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ORIGINAL ARTICLE

Do self-reported data accurately measure health inequalities in risk factors for cardiovascular disease?

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Abstract

Objectives This study aimed to compare the magnitude of educational inequalities in self-reported and examination-based hypertension and hypercholesterolemia and to assess the impact of self-reported measurement error on health inequality indicators.

Methods We used the Portuguese National Health Examination Survey data (n = 4911). The slope index of inequality (SII) and the relative index of inequality (RII) were used to determine the magnitude of absolute and relative education-related inequalities.

Results Among the 25–49-year-old (yo) men, absolute and relative inequalities were smaller for self-reported than for examination-based hypertension ($SII_{eb} = 0.18$ vs. $SII_{sr} = -0.001$, $p < 0.001$; $RII_{eb} = 1.99$ vs. $RII_{sr} = 0.86$, $p = 0.031$). For women, the relative inequalities were similar despite differences in self-reported and examination-based hypertension prevalence. For hypercholesterolemia, self-reported relative inequalities were larger than examination-based inequalities among the 50–74-yo men ($RII_{sr} = 2.28$ vs. $RII_{eb} = 1.21$, $p = 0.004$) and women ($RII_{sr} = 1.22$ vs. $RII_{eb} = 0.87$, $p = 0.045$), while no differences were observed among 25–49-yo.

Conclusions Self-reported data underestimated educational inequalities among 25–49-yo men and overestimated them in older individuals. Inequality indicators derived from self-report should be interpreted with caution, and examination-based values should be preferred, when available.

Keywords Health examination survey · Health inequalities · Hypercholesterolemia · Hypertension · Self-report

Introduction

Cardiovascular diseases (CVD) are the main cause for premature mortality in Europe, with a noteworthy social and economic impact (Wilkins et al. 2017). Hypertension and hypercholesterolemia are two modifiable CVD risk factors, annually responsible for more than 2/3 of deaths by CVD (Wilkins et al. 2017). Timely diagnosis, effective management, and prevention of these conditions are crucial for improvement in overall population health.

Socioeconomic gradients in CVD and its risk factors are well established: Individuals with lower socioeconomic status (SES) tend to have poorer health outcomes and face greater risk factors (Sommer et al. 2015; de Mestral and Stringhini 2017). Reduction in unfair differences between SES groups constitutes an important public health challenge in Europe (Official Journal of the European Union 2014). To monitor progress on this goal, health inequalities are most frequently measured based on self-reported data

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from population surveys. However, self-report, as a method of data collection, possesses some limitations. Individuals may report information incorrectly due to underdiagnoses, social desirability (i.e., people reporting what they expect to be the desirable behavior), or low literacy (i.e., misunderstanding of medical terms or confusion between cure and drug-related controlled disease). The misreport of disease is expected to be greater among low-SES people because of lower literacy and lower access to diagnosis, related to affordability or discrimination (Burgard and Chen 2014; Choi and Cawley 2018). Hence, the misreport may affect not only the prevalence estimates, but also the SES-related inequality measures.

It has been acknowledged in the literature that self-reported data do not always accurately measure the clinical diagnoses of CVD (Eliassen et al. 2016) or its risk factors (Newell et al. 1999; Mosca et al. 2013; Tolonen et al. 2014b; Paalanen et al. 2018). Namely, self-reported data tend to underestimate the prevalence of obesity, hypercholesterolemia, hypertension, and diabetes (Newell et al. 1999; Mosca et al. 2013; Tolonen et al. 2014a; Paalanen et al. 2018). Health examination surveys, which in addition to interview assemble biomarkers collection and physical examination, have been extensively used in the last two decades to perform studies on accuracy of self-reported data on CVD risk factors (Paalanen et al. 2018); however, to our best knowledge, little evidence is available regarding how the socioeconomic distribution of reporting errors affects health inequality estimates.

