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Household Disposable Income and Long-Term Survival After Cardiac Surgery

A Swedish Nationwide Cohort Study in 100,534 Patients

Magnus Dalén, MD,*† Torbjörn Ivert, MD, PhD,*† Martin J. Holzmann, MD, PhD,‡§ Ulrik Sartipy, MD, PhD*†

ABSTRACT

BACKGROUND Lower socioeconomic groups face higher mortality risk, possibly due to a higher burden of cardiovascular risk factors. The independent association between income and survival following cardiac surgery is not known.

OBJECTIVES This study sought to investigate the association between household disposable income and long-term mortality after cardiac surgery.

METHODS In a Swedish nationwide population-based analysis, we included all patients who underwent cardiac surgery between 1999 and 2012 using a large national registry. Information regarding income, education, marital status, medical history, and cardiovascular risk factors was obtained from data managed by the National Board of Health and Welfare and Statistics Sweden. The adjusted risk for all-cause mortality was estimated using Cox regression by quintiles of household disposable income.

RESULTS We included 100,534 patients and, during a mean follow-up of 7.3 years, 29,176 (29%) patients died. There was a stepwise inverse association between household disposable income and all-cause mortality: the adjusted hazard ratio was 0.93 (95% confidence interval [CI]: 0.89 to 0.96), 0.87 (95% CI: 0.84 to 0.91), 0.78 (95% CI: 0.75 to 0.82), and 0.71 (95% CI: 0.67 to 0.75), for the second, third, fourth, and fifth income quintiles, respectively, compared to the first (and lowest) income quintile. The inverse association between income and mortality was consistent through the study period and in selected subgroups, although it was slightly attenuated in older patients.

CONCLUSIONS We found a strong inverse association between income and mortality following cardiac surgery in Sweden that was independent of other socioeconomic status variables, comorbidities, and cardiovascular risk profile. Ways to better implement secondary prevention measures should be explored in low-income patient groups. (HeAlth-data Register sTudies of Risk and Outcomes in Cardiac Surgery [HARTROCS]; NCT02276950) (J Am Coll Cardiol 2015;66:1888–97) © 2015 by the American College of Cardiology Foundation.

There is a well-known association between low socioeconomic status (SES) and higher risk for cardiovascular disease (CVD) and all-cause mortality (1–3). It remains uncertain exactly how this association is mediated, although it may partly be explained by the inverse relationship between SES and prevalence of classic cardiovascular risk factors (1); lower socioeconomic groups experience a clustering of multiple risk factors (4).

SES also has been associated with differences in access to and quality of care (1,2,5–7). In countries without universal health care coverage, insurance status highly correlates with SES. Therefore, it is of interest to examine the relationship between SES and mortality in a population with universal tax-financed health care independent of individual SES (8). Despite this, most studies demonstrating an association between SES and mortality have been conducted

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From the *Department of Cardiothoracic Surgery and Anesthesiology, Karolinska University Hospital, Stockholm, Sweden; †Department of Molecular Medicine and Surgery, Karolinska Institutet, Stockholm, Sweden; ‡Department of Emergency Medicine, Karolinska University Hospital, Stockholm, Sweden; and the §Department of Internal Medicine, Karolinska Institutet, Stockholm, Sweden. This study was supported by grants from the Swedish Society of Medicine and the Karolinska Institutet Foundations and Funds to Drs. Holzmann and Sartipy, and the Mats Kleberg Foundation to Dr. Sartipy. The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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in populations without universal tax-financed health care (5,6,9). Furthermore, very few studies have examined the association between SES and mortality in patients undergoing cardiac surgery (4,9–11).

We performed a nationwide population-based cohort study to determine whether SES measured by household disposable income was associated with mortality in all adult patients who underwent cardiac surgery in Sweden during a 14-year period.

METHODS

This was a nationwide population-based observational cohort study that was approved by the regional Human Research Ethics Committee in Stockholm, Sweden.

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We identified all patients in the country who underwent cardiac surgery using the SWEDEHEART (Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies) registry, which records details on patient background and surgical procedures for all patients undergoing cardiac surgery in Sweden since 1992. The registry has proved to have a high validity and completeness (12–14). Using unique personal identity numbers, assigned to all residents (15), information from SWEDEHEART was linked with data from several other nationwide health care registries as previously described (16). The Cause of Death Register was used to ascertain dates and cause of death, the National Patient Register (17) was used to determine previous relevant medical history, and the LISA (Longitudinal integration database for health insurance and labor market studies) database (18), managed by Statistics Sweden, a government agency, was used to obtain details regarding educational level, country of birth, and marital status. Record linkages were performed by the Swedish National Board of Health and Welfare. The International Classification of Diseases codes used for extraction of concurrent important medical conditions are listed in Online Table 1 and codes used for definition of cardiovascular death are listed in Online Table 2. Level of education was categorized as <10 years, 10 to 12 years, and >12 years. Marital status was categorized as married, not married, divorced, and widowed.

HOUSEHOLD DISPOSABLE INCOME. Using the LISA database, we acquired information regarding household disposable income in all patients from 1999 to 2012. The LISA database contains individual- and family-level data regarding demographics, education, employment, and income, including that from salaries and benefits from social welfare. The LISA database is updated annually with new information for the past year. The personal identity number is the unique identifier in the LISA database, making it possible to link individual-level data with other national health care registries. The household disposable income in LISA is calculated as the sum of all taxable and tax-free income minus final tax and other negative transfers. Taxable income consists of total earned income (the sum of income from services and business income) and capital income. Tax-free income consists of housing and child benefit, student aid including student loans, financial aid, and introductory benefits for refugees. Negative transfers consist of repayment of student loans and paid alimony. We calculated the household disposable income as the mean of all yearly household disposable income figures registered for each patient until, and including, the calendar year of surgery.

