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REVIEW ARTICLE

Socioeconomic status and risk factors for cardiovascular disease: Impact of dietary mediators

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Abstract It is well known that cardiovascular disease is the leading cause of mortality in the western societies. A number of risk factors such as family history, diabetes, hypertension, obesity, diabetes, smoking and physical inactivity are responsible for a significant proportion of the overall cardiovascular risk. Interestingly, recent data suggest there is a gradient in the incidence, morbidity and mortality of cardiovascular disease across the spectrum of socioeconomic status, as this is defined by educational level, occupation or income. Additionally, dietary mediators seem to play significant role in the pathogenesis of cardiovascular disease, mediating some of the discrepancies in atherosclerosis among different socioeconomic layers. Therefore, in the present article, we aim to review the association between socioeconomic status and cardiovascular disease risk factors and the role of different dietary mediators.

Abbreviations: CHD, coronary heart disease; CVD, cardiovascular disease; SES, socioeconomic status.

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1. Introduction

It is well established that cardiovascular disease (CVD) is the leading cause of mortality in the western societies, with coronary heart disease (CHD) accounting for more than 50% of the cases.[1–3] Although traditional risk factors form the basis of most of the cardiovascular risk prediction models, these factors account for only a part of the overall risk for CVD.[4,5] In many countries socioeconomic (SE) inequalities in CVD have been reported.[6,7] The gradient incidence of CVD morbidity and mortality across the spectrum of socioeconomic status (SES), as this is mainly defined by income, occupation and educational status, has pronouncedly rendered clear the need to take into account more than the classical risk factors when trying to determine objectively the individual overall CVD risk. The behavioral aspects, such as physical inactivity, smoking and alcohol consumption, explain only 13–60% of the SE differences in CVD morbidity and 19–55% of CVD mortality.[8]

Therefore, in the present review article we aim to summarize the acquired so far knowledge on association between socioeconomic status and CVD risk factors, as well as to shed light on the potential mediating role of diet. In specific, dietary intakes (patterns, food groups, macromolecules), and nutrition-mediating diseases, such as obesity, diabetes and hypertension, will be analysed for their impact in the aforementioned relation.

2. Socioeconomic status and diet

Recent data suggest that SES, as assessed by occupation, education and income level[9] is closely related with the quality of diet.[10–12] Given the fact that socioeconomically disadvantaged groups are well associated with higher prevalence of CHD and CVD mortality,[13–17] it may seem a rational alternative to presume that diet could partly explain the documented discrepancies.[18,19]

Concerning the intake of various food groups, low SE groups prefer white bread, potatoes and pasta or rice and refined cereals[10,20–28] compared to those of high SES, who prefer whole bread or wholegrain products that have a lower glycaemic index and load as well as a greater amount of fiber.[20,23–26,29,30] On the contrary, higher SES is associated with considerably larger consumption of fruit and fresh vegetables compared to middle and lower SES groups.[31–33] Few studies have also tried to quantify such differences. For instance, in the study of Irala-Estevez et al summarizing the data from 11 European studies from 7 countries, the difference was 24.3 gr/day/person between the highest and lowest SES group in men in the field of fruit intake, while the difference among women was even more pronounce (approximately 33 gr/day/person).[34] In the same study, a similar trend was observed in the field of vegetable intake, with men presenting with more notable differences compared to women (17 gr/day/person vs 13 gr/day/person). To the same direction, income appeared to be an important determinant in fruit and vegetable intake in a cohort from 1995 Australian National Nutrition Survey, with the differences being considerable not only among adults, but in adolescents as well.[35] Similar data were confirmed in Canada and U.S.A.[36,37]