In the USA, according to NHANES data, self-reporting overestimated the educational disparities in hypercholesterolemia and underestimated disparities in hypertension and diabetes, when comparing prevalence rates among educational level groups (Choi and Cawley 2018). In the European context of universal health care, Mackenbach et al. (1996) showed that reporting error in diabetes and heart disease varied by level of education and self-reported data underestimated inequalities in the Netherlands. In Ireland, the educational gradient in hypertension was underestimated by self-reported data, while for hypercholesterolemia, no association with educational attainments was observed for either self-reported or objectively measured cholesterol (Mosca et al. 2013). Vellakkal et al. (2015) demonstrated, using a concentration index, that socioeconomic inequalities in hypertension in low- and middle-income countries may be underestimated or even have an opposite direction when self-reported data are used. However, none of those studies used regression-based inequality measures such as slope index of inequality (SII) or relative index of inequality (RII), which allow to account for the complete distribution of SES and not only extreme categories (Mackenbach and Kunst 1997; Speybroeck et al. 2012).

Although not consistent, these findings suggest that measurement error in self-reported CVD risk factors may differ between socioeconomic groups. In such a case, survey estimates based on self-reports may be more distant from "true" values for some population subgroups than for others, resulting in biased estimates of associations between health outcomes and their social determinants. So additional studies are needed to provide a more comprehensive view on the impact of measurement error from self-reported survey data on estimates of socioeconomic inequalities in CVD risk factors.

The study objectives were to: (1) compare the magnitude of educational inequalities in self-reported and examination-based hypertension and hypercholesterolemia in the Portuguese population and (2) assess the impact of self-reported measurement error on absolute and relative regression-based health inequality indicators (SII and RII).

Methods

Study design

We used data from the Portuguese National Health Examination Survey (INSEF), which has been described elsewhere (Nunes et al. 2018). Briefly, INSEF is a cross-sectional nationwide survey conducted in 2015 on a probability sample of community-dwelling individuals aged between 25 and 74 years old, resident in Portugal for more than 12 months, and able to follow an interview in Portuguese. The INSEF sample was designed to be representative at the national level as well as at the level of autonomous regions and the five mainland health regions. The sample was selected using a two-stage stratified probability-based cluster design.

INSEF combined information on measured biochemical parameters (total cholesterol, glycated hemoglobin, and blood count) and blood pressure measurements with a questionnaire applied through computer-assisted personal interview on demographic and socioeconomic characteristics, health conditions, medication intake, and health care use.

The fieldwork took place between February and December 2015 in primary care settings that offered all the necessary facilities for the survey implementation. Recruitment of participants was performed by 43 trained interviewers; interviews, physical examinations, and blood collections were conducted by 74 health professionals who had completed a 21-h training program on standardized survey procedures.

All measurements in INSEF were conducted using a standardized measurement protocol based on the recommendations of the Feasibility of a European Health

Examination Survey and the European Health Examination Survey Pilot Joint Action (Tolonen et al. 2008; Kuulasmaa et al. 2012) projects. All participants ($n = 4911$) provided written informed consent before data collection. INSEF was approved by the Ethics Commission of the National Health Institute Doctor Ricardo Jorge and by National Data Protection Authority (Authorization no. 9348/2010).

For each cardiovascular disease risk factor, analyses were limited to individuals with complete self-reported and examination-based data, and individuals with missing data ($n = 25$ for hypertension and $n = 104$ for hypercholesterolemia) were excluded from the analysis.

Definitions

Individuals were considered to have self-reported hypertension/hypercholesterolemia if they answered positively to both questions: "Do you have any of the following diseases or conditions: High blood pressure or hypertension; hypercholesterolemia? (Yes/No)" and if yes, "Were these conditions diagnosed by a medical doctor? (Yes/No)." Examination-based hypertension and hypercholesterolemia were based on objective measures of health conditions and self-reported use of corresponding medication. Information of medication intake was obtained from two questions: "During the past 2 weeks, have you used any medicines that were prescribed for you by a doctor?" and if yes, "Were the medicines for hypertension/hypercholesterolemia? (Yes/No)." Note that in the self-reported hypertension/hypercholesterolemia, the medication was not accounted for in the definition. This is because the Portuguese National Health Interview Survey, such as its European counterpart, does not include questions about specific medications for specific diseases. This failure is expected to contribute to the underestimation of prevalence and to the bias in inequality measurement.

Examination-based hypertension was defined as having: (1) systolic blood pressure of at least 140 mmHg, or (2) diastolic blood pressure of at least 90 mmHg, or (3) reported use of antihypertensive medication prescribed by a doctor, in 2 weeks prior to the interview.

Examination-based hypercholesterolemia was defined having total serum cholesterol concentration of at least 190 mg/dL or reported use of prescribed lipid-lowering medication in the 2 weeks prior to the interview.