ABBREVIATIONS AND ACRONYMS

CABG = coronary artery bypass grafting

CI = confidence interval

CVD = cardiovascular disease

HR = hazard ratio

SES = socioeconomic status

STATISTICAL ANALYSES. The household disposable income was categorized according to quintiles from lowest to highest income. Each quintile represents 20%, or one-fifth, of all patients. Quintiles of household disposable income were set across all study years. Baseline characteristics were described with frequencies and percentages for categorical variables and mean ± SD for continuous variables, by quintile of income. The primary outcome measure was death from any cause. Person-time in days was counted from the date of surgery until the date of death or the end of follow-up (March 24, 2014). The crude incidence rates and 95% confidence intervals (CIs) were calculated and the Kaplan-Meier method was used to calculate cumulative survival. We used Cox proportional hazards regression with and without multivariable adjustment to model survival. The association between quintiles of household disposable income and all-cause mortality was estimated by hazard ratios (HRs) and 95% CI. The multivariable Cox model included all variables listed in **Table 1** and was stratified by calendar year of surgery and hospital. Patient age was modeled using restricted cubic splines and all other variables were included as categorical terms. The association between income and all-cause mortality was also investigated in selected subgroups.

Missing data (educational level [5%], left ventricular ejection fraction [32%], renal function [11%], urgency of the procedure [32%], and body mass index [12%]), were handled using multiple imputation by

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TABLE 1 Baseline Characteristics

		Household Disposable Income by Quintile				
	All Patients (N = 100,534)	Q1 (Lowest) (n = 20,107)	Q2 (n = 20,116)	Q3 (n = 20,099)	Q4 (n = 20,106)	Q5 (Highest) (n = 20,106)
Age, yrs	66.69 ± 10.92	69.27 ± 11.17	69.13 ± 10.76	67.98 ± 10.44	64.68 ± 10.41	62.38 ± 10.04
Sex						
Male	73,500 (73)	11,268 (56)	14,110 (70)	15,138 (75)	16,138 (80)	16,846 (84)
Female	27,034 (27)	8,839 (44)	6,006 (30)	4,961 (25)	3,968 (20)	3,260 (16)
Birth region						
Nordic countries	92,282 (92)	17,613 (88)	18,514 (92)	18,654 (93)	18,646 (93)	18,855 (94)
Other	8,252 (8)	2,494 (12)	1,602 (8)	1,445 (7)	1,460 (7)	1,251 (6)
Education						
<10 yrs	42,091 (44)	10,422 (59)	10,004 (54)	9,286 (48)	7,581 (38)	4,798 (24)
10–12 yrs	36,168 (38)	5,887 (34)	6,618 (36)	7,439 (38)	8,376 (42)	7,848 (40)
>12 yrs	16,731 (18)	1,245 (7)	1,893 (10)	2,637 (14)	3,767 (19)	7,189 (36)
Marital status						
Married	64,376 (64)	3,417 (17)	11,416 (57)	15,259 (76)	16,810 (84)	17,474 (87)
Not married	13,104 (13)	4,880 (24)	3,123 (16)	1,959 (10)	1,602 (8)	1,540 (8)
Divorced	14,684 (15)	6,587 (33)	3,825 (19)	2,088 (10)	1,304 (6)	880 (4)
Widowed	8,370 (8)	5,223 (26)	1,752 (9)	793 (4)	390 (2)	212 (1)
Body mass index, kg/m^2	26.89 ± 4.17	26.91 ± 4.47	26.83 ± 4.23	26.92 ± 4.13	26.96 ± 4.04	26.81 ± 3.93
Diabetes mellitus	20,108 (20)	4,536 (23)	4,284 (21)	4,165 (21)	3,823 (19)	3,300 (16)
Hypertension	30,791 (31)	6,147 (31)	6,116 (30)	6,184 (31)	6,224 (31)	6,120 (30)
Hyperlipidemia	18,419 (18)	3,391 (17)	3,510 (17)	3,666 (18)	3,971 (20)	3,881 (19)
Peripheral vascular disease	9,826 (10)	2,081 (10)	2,164 (11)	2,032 (10)	1,916 (10)	1,633 (8)
eGFR, ml/min/1.73 m^2						
>60	66,413 (74)	11,351 (65)	12,109 (69)	12,935 (72)	14,441 (79)	15,577 (84)
45–60	15,532 (17)	3,892 (22)	3,603 (20)	3,407 (19)	2,594 (14)	2,036 (11)
30–45	5,789 (6)	1,736 (10)	1,412 (8)	1,187 (7)	859 (5)	595 (3)
15–30	1,193 (1)	337 (2)	315 (2)	245 (1)	158 (1)	138 (1)
<15*	920 (1)	218 (1)	181 (1)	165 (1)	183 (1)	173 (1)
Chronic pulmonary disease	6,796 (7)	1,748 (9)	1,508 (7)	1,434 (7)	1,158 (6)	948 (5)
Prior myocardial infarction	39,489 (39)	8,610 (43)	8,598 (43)	8,018 (40)	7,519 (37)	6,744 (34)
Prior PCI	11,798 (12)	2,070 (10)	2,203 (11)	2,362 (12)	2,565 (13)	2,598 (13)
Heart failure	16,008 (16)	4,165 (21)	3,552 (18)	3,207 (16)	2,691 (13)	2,393 (12)
Left ventricular ejection fraction, %						
>50	47,257 (69)	7,576 (64)	8,309 (66)	9,261 (68)	10,253 (71)	11,858 (74)
30–50	17,162 (25)	3,434 (29)	3,495 (28)	3,541 (26)	3,390 (24)	3,302 (21)
<30	3,989 (6)	897 (8)	765 (6)	773 (6)	773 (5)	781 (5)
Stroke	8,632 (9)	1,965 (10)	1,939 (10)	1,767 (9)	1,596 (8)	1,365 (7)
Atrial fibrillation	12,580 (13)	2,661 (13)	2,595 (13)	2,590 (13)	2,409 (12)	2,325 (12)
Cancer	6,035 (6)	1,197 (6)	1,260 (6)	1,322 (7)	1,177 (6)	1,079 (5)
Alcohol dependency	1,956 (2)	788 (4)	398 (2)	320 (2)	239 (1)	211 (1)
Emergent operation	4,399 (6)	808 (7)	785 (6)	791 (6)	905 (6)	1,110 (7)
Procedure						
Isolated CABG	63,456 (63)	12,504 (62)	13,058 (65)	13,010 (65)	12,887 (64)	11,997 (60)
Isolated valve	12,465 (12)	2,630 (13)	2,396 (12)	2,425 (12)	2,337 (12)	2,677 (13)
Valve + CABG	15,696 (16)	3,500 (17)	3,167 (16)	3,129 (16)	2,944 (15)	2,956 (15)
Other	8,917 (9)	1,473 (7)	1,495 (7)	1,535 (8)	1,938 (10)	2,476 (12)