2.1. Ecologic studies

The interesting hypothesis between SES and daily intake of fruits and vegetables has also been addressed, with the direct comparison in ecologic studies with higher standard of living and developing countries. Of course, the greater intake of fruits and vegetables in the economically disadvantaged regions of Southern Europe, consistent with Mediterranean diet, compared to the economically powerful countries of central and western Europe has underestimated the critical role of the agricultural profile of the national economy in Southern Europe, where the domestic production of such products render them more available and of course more cost-effective in relation to developed countries of North Europe. The intake of meat and seafood seems also to be influenced by SES, since it has been observed a notable difference in the consumption of these nutrition categories among groups of diverse SES. High SES is related with higher consumption of lean meat and seafood, whereas lower SES groups tend to consume more fried and canned fish and fatty meats.[11,20,24,25,38,39] Similarly, superior SES layers intake more low fat cheese and milk, although there was not an important difference in overall dairy consumption among the groups according to their SES.[40] The meta-analysis of studies from several European countries revealed that women in higher SES consume 9gr/day more cheese than their counterparts in lower SES, while the difference in men run up to 7 g/day.[40] Lower SES level groups eat also more butter, implying a different source of saturated fats among the different SES groups, since people with higher SES follow a rather more modern dietary pattern, while these belonging to lower SES tend to adopt the more traditional dietary archetype.[39] The consumption of sugar and sweets could not be an exception to the rule of diet quality. More specifically, socially disadvantaged people eat more sweets, such as cakes with extra sugar, while their counterparts in high SES classes consume mainly pastries and desserts with lower sugar content.[21,25,29,41,42] Last but of not least, people with lower economic power consume beer and sweetened beverages, whereas economic powerful layers of the society are associated with wine consumption, a habit that is already known for its beneficial effect on CVD health.[10,24,25,42] The SE mediated inequality in dietary habits among adults has also been observed in children and adolescents in several studies all over the world.[43–46] Children and adolescents coming from families with a lower SES tend to consume more bread, much more sweets, exercise less, drink more and eat significantly smaller amounts of fruit and vegetables in comparison with youths from socioeconomically powerful families.[47–52]

2.2. Cost

Data suggest that low income families purchase low cost items and spend their limited resources on saturated fats, sweets, and sweetened beverages, with only a minimal part to fruit, vegetables, fish or lean meat. Poverty leads to the selection of dry packaged foods[53] with no or not proximate expiration date· such food consists mainly of sugar, starches and a high proportion of saturated fat. There is no

doubt that SE gradient.[54–56] Eating healthy, although desirable, means more money: a healthy diet costs more. Despite the overt difficulties in terms of defining cost (price of food bought), several study efforts have been undertaken in order to specify the exact role of cost in diet quality. In the analysis from the UK's Women's Cohort Study comprising of more than 15.000 participants it was found that cost was an independent predictive factor of healthy diet, with women adopting the healthiest diet spending more than 600 pounds per year compared to women in the least healthy diet group.[57] The absolutely detrimental role of cost on food choice is also depicted in a series of studies by French et al, where the perceived cost of certain food species influenced to the greatest manner the purchase of the products.[58–62] Similarly, the price of fruit and vegetables was the most determinative barrier in the consumption of these products from low-income families.[63]

2.3. Education

Although the lack of nutrition knowledge could be associated with the diet quality,[64,65] the results are not always reproduced.[66,67] In an absolutely theoretical basis, the higher educational level could be related with more stressed occupation, less available time for cooking and consequently with a bigger trend for consumption of ready-to eat food or fast-food habits.[68] However, bibliographic data denote the trend to the opposite side, as far as diet quality is concerned. In the recent study by Hiza et al using the Health Eating Index-2005 as a means of measuring diet quality, it was demonstrated that adults with a college diploma had higher scores for whole fruit, total vegetables, whole grains, and calories from solid fats, alcoholic beverages, and added sugars compared to all other education levels.[69] Those with less than a high school education had a lower score for oils and higher scores for saturated fat and sodium compared with all other education levels. In the longitudinal analysis of the effect of education, along with other factors, in CARDIA group it was shown that the demographic gap in diet quality between high educated participants and their low educated counterparts persisted in a significant degree, although the gap was reduced compared to 20 years ago.[70] Intervention studies focused on the role of education on improvement of diet quality have managed to demonstrate favorable changes in dietary parameters not only in adults,[71] but in children as well.[72] Although it seems quite difficult to quantify the role of education on diet composition and dietary habits, it is of not dispute the fact that education proceeds proportionally to diet quality and vice versa.