The cutoff points for examination-based definitions were based on the current European and national clinical guidelines for CVD prevention (Reiner et al. 2011; Fifth Joint Task Force of the European Society of Cardiology et al. 2012; Direção Geral da Saúde 2013).

Participants' SES was measured through the highest level of education completed according to the 2011 International Standard Classification of Education (ISCED-2011) (United Nations Educational Scientific and Cultural Organization 2011). Four educational groups were considered: ISCED 0–1 levels (no formal education/basic [(1 cycle)/basic (2 cycles)]), ISCED 2 level [basic (3 cycles)], ISCED 3–4 levels (secondary/postsecondary), and ISCED 5–8 levels (higher/postgraduate).

Statistical analysis

Proportions of individuals with examination-based and self-reported hypertension and hypercholesterolemia were estimated at national level and stratified by sex, age group, and level of education.

To determine the magnitude of inequalities in CVD risk factors between the highest and lowest educational groups, we used the slope index of inequality (SII) and relative index of inequality (RII) (Mackenbach and Kunst 1997; Ernstsen et al. 2012). Mathematical formulation of RII and SII is described in detail elsewhere (Mackenbach and Kunst 1997; Ernstsen et al. 2012). SII and RII are regression-based inequality measures that take into account socioeconomic positions of population subgroups and their relative size. RII can be interpreted as a prevalence ratio between the most educated and the less educated, and SII represents the absolute difference in prevalence rates between the top and the bottom of educational hierarchy (Mackenbach and Kunst 1997).

To account for repeated measurements (self-reported and examination based) for the same individuals, we used generalized estimating equations (GEE). To estimate SII and RII, population was ranked from the highest (0) to lowest (1) level of education, and for each educational group, the *ridit score* was assigned based on midpoint of cumulative distribution of individuals. RII was estimated by log-link Poisson GEE with robust standard errors and an exchangeable working correlation structure, including age, *ridit*, type of measurement, and the *ridit* * type of measurement interaction. Statistically significant interaction term indicates that RIIs estimated with self-reported and examination-based data are different. Similar approach was used to assess inequalities in absolute scale. SII was estimated by Poisson GEE with identity link function. Poisson model was used since it provides direct estimates of prevalence ratios and differences and is recommended in the literature for cross-sectional studies (Barros and Hirakata 2003). Estimates of inequalities were stratified by age and sex, using four population groups [men 25–49-yo, women 25–49-yo, men 50–75-yo, and women 50–75-yo].

All statistical analyses were performed using sampling weights, to provide nationally representative results. The data were analyzed using the [SVY] package of Stata 15.1® software (StataCorp 2017). The significance level for all analyses was set at 5%.

Results

Sample characteristics

In total, of 4911 individuals participated in the INSEF survey (43.9% participation rate), 2265 (47.5%) were men and 2646 (52.5%) were women (Table 1). The majority had an ISCED 0–1 education level (40.3%). Hypertension was reported by 25.7% of participants, while 35.9% were considered to have hypertension according to examination-based data. Hypercholesterolemia was reported by 24.9%, but the proportion of individuals with measured high levels of total cholesterol was considerably higher (63.2%).

Prevalence

For hypertension, the self-reported and examination-based prevalence showed similar educational patterns in all four groups; namely, the proportion of hypertensive people was the highest among those with the lowest education levels (Fig. 1, Table S2). In general, the difference between self-reported and examination-based data was more pronounced among men than among women. The highest difference between self-reported and examination-based hypertension [23.5 percentage points (pp)] was observed among younger men with ISCED 2011 levels 0–1, i.e., the lowest level of education. The most accurate report of hypertension was verified for 25–49-yo women with ISCED 2011 levels 5–8 education.

For hypercholesterolemia, in general, the differences between self-reported and examination-based data were substantially larger than for hypertension (Fig. 2, Table S3). Likewise, for hypertension, the highest difference between proportion of self-reported and examination-based hypercholesterolemia was registered for younger men with the lowest level of education (48.7 pp).

Self-report of hypercholesterolemia varied considerably across educational categories in two population subgroups (25–49-yo women and 50–74-yo men). In both situations, individuals with the lowest level education had the highest prevalence. For examination-based hypercholesterolemia, the educational differences were less evident, in particular among older individuals. Among 50–74-yo women, the highest proportion of examination-based hypercholesterolemia (83.1%) was observed for those with the highest education levels.