Values are mean ± SD or n (%). *Includes patients on pre-operative dialysis.
CABG = coronary artery bypass grafting; eGFR = estimated glomerular filtration rate; PCI = percutaneous coronary intervention; Q = quintile.

chained equations (19). The imputation models included all variables in **Table 1**, and also the event indicator and the Nelson-Aalen estimator of the cumulative baseline hazard (20). Ten datasets were imputed and estimates from these datasets were combined according to Rubin's rules. A complete-case analysis showed similar results as the main analysis of the imputed dataset.

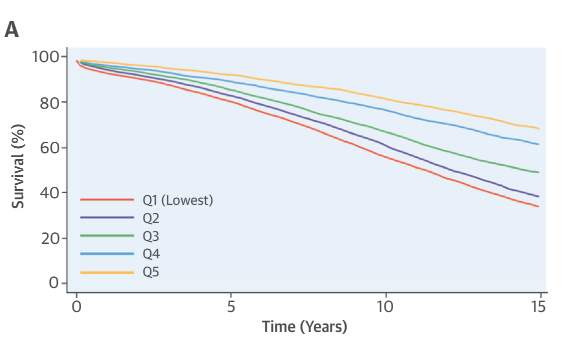
Data management and statistical analyses were performed using Stata version 14.0 (StataCorp LP, College Station, Texas) and R version 3.2.0 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

From the SWEDEHEART registry, we extracted data on all patients who had undergone coronary artery bypass graft (CABG) surgery, valve repair/replacement surgery, or a combination of both, from 1999 until 2012. Patient characteristics according to categories of household disposable income are presented in **Table 1**. The distribution of household disposable income in the total study population and selected subgroups is shown in Online Figures 1 and 2, respectively. A total of 100,534 patients with a mean age of 67 years were included, 27% of whom were women. Each quintile consisted of 20,099 to 20,116 patients. Patients with lower household disposable income were more likely to be older, female, and have chronic kidney disease, diabetes mellitus, chronic obstructive pulmonary disease, previous acute myocardial infarction, reduced left ventricular ejection fraction, heart failure, and previous stroke in comparison with patients with higher household disposable income. Fewer patients in the lower household disposable income quintiles had previously undergone percutaneous coronary intervention. Furthermore, patients with lower household disposable income had a lower educational level and were more likely to be born in a non-Nordic country, less likely to be married, more likely to be divorced or widowed, and more likely to have an alcohol dependency.

FOLLOW-UP AND MORTALITY. During a mean follow-up time of 7.3 ± 4.1 years (median 7.1 years; 732,553 person-years), 29% of patients (29,176 of 100,534) died: 43% (8,645 of 20,107) in quintile 1 (lowest household disposable income); 38% (7,598 of 20,116) in quintile 2; 30% (5,974 of 20,099) in quintile 3; 20% (4,113 of 20,106) in quintile 4; and 14% (2,846 of 20,106) in quintile 5. The unadjusted Kaplan-Meier estimated survival according to category of household disposable income is shown in the **Central Illustration**. After 1 year of surgery, survival was 93%, 94%, 95%, 96%, and 97%, in household disposable income quintiles 1 to 5, respectively. The corresponding figures after 5 years were 80%, 83%, 85%, 89%, and 91%, respectively. There was a stepwise inverse association between household disposable income and death in the crude, age-adjusted, and multivariable-adjusted analyses (**Table 2**) after 5 years, 10 years, and 15 years of follow-up, respectively. After multivariable adjustment for all variables reported in **Table 1**, the HR for death was 0.71 (95% CI: 0.67 to 0.75) in the highest compared with the lowest household disposable income quintile after 15 years of follow-up. The multivariable adjusted association between income as a continuous variable modeled

CENTRAL ILLUSTRATION Household Income and Survival After Cardiac Surgery



Number at Risk

Q1	20,107	13,693	6,136	191
Q2	20,116	13,912	6,215	201
Q3	20,099	13,580	6,060	204
Q4	20,106	13,632	6,162	178
Q5	20,106	12,223	4,948	144

B

Household Disposable Income	Events/Person-Years	Incidence Rate per 1,000 Person-Years (95% CI)
Q1 (Lowest)	8,643/148,320	58 (57-60)
Q2	7,595/150,222	51 (49-52)
Q3	5,972/148,390	40 (39-41)
Q4	4,112/149,260	28 (39-41)
Q5 (Highest)	2,846/136,270	21 (20-22)

Dalén, M. et al. J Am Coll Cardiol. 2015; 66(17):1888–97.