2.4. Environmental factors (obesogenic environment)

Such factors have to do with SES and may also affect diet quality and can have their own share to the justification of the observed disparities. Supermarkets and grocery stores are more often in affluent neighborhoods rather than in areas, where socially disadvantaged groups may reside. Low income neighborhoods, often characterized as 'Food desserts', cannot be expected to favor healthy dietary habits and a nutrition pattern that is close to this recommended from the authorized organizations for an optimal CV health. Cultural, racial and other social factors that have to do with SES can influence diet quality.[73–75] Although these factors do not constitute major determinants of SES and their role in defining diet quality may be of secondary importance, they should not be neglected when trying to highlight the potent correlation between SES and diet. All the aforementioned data gain a special interest, when they are reviewed in light of the main risk factors of CVD, such as obesity, diabetes or hypertension.

3. Socioeconomic status and alcohol consumption

The association between alcohol and CVD mortality follows a J-shaped pattern, especially in western societies, where there is a high prevalence of CVD.[76–80] A consistent protective effect from moderate alcohol consumption has been evaluated in several prospective studies, whereas the consumption of an important quantity of alcohol is seriously related with greater incidence of adverse cardiovascular events, including strokes.[81] The favorable effects of alcohol to the cardiovascular system are related to increased HDL, reduced platelet aggregation/activation, enhanced fibrinolysis and potent anti-oxidant effects on endothelium.[76] However, there are numerous types of data suggesting a role of SES in alcohol consumption, although the evidence is not always clear. Several studies have demonstrated that lower SES is associated with greater alcohol consumption and that socially disadvantaged are at an increased risk of being heavy drinkers.[82–85] There is a reasonable explanation for this fact, since high SES, high income and high educational level lead to an increased awareness about the unhealthy stereotypes and the adoption of more beneficial to health dietary patterns. Maternal deprivation, excessive psychological stress, anger, mental illness and poverty lead to the adoption and the copying of unhealthy behaviors, such as alcohol abuse. Increased alcohol consumption is inversely related to blood pressure levels and triglycerides. The possible beneficial effects of low or moderate alcohol intake should be weighed against the detrimental effects of high intake, such as hemorrhagic stroke and cardiomyopathy, which also constitute major adverse determinants of cardiovascular health and homeostasis.

4. Socioeconomic status and obesity

Obesity is thought to be, along with smoking, the first preventable cause of deaths.[86,87] Only in US population obesity is responsible for 5–15% of deaths.[88] Obesity is a traditional risk factor for CVD and it is well correlated with insulin resistance and hyperglycaemia.[89] Absence of wealth, educational level as well as the residency in poverty stricken areas appear to be major predictors of obesity,[90–92] while comparisons of obesity prevalence using geographic criteria indicate that low income areas and countries are associated with higher rates of obesity.[93] Plethora of studies has examined the causal role of SES on increasing obesity incidence. In the landmark review by Sobal et al based on the results from more than 140 studies from the 60s until mid1980s, it was found that the way that

SES acts a moderator variable on obesity is far less clear in developed societies compared to its role in developing countries.[94] The relationship is inconstant as far as men and children are concerned, but there was a definite association between SES and obesity in women. On the other hand, the data were quite clear in developing societies, where obesity was an inverse phenomenon to SES. On the update review almost 20 years later, encompassing 333 published studies from 1988 to 2004, the pattern of the overall results remained with an invigorating form of the initial positive associations and a weakening of the previously observed negative correlations among these entities.[95]