Table 1 General participants' characteristics, Portuguese National Health Examination Survey 2015

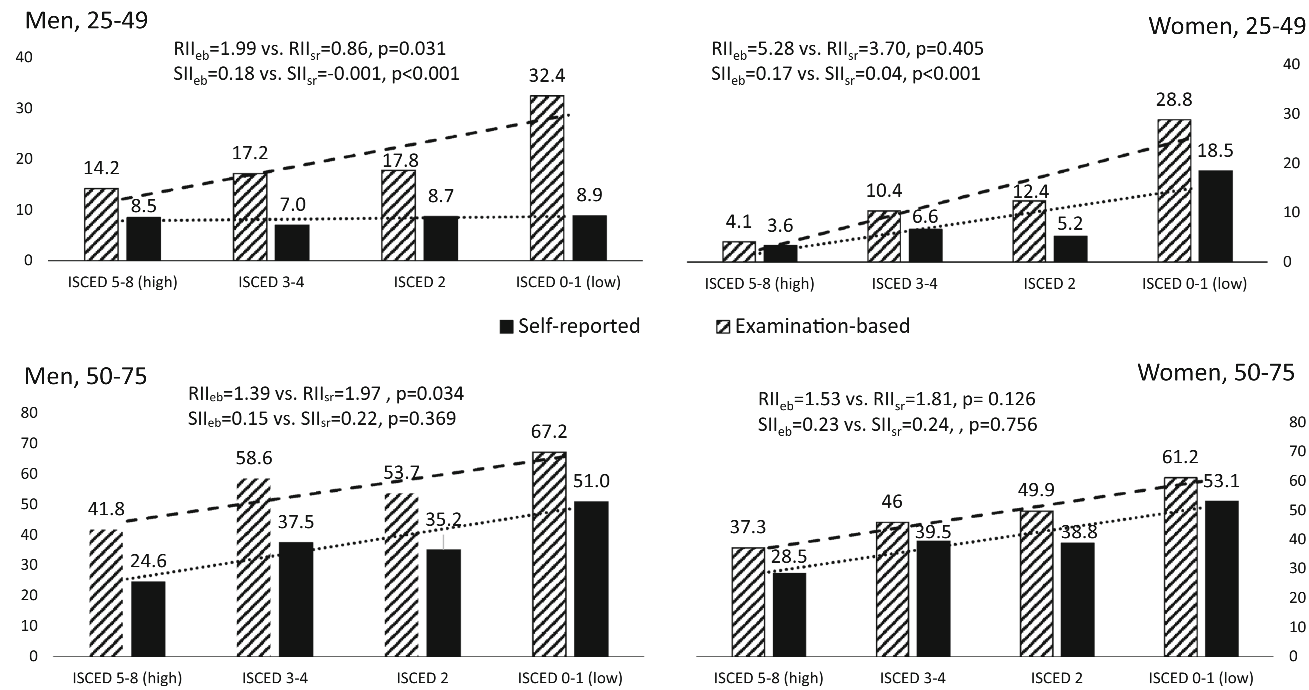
Participants' characteristics	n	%
Sex (n = 4911)		
Women	2646	52.5
Men	2265	47.5
Age group (n = 4911)		
25–49	2422	52.8
50–74	2489	47.2
Education (n = 4907)		
ISCED 2011 levels 0–1*	2193	40.3
ISCED 2011 level 2	918	18.9
ISCED 2011 levels 3–4	958	21.4
ISCED 2011 levels 5–8	838	19.4
Self-reported hypercholesterolemia (n = 4807)		
No	3573	75.1
Yes	1234	24.9
Examination-based hypercholesterolemia (n = 4807)		
No	1604	36.8
Yes	3203	63.2
Self-reported hypertension (n = 4886)		
No	3580	74.3
Yes	1306	25.7
Examination-based hypertension (n = 4886)		
No	3065	64.1
Yes	1821	35.9