In the unadjusted Kaplan-Meier estimated survival in 100,534 patients who underwent cardiac surgery in Sweden from 1999 to 2012 **(A)**, survival rose along with income according to quintiles (Q) of household disposable income (with Q5 representing the highest quintile). The same inequalities by quintile are seen in event rates for all-cause mortality after 15 years of follow-up **(B)**. CI = confidence interval.

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TABLE 2 All-Cause Mortality

Household Disposable Income (Quintiles)	Number of Deaths/ Person-Years	Incidence Rate per 1,000 Person-Years (95% CI)	Crude HR (95% CI)	Age-Adjusted HR (95% CI)	Multivariable-Adjusted HR* (95% CI)
30-day follow-up					
Q1 (lowest)†	707/1,611	439 (408–472)	1.00	1.00	1.00
Q2	612/1,617	378 (350–410)	0.85 (0.77–0.95)	0.87 (0.78–0.97)	0.94 (0.83–1.07)
Q3	547/1,620	338 (311–367)	0.75 (0.67–0.84)	0.82 (0.73–0.92)	0.93 (0.81–1.07)
Q4	411/1,627	253 (229–278)	0.55 (0.49–0.63)	0.69 (0.61–0.78)	0.82 (0.70–0.95)
Q5 (highest)	335/1,631	205 (185–229)	0.44 (0.38–0.50)	0.60 (0.52–0.69)	0.73 (0.62–0.88)
5-yr follow-up					
Q1 (lowest)†	3,821/84,376	45 (44–47)	1.00	1.00	1.00
Q2	3,246/85,553	38 (37–39)	0.83 (0.80–0.87)	0.85 (0.81–0.89)	0.90 (0.85–0.95)
Q3	2,738/85,415	32 (31–33)	0.70 (0.66–0.73)	0.77 (0.73–0.81)	0.85 (0.80–0.90)
Q4	2,012/85,999	23 (22–24)	0.50 (0.48–0.53)	0.66 (0.62–0.70)	0.78 (0.73–0.83)
Q5 (highest)	1,535/83,520	18 (17–19)	0.39 (0.36–0.41)	0.57 (0.53–0.61)	0.70 (0.65–0.76)
10-yr follow-up					
Q1 (lowest)†	7,265/133,961	54 (53–55)	1.00	1.00	1.00
Q2	6,264/135,830	46 (45–47)	0.85 (0.82–0.88)	0.87 (0.84–0.90)	0.91 (0.88–0.95)
Q3	5,066/133,971	38 (37–39)	0.69 (0.67–0.72)	0.79 (0.76–0.82)	0.87 (0.83–0.91)
Q4	3,485/134,660	26 (25–27)	0.47 (0.45–0.49)	0.67 (0.64–0.70)	0.77 (0.74–0.82)
Q5 (highest)	2,471/125,066	20 (19–21)	0.36 (0.34–0.37)	0.58 (0.55–0.61)	0.70 (0.66–0.74)
15-yr follow-up					
Q1 (lowest)†	8,643/148,320	58 (57–60)	1.00	1.00	1.00
Q2	7,595/150,222	51 (49–52)	0.87 (0.84–0.89)	0.89 (0.86–0.92)	0.93 (0.89–0.96)
Q3	5,972/148,390	40 (39–41)	0.69 (0.66–0.71)	0.79 (0.77–0.82)	0.87 (0.84–0.91)
Q4	4,112/149,260	28 (27–28)	0.47 (0.45–0.49)	0.68 (0.65–0.70)	0.78 (0.75–0.82)
Q5 (highest)	2,846/136,270	21 (20–22)	0.36 (0.34–0.37)	0.59 (0.56–0.61)	0.71 (0.67–0.75)
15-yr follow-up conditional on 30 days' survival					
Q1 (lowest)†	7,930/148,302	53 (52–55)	1.00	1.00	1.00
Q2	6,971/150,206	46 (45–48)	0.87 (0.84–0.90)	0.89 (0.86–0.92)	0.92 (0.89–0.96)
Q3	5,421/148,374	37 (36–38)	0.68 (0.66–0.70)	0.79 (0.77–0.82)	0.86 (0.83–0.90)
Q4	3,695/149,246	25 (24–26)	0.46 (0.44–0.48)	0.68 (0.65–0.70)	0.78 (0.74–0.82)
Q5 (highest)	2,509/136,263	18 (18–19)	0.35 (0.33–0.37)	0.59 (0.56–0.61)	0.71 (0.67–0.75)

*Model included all variables reported in Table 1. †Reference category.
HR = hazard ratio; CI = confidence interval; Q = quintile.

using restricted cubic splines and all-cause mortality after 5, 10, and 15 years of follow-up is shown in Figure 1.