The increasing negative associations between SES and obesity in women of higher educational and economical power depicts the modern models of western society that impose women to make every effort to become thinner and thinner[96] in a rather obesogenic environment. However, the inverse relationship remains stronger among women of the most advantaged socially group, where a healthy diet rich in fruit and vegetables is more accessible.[97–99] As far as men is concerned, the fact of the non significant correlations in high and middle-income counties among SES and obesity may be explained from the psychological part, according to which body size and shape has symbolic value· for men, a larger body is likely to be conceived as sign of dominance and superiority.[100] The adverse effect of SES is also prominent in children and adolescents. Some studies on this issue are referred on Table 1. Childhood SES can be measured in terms of parents' education and occupation, household income and household conditions.[101,102] Only in US, the incidence of obesity in children has quadruplicated in the last 30 years,[103] while closer analysis reveals that obesity in children aged 2–5 years raised from 5% in 1980 to 10.4% in 2008 and it has been triplicated in children 6–11 years and adolescents 12–19 years of age.[104] Childhood obesity is mainly influenced by SES and it is observed with higher frequency in urban groups in developing countries and in the most socially disadvantaged in the developed.[105] Interestingly, childhood poverty is associated with greater incidence of obesity and other metabolic disturbances, such as diabetes or metabolic syndrome, latter in adult life.[106,107] The limited access to supermarkets and groceries in the 'food dessert' neighbourhoods of low SES groups as well as the adoption of an absolutely damaging dietary habit of the ready-to-eat lifestyle close to that dominating in the western societies along with the absence of appropriate facilities for physical activities is quite enough to justify the role of SES on obesity.[108]

5. Socioeconomic status and hypertension

The gradient in hypertension incidence along the pyramid of SES seems to be based mainly on dietary habits, especially salt intake. Salt intake has been incriminated as major cause of hypertension in several experimental, epidemiological, controlled clinical and population trials.[117] In the INTERSALT study, the 24 h sodium excretion was well correlated with the incidence of essential hypertension and, in contrast to general beliefs about vessel aging, the urinary excretion of less than 100 mmol/d was a major determinant of normal arterial pressure even at advanced age.[118–120] Based on an overview of 32 different studies, Gutler et al resumed that a daily reduction in intake of sodium by 70–80 mmol drove to a significant reduction of arterial blood pressure not only in hypertensive, but in normotensive subjects as well.[121] The importance of sodium consumption in hypertension appearance is also depicted by the significant decrease of hypertension and CHD rates among subjects that adopt special dietary programs, such as the DASH diet.[122] The consumption of snacks, with the fatty and salty content, or the intake of fast type of food full of salt and dietary saturated fats is detrimentally associated with the increased prevalence of hypertension, mainly among the socioeconomically underpriviledged groups, who usually consume such type of food. In a representative sample of 2.000 Vietnamese adults aged 25–64 years, men in the lowest education category appeared to have a 2.5 times greater risk for hypertension, while occupation was also found to be a major determinant in hypertension incidence among women. Similarly, women of low and middle SES had significantly greater risk of developing systemic hypertension.[123] In another study from Germany and Czech Republic (Health, Alcohol and Psychosocial Factors in Eastern Europe Study, HAPIEE Study) with more than 11.000 participants, hypertension was marginally increased in areas characterized by high unemployment rates or measures of overcrowding, that is an indicator of low SES.[124]

Diet also seems to offer a sensible explanation to these phenomena. Firstly, malnutrition and maternal SES can be serious determinants of low birth weight, which in turn may be related with the later onset of hypertension.[125,126] The lack of knowledge about the nature of hypertension as well as its predisposing factors among the least educated social layers can result to an unawareness of hypertension prevention and control and can lead to the adoption of a detrimental for the health dietary lifestyle.[127]

