the usefulness and relevance of the SDH approach to understand the complex and multi-dimensional relationship between international migration and cardiovascular diseases/CVRF. This research has as strengths the integrative search and detailed reporting by cardiovascular "condition" (cardiovascular disease and CVRF). Its main weaknesses are related to the admitted evidence period and the low representation of Latin American literature. Future studies should make the situation of migrants in the region more visible and generate knowledge transferable to health planning and public policies in Latin America.

CONCLUSIONS

The current evidence for the HME in cardiovascular diseases and CVRF is complex, multidimensional, and inconclusive, so that attention to SDH in this relationship needs to be expanded. Because the migratory experience possibly confers susceptibility to cardiovascular diseases in some migrant groups, similar studies are required that evidence learning and knowledge gaps; as well as new studies that explores trajectories during the migratory process, in order to achieve health planning with recognition and understanding of the complexity of health care and the particular risks of diverse groups.

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