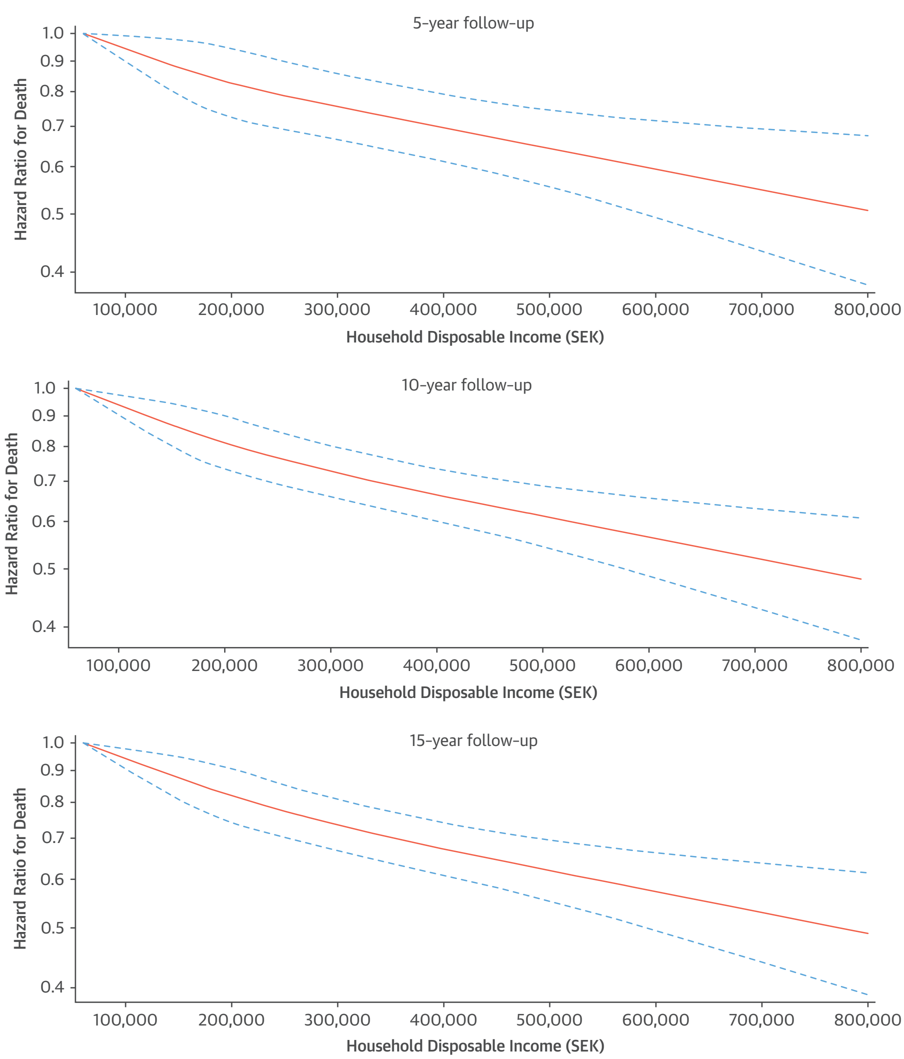
Thirty days after surgery, all-cause mortality was 3.5%, 3.1%, 2.7%, 2.1%, and 1.7% in household disposable income quintiles 1 to 5, respectively (Table 2). There was a stepwise inverse association between household disposable income quintile and 30-day mortality in the crude, age-adjusted, and multivariable-adjusted analyses. After multivariable adjustment for all variables reported in Table 1, the HR for death was 0.73 (95% CI: 0.62 to 0.88) in the highest compared with the lowest household disposable income quintile.

The association between household disposable income and early mortality was similar to the association between household disposable income and long-term mortality (Table 2). After exclusion of patients who died within 30 days of surgery, the relationship between income and mortality was similar compared with the total population (Table 2).

The inverse association between household disposable income and mortality was consistent in selected subgroups divided by age, sex, educational level, marital status, type of procedure, and year of surgery (Figure 2), although this association was somewhat attenuated in older patients and in patients who were married.

Information regarding cause of death was available for the subset of patients who died before January 1, 2013. The association between household disposable income and mortality was stronger for cardiovascular death than noncardiovascular death (HR: 0.53; 95% CI: 0.49 to 0.57 vs. HR: 0.64; 95% CI: 0.60 to 0.69 in the highest compared with the lowest household disposable income quintile), as shown in Table 3.