6. Socioeconomic status and diabetes

The increasing incidence of diabetes has increased the need for search of risk factors beyond the traditional, such as obesity or absence of physical activity. One possible determinant that could influence diabetes rates is SES. The established relationship of SES with obesity renders the connection of SES to diabetes quite predictable. However, the association of diabetes with SE position is rather complex, encompassing parameters, such as unhealthy dietary habits, smoking, absence of knowledge about the disease, problematic access to health care services as well as individual beliefs and life attitudes. Although not to the same extent studied as obesity, the connection of SES, in terms of income, education or occupation, with diabetes has also been investigated by multiple researchers. In the recent meta-analysis by Agardh et al consisting of 23 studies, it was found an overall increased risk for diabetes in low SE groups, either specified by income (40%), or educational status (41%) or occupation (31%).[128] Some additional studies on the role of SES on diabetes are referred on Table 2.

Although the differential stereotype of diabetes prevalence according to SES was quite consistent in high income countries, especially among women. In addition, SE

Table 1 The impact of socioeconomic status on childhood obesity.

Study group	Type of population	Number of subjects	Study period	SES variables	Concluding remarks
Navalpotro et al[109]	Children and adolescents, Spain	4.529	2006	Wealth, Area deprivation	Obesity prevalence was higher in areas with lower wealth (HR: 1.45). Overweight incidence was 1.26 times higher in deprived areas.
Caballero et al[110]	Children (6 to 13 yo), Mexico	1.172	2001–2002	Income, lessons in private/public schools	Children living in low-income areas had the thickest bicept skinfolds ($p<0.01$). Children in moderate-income areas and public schools had the thickest tricept skinfolds ($p<0.001$). Children of private schools a 75% increased risk of overweight (H.R.: 1.75).
Eagle et al[111]	Children, Massachusetts	109.634	2009	Income	As household income drops, the incidence of overweight/obese children rises. Among Michigan 6th graders, as household income drops, dietary habits worsen and physical activity decreases.
Whitaker et al[112]	Children (3 yo), USA	2.452	2001–2003	Maternal Education, income, food security	Neither of 3 SES was related to the possibility of obesity.
Hawkins et al[113]	Children (3 yo), England	13.188	2000–2002	Income, number of parents, maternal socioeconomic Circumstances/educational attainment/employment	Low parent status (vs 2 parents) and maternal work $>$ 21 h was associated with higher incidence of childhood overweight. High socioeconomic circumstances, income and education were associated with lower prevalence of childhood obesity ($p<0.01$).
Rutter et al[114]	Children (4–5 or 10–11 yo), UK	876.000	2006–2007	Multiple deprivation index	There was a significant association between deprivation and obesity.
Taylor et al[115]	Children (11–14 yo), England	2.482	2001	Parental unemployment, family access to a vehicle; persons per room, free school meals	Family access to a vehicle was associated with higher risk for obesity among girls, and higher risk for overweight among boys. Parental unemployment was associated with lower risk for overweight.
Saxena et al[116]	Children, adults (2–20 yo), England	5.689	1999	Occupational status of the head of the household	Social class was not associated with overweight or obesity among males or females.

Abbreviations: HR: Hazard Ratio, O.R: Odds Ratio, yo: years old, LDL: Low Density Lipoprotein, SES: socioeconomic status, UK: United Kingdom, vs: versus.

Table 2 The association between socioeconomic status and incidence of diabetes.