*ISCED International Standard Classification of Education 2011

Inequalities in hypertension

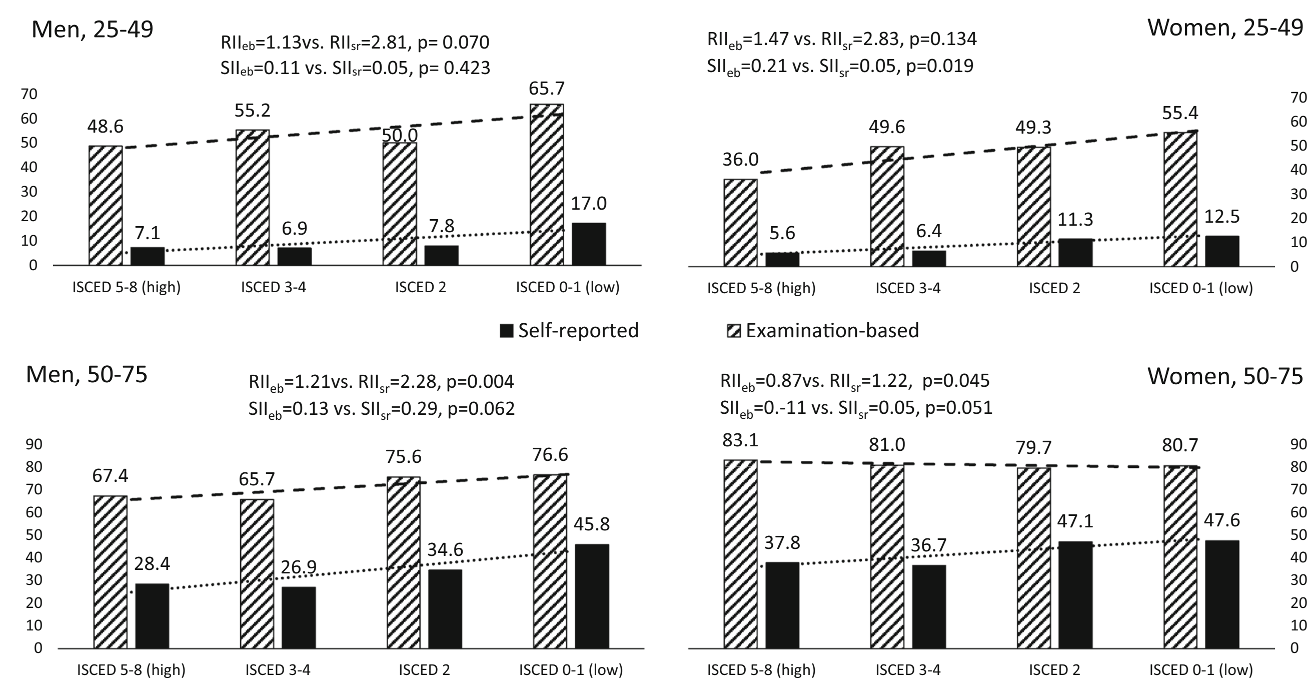
For survey results in general, relative inequalities were similar in magnitude for self-reported and examination-based (RII_{sr} = 1.74 vs. RII_{eb} = 1.76, p = 0.912) hypertension, indicating a lower prevalence of disease among the highly educated (Fig. 1, Table S4). Absolute inequalities were smaller for self-reported hypertension compared to examination-based hypertension ($p < 0.001$). Namely, according to self-reports, the discrepancy in hypertension prevalence between the lowest and highest educational categories was about 6% (SII_{sr} = 0.06), while according to examination-based data, the difference was 18% (SII_{eb} = 0.18).

Age- and sex-specific results showed considerable discrepancies in inequality indicators between self-reported and examination-based data. Among young men, self-reported data underestimated both absolute and relative inequalities. Namely, examination-based RII was 2.31 times as high as self-reported RII (RII_{eb} = 1.99 vs. RII_{sr} = 0.86, p = 0.031). Difference between examination-based and self-reported absolute inequalities estimates (18 pp) was statistically significant as well. (SII_{eb} = 0.18 vs. SII_{sr} = − 0.001, $p < 0.001$). Among 25–49-yo women, absolute inequalities were greater in magnitude for examination-based hypertension (SII_{eb} = 0.17 vs. SII_{sr} = 0.04, $p < 0.001$), while difference in relative inequalities estimates (RII_{eb} = 5.28 vs. RII_{sr} = 3.70, p = 0.405) was not statistically significant. Among 50–74-yo men, self-



* ISCED - International Standard Classification of Education 2011

Fig. 1 Proportion of participants with self-reported and examination-based hypertension according to educational level and absolute (SII) and relative (RII) inequality indexes stratified by age group and sex, Portuguese National Health Examination Survey 2015