FIGURE 1 Association Between Income and Mortality at Follow-Up



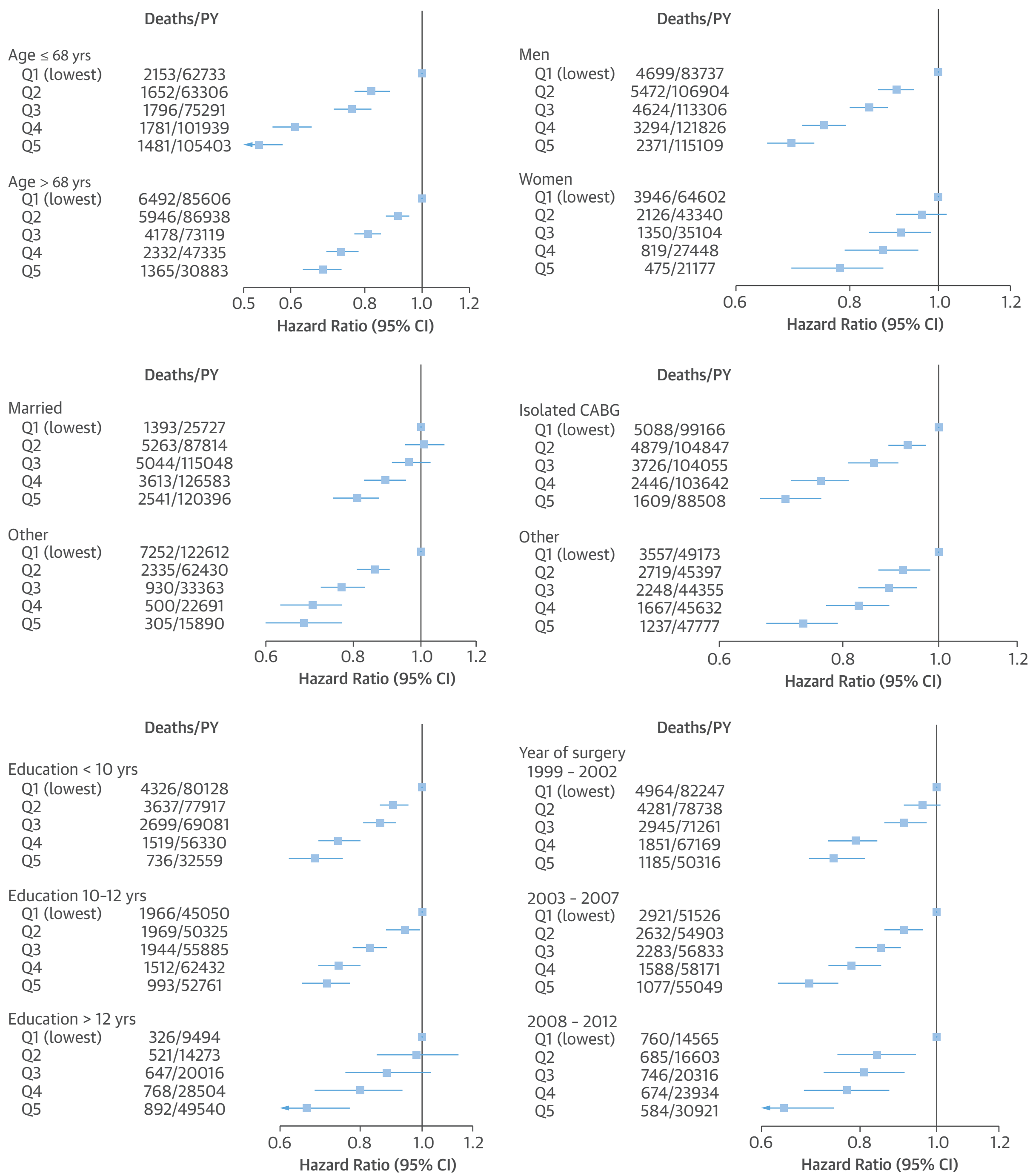
A consistent association between household disposable income and all-cause mortality in patients who underwent cardiac surgery in Sweden from 1999 to 2012 is seen at 5, 10, and 15 years of follow-up. The household disposable income was modeled with restricted cubic splines with 4 knots in a Cox regression model, and the reference level was set at 60,000 SEK to estimate hazard ratios. The smallest 1% and the largest 1% of household disposable income values were excluded in this graph for presentational purposes. **Solid orange line** = adjusted hazard ratio; **dashed blue lines** = 95% confidence interval. SEK = Swedish krona.

DISCUSSION

Our results demonstrated that lower SES measured by household disposable income was associated with increased early and long-term mortality after cardiac surgery, an association that persisted after adjustment for cardiovascular risk factors and other factors. Patients with lower household disposable income had a higher prevalence of cardiovascular risk factors and a different pattern regarding educational level, civil status, and birth region compared to patients in higher income groups. The association between household disposable income and mortality was consistent in subgroups divided by age, sex, educational level, marital status, type of procedure, and year of surgery.

The association between low SES and higher risk for CVD and all-cause mortality is well established (1–3). It is, however, still uncertain how this association is mediated. As there is an inverse relationship between SES and cardiovascular risk factors (1), it has been suggested that the association between SES and

FIGURE 2 Association Between Income and Mortality by Subgroups



The inverse association between quintiles (Q) of household disposable income and all-cause mortality is seen in selected subgroups of patients. Q1, the lowest income category, served as the reference category. CABG = coronary artery bypass grafting; CI = confidence interval; PY = person-years.

mortality is merely a result of an adverse risk profile (21). Other authors have claimed that the association between SES and clinical outcomes can be due to SES-related differences in access to and quality of health care (1,2,5–7). Our study extends the findings from previous investigations regarding the role of risk factor profile and health care availability and quality in the relationship between SES and mortality.

TABLE 3 Cardiovascular and Noncardiovascular Mortality

Household Disposable Income (Quintiles)	Deaths/Person-Years	Incidence Rate per 1000 Person-Years (95% CI)	Crude HR (95% CI)	Age-Adjusted HR (95% CI)	Multivariable-Adjusted HR* (95% CI)
Cardiovascular mortality					
Q1 (lowest)†	4,041/133,678	30 (29–31)	1.00	1.00	1.00
Q2	3,383/134,283	25 (24–26)	0.83 (0.80–0.87)	0.85 (0.82–0.89)	0.92 (0.87–0.97)
Q3	2,528/130,574	19 (19–20)	0.64 (0.61–0.67)	0.74 (0.70–0.78)	0.85 (0.80–0.90)
Q4	1,738/129,275	13 (13–14)	0.44 (0.41–0.46)	0.63 (0.60–0.67)	0.78 (0.73–0.84)
Q5 (highest)	1,150/114,856	10 (9.5–11)	0.32 (0.30–0.35)	0.53 (0.49–0.57)	0.69 (0.63–0.75)
Noncardiovascular mortality					
Q1 (lowest)†	3,742/133,678	28 (27–29)	1.00	1.00	1.00
Q2	3,353/134,283	25 (24–26)	0.89 (0.85–0.93)	0.91 (0.87–0.96)	0.94 (0.89–0.99)
Q3	2,744/130,574	21 (20–22)	0.74 (0.71–0.78)	0.86 (0.81–0.90)	0.91 (0.86–0.97)
Q4	1,846/129,275	14 (14–15)	0.50 (0.47–0.53)	0.71 (0.67–0.75)	0.79 (0.74–0.85)
Q5 (highest)	1,335/114,856	12 (11–12)	0.40 (0.38–0.43)	0.64 (0.60–0.69)	0.74 (0.68–0.80)

*Model included all variables reported in Table 1. †Reference category.
Abbreviations as in Table 2.