Study group	Type of population	Number of subjects	Study period	SES parameter	Cases	Concluding remarks
Nagaya et al[141]	Healthy Japanese men (30—49 yo)	5.130	1988—2001	Occupation	280	Lower occupational status is related to higher incidence of diabetes (H.R.: 1.65)
Agardh et al[142]	Subjects from Sweden	7.949	1992—1994/1996—1998	Occupation, education, father's occupation	140	Adjusted RR for diabetes was 2.3 if having a father with middle occupational position. Low education and low occupational position in women were associated with incidence of diabetes (RRs: 2.5 and 2.7 respectively)
Maskarinec et al[143]	Caucasians, Japanese Americans, native Hawaiians (45—79 yo)	93.860	1993—2007	Educational status	11.838	Educational status was inversely correlated with diabetes incidence for the highest level.
Maier et al[144]	Subjects from Germany, (45—74 yo)	11.688	1997—2006	Income, educational level, area deprivation	1.008	Risk diabetes was higher for the lowest educational level (O.R.: 1.46) and for the lowest income group (O.R.: 1.53)
Maty et al[145]	Subjects from USA, (average 59 yo)	6.147	1965—1999	Educational Level, Occupation, Income	954	Education was the strongest predictor for the disparities in diabetes incidence (H.R.: 1.5 for those with $>$ 12 yo of education vs those with $<$ 12 yo)
Tanaka et al[146]	Subjects from England, ($>$50yo)	8.332	1998—2005	Income	246	The adjusted O.R: 1.56 for diabetes for the lowest quintile of income for men and OR: 2.08 for women
Larranaga et al[147]	Subjects from Basque Spain, ($>$24yo)	65.651	2000	Area-based deprivation measures	2.985	The prevalence of type 2 diabetes was higher in patients of lower SES (O.R.: 2.17), especially among women (O.R.: 2.28). Obesity, abnormal levels of HBA1c and LDL were inversely associated with SES
Kumari et al[148]	Subjects from United Kingdom	10.308	1985—1999	Occupation	361	Participants in lower employment grades had significantly higher diabetes incidence (O.R.: 2.9 for men and 1.7 for women)
Wandell et al[149]	Subjects from Stockholm, Sweden, (35—65 yo)	72.347	2001	Education, Area, Income, Social parameters	1.600	The highest incidence of diabetes was marked in underprivileged areas. Higher education was protective for microvascular complications of diabetes (O.R.: 0.5)

Abbreviations: H.R.: Hazard Ratio, O.R.: Odds Ratio, yo: years old, LDL: Low Density Lipoprotein, SES: socioeconomic status, vs: versus.

adversity early in life has been related with diabetes incidence. In the Whitehall Prospective Cohort Study, cumulative exposure to low SES was associated with an increased risk of diabetes in adult life, with low grade chronic inflammation being an important mediator.[129] Similarly, in the post hoc analysis of data from 10 studies, low parental status in children was related with a significant incidence of diabetes and metabolic abnormalities.[49] These associations were confirmed by another similar prospective study, where the lowest occupational group presented a greater risk of developing diabetes.[130,131] In the large epidemiologic study NHAVES I-III plus the NHAVES 1999–2002, the prevalence of diabetes was significantly higher in the lowest SES groups.[132] In the years to come from NHAVES I, the incidence of diabetes increased in all SES groups, except for those being in the highest SE position. However, the increase significantly denoted for the most socially disadvantaged, resulting to the augmentation of the disparity in obesity incidence among groups. It seems that food insecurity, offers an attractive framework for the role of diet in such entities.[133–136] This fact enforced households belonging to the lowest SE groups to consume food that can offer a high amount of energy, that is with the highest energy density. Such dietary stereotype is mainly characterized by food of no quality or variation, rich in starches and sugars and poor in fruit and vegetables.[137] High energy density cheap food means cheap food offering notable amounts of energy that is food with low energy cost. Given the fact that such food rich in fat is palatable, the neurobiological reward in people of usually low educational level, encourages the consumption of such food components, leading to metabolic abnormalities/diabetes.[138–140]

Conclusions

It has become evident that there is a strong association between SES and CVD, while diet may represent an important explanatory factor for this association, as diet quality and variation follows a gradient across the socioeconomic spectrum, with the most advantaged social groups enjoying a favorable effect in terms of CVD risk. However, the interpretation of the discrepancies that are observed among the SES groups regarding to the CVD incidence and severity is rather a complex process. Due to the global economic crisis, the diet mediated inequalities in terms of CVD incidence among SES groups gain even more interest underlining the need for further studies, which will evaluate the effect of specific dietary stereotypes on CVD mortality under the prism of SES.

Conflict of interest

None to declare.

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