* ISCED - International Standard Classification of Education 2011

Fig. 2 Proportion of participants with self-reported and examination-based hypercholesterolemia according to educational level stratified by age group and sex, and absolute (SII) and relative (RII) index of inequality, Portuguese National Health Examination Survey 2015

reported data overestimated relative educational inequalities ($RII_{sr} = 1.97$ vs. $RII_{eb} = 1.39$, $p = 0.034$). Difference in magnitude of self-reported and examination-based absolute inequalities in hypertension in this group was not statistically significant ($SII_{sr} = 0.22$ vs. $SII_{eb} = 0.15$, $p = 0.369$). Among 50–74-yo women, absolute and relative inequalities in self-reported and examination-based hypertension were similar ($SII_{sr} = 0.24$ vs. $SII_{eb} = 0.23$, $p = 0.756$; $RII_{sr} = 1.81$ vs. $RII_{eb} = 1.53$, $p = 0.126$).

Inequalities in hypercholesterolemia

For survey results in general, self-reported data overestimated educational gradient in hypercholesterolemia ($RII_{sr} = 1.67$ vs. $RII_{eb} = 1.12$, $p = 0.001$) (Fig. 2, Table S5). Although RII point estimates were greater in magnitude for self-reported data in all population subgroups, statistically significant gap in relative inequalities between examination-based and self-reported data was verified for 50–74-yo men ($RII_{sr} = 2.28$ vs. $RII_{eb} = 1.21$, $p = 0.004$) and women ($RII_{sr} = 1.22$ vs. $RII_{eb} = 0.87$, $p = 0.045$). Absolute inequalities in self-reported and examination-based hypercholesterolemia were similar for all population subgroups, except for 25–49-yo women. In this group, absolute inequalities were greater in magnitude for examination-based hypertension ($SII_{eb} = 0.21$ vs. $SII_{sr} = 0.05$, $p = 0.019$), suggesting a 21% difference in disease prevalence between women with the highest and lowest educational attainments, compared to 5% difference in prevalence obtained with self-reported data.

Discussion

Key findings

Using nationally representative data, this study examined how participants' self-reporting errors affected estimates of absolute and relative health inequalities for two major CVD risk factors: hypertension and hypercholesterolemia. In Portugal, self-reported data underestimated the prevalence of hypertension and hypercholesterolemia for the overall sample, and for all educational groups. This is in line with the previous research (Newell et al. 1999; Mosca et al. 2013). However, the magnitude of differences and, as such, the reporting error varied by educational attainment, suggesting a differential bias in education-related inequality indicators based on self-reported data. Among 25–49-yo men, the social gradients in self-reported hypertension systematically underestimated absolute and relative inequalities, while among 50–74-yo men, self-reported data overestimated relative inequalities, although to a smaller extent. Among women, self-reported data measured relative inequalities more accurately in both 25–49-yo and 50–74-yo groups. For hypercholesterolemia, self-reported data slightly overestimated inequalities. There was greater reporting bias among the highly educated 50–74-yo men and women.

Interpretation

In younger men, hypertension was more prevalent among those with lower education, although in a group more individuals failed to report it, leading to underestimation of absolute and relative inequalities. Less accurate report of hypertension by those with lower education levels in our study is in line with the previous research from the USA (Choi and Cawley 2018). Underreporting of disease in health surveys is attributed in the literature to underdiagnoses and lack of "awareness," which are strongly related to health literacy, health care access, health care quality, and type/form of health care use (Molenaar et al. 2007; Burgard and Chen 2014; Kulhánová et al. 2014; Tolonen et al. 2014b; Vellakkal et al. 2015). Hypertensive individuals, in particular at early stages of disease, may not experience any symptom (Tolonen et al. 2014b), so they may consider themselves healthy and do not seek medical care. However, men with higher education have a better understanding of the importance of disease prevention, so even without symptoms they are more likely to engage in screening programs and are more likely to be diagnosed (Lorant et al. 2002; Cutler and Lleras-Muney 2010; Kulhánová et al. 2014). Also due to higher health literacy and better access to health information, the highly educated have a greater ability to recognize symptoms, and therefore to discuss them with health professionals and be diagnosed (Burgard and Chen 2014). Besides universal health care coverage in Portugal, there still may exist some barriers in access to health care among young men with low socioeconomic status, explaining more undiagnosed diseases in this group. Other sex–age subgroups did not show the pattern observed for young men. In women, self-reported and examination-based inequality estimates were similar, while in older men, self-reported data overestimated inequalities in hypertension. Although these differences are difficult to explain, the gender gap in reporting errors in the young age group may be related to differences in health care use between men and women. Men use health care less frequently, are less likely to receive preventive care (Jeffries and Grogan 2012; Perelman et al. 2012), and consequently are less aware of their hypertension status and report it less accurately than women (Zhang and Moran 2017). This gender gap may be less present among older people, when both men and women are more likely to suffer from poor health and equally likely to use medical care (even, some studies show a lower use among women) (Cameron et al. 2010).