The study population was well characterized regarding risk profile and included information about well-established cardiovascular risk factors and relevant socioeconomic variables. Household disposable income still added clinically valuable information regarding early and long-term prognosis after adjusting for baseline risk factors. Our findings suggest that the association between low household disposable income and mortality is unlikely to be explained only by an adverse risk profile. Important limitations are that our data did not include information on important lifestyle factors such as smoking habits, job strain, diet, level of physical activity, compliance to secondary prevention medication, and long-term sick leave or early retirement that are related to both long-term outcomes and SES (22). Therefore, household disposable income might, to an unknown extent, be a proxy for these unregistered lifestyle behaviors. The combined exposure to low personal disposable income and low income level in the neighborhood has additive effect on risk of myocardial infarction (23). Also, there may be work-related or psychosocial stress contributing to development of the metabolic syndrome mediated via the hypothalamic-pituitary-adrenal axis (24–26). However, household disposable income could serve as a useful surrogate for these characteristics since they are often unknown or hard to quantify in the clinical setting and usually not included in health care registries.

Apart from patient risk profile, SES-related disparities in health also have been shown to involve health care system factors. Previous studies have linked SES to differences in access to and quality of care (1,2,5–7). In countries without universal health care coverage, insurance status and SES are highly correlated, which represents an important confounding factor (27). Despite this, most studies demonstrating an association between SES and all-cause mortality have been conducted in populations without universal tax-financed health care, leading to inequities regarding access to health care depending on SES. In the United States, insurance status has been associated with the use of invasive cardiac procedures (28) as well as in-hospital (27) and long-term (29) mortality after CABG. This makes it hard to determine whether SES-related differences in clinical outcomes are solely a result of differences in access to and quality of health care between different SES categories.

In our study, all patients benefited from universal tax-financed health care. It is conceivable that health care for cardiac surgery patients from different income groups is more similar in countries with universal tax-financed health care compared to countries with other health care systems. Furthermore, cardiac surgery in Sweden was performed at a small number of centers with similar standards of care and performance. This is important because hospital selection has been shown to be significantly associated with SES and mortality after CABG in the United States (10). Our finding that household disposable income was associated with mortality supports the concept that the impact of SES on long-term outcomes cannot solely be explained by disparities in health care among different SES categories.

Very few studies have examined the association between SES and mortality in patients after cardiac surgery (4,9–11). These studies were small or single-center reports and relied on area-level data for estimation of SES. These studies showed poorer long-term survival in lower SES categories (4,9), but the results regarding early mortality were conflicting (9–11). We found a progressive inverse association between household disposable income and early mortality, similar in magnitude to the association found between household disposable income and long-term mortality as well as long-term mortality conditional on survival beyond 30 days. The finding of increased early mortality after cardiac surgery in patients with low household disposable income could be explained by SES-related differences or an adverse risk factor profile, but we cannot rule out the possibility that unmeasured or unknown confounders influenced our results. Although these findings suggest that perioperative and early postoperative care does not assert a large impact on the significant relationship between income and survival, this area requires further study.

STUDY STRENGTHS AND LIMITATIONS. The strengths of our study included the large contemporary study population and the complete and accurate follow-up and survival ascertainment due to the high-quality national Swedish registries. Furthermore, we used an individual-level estimation of household disposable income and the study was conducted in a population provided with universal tax-financed health care. However, there are several important limitations of the study that need to be addressed. The national registries utilized did not provide information regarding all recognized cardiovascular behavioral risk factors, such as smoking, diet, physical activity, and compliance to prescribed medication. Furthermore, we did not have information regarding medication or health care during the follow-up period. Guideline-directed medical therapy for secondary prevention has been shown to improve clinical outcomes in patients with CVD (30) and it is possible that optimal medical therapy is related to SES. Indeed, a Swedish study showed that patients with a higher income and a higher level of education more often received a prescription of a statin following an ischemic stroke compared with patients with lower income and education (31). Although the association between household disposable income and mortality persisted after adjustment for a number of established cardiovascular risk factors and other factors, the possibility remains that residual confounding could have influenced the results. It should also be noted that we calculated the household disposable income as the mean of all yearly household disposable income figures registered for each patient, and thus the mean income was derived from many years in some patients and only 1 or a few years in others. It is possible that low income might have arisen from poor health status and severe heart disease. Because of inherent limitations due to study design, we can only speculate regarding underlying reasons for our findings and explanatory mechanisms need to be investigated in future studies.

CONCLUSIONS

Household disposable income was independently and inversely associated with early and long-term mortality after cardiac surgery. The association between household disposable income and mortality persisted after adjusting for cardiovascular risk factors. These findings are of particular interest because the study was conducted in a population that benefited from universal tax-financed health care. Our results demonstrate that the association between household disposable income and mortality cannot fully be explained by differences in risk profile or access to and quality of health care. Ways to better implement secondary prevention measures should be explored in low-income patient groups.