For hypercholesterolemia, use of self-reported data led to overestimation of educational gradient. This result reflects the underreporting of disease diagnosis by individuals with higher educational attainments in older age group. This may be explained by social desirability bias (Newell et al. 1999; Burgard and Chen 2014; Choi and Cawley 2018). It has been shown in the literature that individuals with higher education are more capable of identifying "sensitive" questions and are more concerned about their self-presentation (Preisendörfer and Wolter 2014), such that individuals may be more deceptive to report socially stigmatized diseases and unhealthy lifestyles. Similar results regarding the direction of educational gradient in reporting errors were found in the USA with NHANES data (Choi and Cawley 2018). Moreover, hypercholesterolemia is often linked to obesity, which is more prevalent among the worse-off (Gaio et al. 2017), so that medical doctors may be more prone to screen for cholesterol among the patients with low educational attainments because of their weight excess. Such discrimination in screening may also contribute to overestimation of educational inequalities in hypercholesterolemia. Lastly, more educated people may be more prone to consider hypercholesterolemia as a risk factor and not as a disease (Durack-Bown et al. 2003), and hence, they may not report it when interviewed about their health conditions.

Strengths and limitations

The INSEF survey presents methodological strengths: use of standardized measurement protocols, interviewers training, and continuous quality control of all survey procedures. Noticeably, it has the unique contribution in Portugal to include self-reported and examination-based ones for the same persons, which allows to compare indicators. The evaluation of inequalities was based on education as a measure of SES, which is stable along the life course, easy to report and collect, and less subject to reverse causality (von dem Knesebeck et al. 2006; Kulhánová et al. 2014; Campos-Matos et al. 2016; Choi and Cawley 2018). The use of ISCED 2011 contributes to comparability of our results at an international level. Finally, we reported both absolute and relative inequality measures, since both are recognized to be important for monitoring inequalities and public health planning (Mackenbach and Kunst 1997; Speybroeck et al. 2012).

Among limitations, the INSEF survey had only non-fasting samples to determine the lipid profile, and single physical examination as proxy for medical diagnosis of hypertension and hypercholesterolemia (Molenaar et al. 2007; Tolonen et al. 2014b). Also the 190 mg/dl cutoff currently recommended in clinical practice for definition of hypercholesterolemia is not consensual in the literature. However, a sensitivity analysis confirmed our findings when using an alternative cutoff value of 200 mg/dL (Table S6). Another methodological weakness is related to achieve participation rate of 43.9%, which can be considered average (Mindell et al. 2015). The INSEF participation rate varied with age, being the lowest among 25–34-yo (36%) and the highest among 55–64-yo (49.1%), which may also contribute for differences in inequality indicators between younger and older individuals. However, we should mention that the distribution of survey sample by sex and age was very close to population figures (Nunes et al. 2018).

Conclusions

Our results illustrated the significant impact of self-reported measurement error on estimates of socioeconomic inequalities in CVD risk factors. There is no straightforward universal answer about the direction and magnitude of the reporting bias. The survey response accuracy depends on the CVD risk factors, age, sex, and educational attainments of the respondents. The use of self-reported data may lead to underestimation of educational inequalities in some situations and overestimation in others. Inequality indicators derived from self-report should be interpreted with caution, and examination-based values should be preferred, when available.

Remarkable educational inequalities among young individuals raise important public health concerns regarding the increase in adverse CVD outcomes in the future, in particular among individuals with lower SES. These results also mean that there are opportunities for intervention to reduce health inequalities in CVD risk factors among the youngest. Development and implementation of specific preventive measures targeting younger age groups with low perception of being at risk of CVD may have important public health benefits.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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