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REPRINT REQUESTS AND CORRESPONDENCE: Dr. Ulrik Sartipy, Department of Cardiothoracic Surgery and Anesthesiology, Karolinska University Hospital, SE-171 76 Stockholm, Sweden. E-mail: Ulrik.Sartipy@karolinska.se.

PERSPECTIVES

COMPETENCY IN SYSTEMS-BASED PRACTICE: The correlations among SES, CVD, and mortality may be partly explained by the inverse relationship between SES and prevalence of cardiovascular risk factors. Among patients undergoing cardiac surgery in Sweden, household disposable income was inversely associated with early and long-term mortality after cardiac surgery, but not fully explained by differences in risk or access to health care.

TRANSLATIONAL OUTLOOK: Further study is necessary to understand the factors responsible for the association between income and survival following cardiac surgery and to develop effective secondary prevention measures for low-income patients.

REFERENCES

1. Kaplan GA, Keil JE. Socioeconomic factors and cardiovascular disease: a review of the literature. Circulation 1993;88:1973–98.

2. Alter DA, Naylor CD, Austin P, Tu JV. Effects of socioeconomic status on access to invasive cardiac procedures and on mortality after acute myocardial infarction. N Engl J Med 1999;341:1359–67.

3. Mackenbach JP, Stirbu I, Roskam AJ, et al. Socioeconomic inequalities in health in 22 European countries. N Engl J Med 2008;358:2468–81.

4. Dzayee DA, Ivert T, Beiki O, et al. Short and long term mortality after coronary artery bypass grafting (CABG) is influenced by socioeconomic position but not by migration status in Sweden, 1995–2007. PLoS One 2013;8:e63877.

5. Philbin EF, McCullough PA, DiSalvo TG, et al. Socioeconomic status is an important determinant of the use of invasive procedures after acute myocardial infarction in New York State. Circulation 2000;102:III107–15.

6. Wenneker MB, Weissman JS, Epstein AM. The association of payer with utilization of cardiac procedures in Massachusetts. JAMA 1990;264:1255–60.

7. Rathore SS, Berger AK, Weinfurt KP, et al. Race, sex, poverty, and the medical treatment of acute myocardial infarction in the elderly. Circulation 2000;102:642–8.

8. Jakobsen L, Niemann T, Thorsgaard N, et al. Dimensions of socioeconomic status and clinical outcome after primary percutaneous coronary intervention. Circ Cardiovasc Interv 2012;5:641–8.

9. Koch CG, Li L, Kaplan GA, et al. Socioeconomic position, not race, is linked to death after cardiac surgery. Circ Cardiovasc Qual Outcomes 2010;3:267–76.

10. Kim C, Diez Roux AV, Hofer TP, et al. Area socioeconomic status and mortality after coronary artery bypass graft surgery: the role of hospital volume. Am Heart J 2007;154:385–90.

11. Taylor FC, Ascione R, Rees K, et al. Socioeconomic deprivation is a predictor of poor postoperative cardiovascular outcomes in patients undergoing coronary artery bypass grafting. Heart 2003;89:1062–6.

12. Jernberg T, Attebring MF, Hambraeus K, et al. The Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies (SWEDEHEART). Heart 2010;96:1617–21.

13. Harnek J, Nilsson J, Friberg Ö, et al. The 2011 outcome from the Swedish Health Care Registry on Heart Disease (SWEDEHEART). Scand Cardiovasc J 2013;47 Suppl 62:1–10.

14. Emilsson L, Lindahl B, Koster M, et al. Review of 103 Swedish Healthcare Quality Registries. J Intern Med 2015;277:94–136.

15. Ludvigsson JF, Otterblad-Olausson P, et al. The Swedish personal identity number: possibilities and pitfalls in healthcare and medical research. Eur J Epidemiol 2009;24:659–67.

16. Dalén M, Ivert T, Holzmann MJ, Sartipy U. Coronary artery bypass grafting in patients 50 years or younger: a Swedish nationwide cohort study. Circulation 2015;131:1748–54.

17. Ludvigsson JF, Andersson E, Ekbom A, et al. External review and validation of the Swedish national inpatient register. BMC Public Health 2011;11:450.

18. Longitudinal Integration Database for Health Insurance and Labour Market Studies (LISA by Swedish Acronym). Statistics Sweden. Available at: http://www.scb.se/en_/Services/Guidance-for-researchers-and-universities/SCB-Data/Longitudinal-integration-database-for-health-insurance-and-labour-market-studies-LISA-by-Swedish-acronym. Accessed August 19, 2015.

19. White IR, Royston P, Wood AM. Multiple imputation using chained equations: issues and guidance for practice. Stat Med 2011;30:377–99.

20. White IR, Royston P. Imputing missing covariate values for the Cox model. Stat Med 2009;28:1982–98.

21. Alter DA, Chong A, Austin PC, et al. Socioeconomic status and mortality after acute myocardial infarction. Ann Intern Med 2006;144:82–93.

22. Stringhini S, Sabia S, Shipley M, et al. Association of socioeconomic position with health behaviors and mortality. JAMA 2010;303:1159–66.

23. Stjärne MK, Fritzell J, De Leon AP, Hallqvist J, Group SS. Neighborhood socioeconomic context, individual income and myocardial infarction. Epidemiology 2006;17:14–23.

24. Brunner EJ, Hemingway H, Walker BR, et al. Adrenocortical, autonomic, and inflammatory causes of the metabolic syndrome: nested case-control study. Circulation 2002;106:2659–65.

25. Chandola T, Brunner E, Marmot M. Chronic stress at work and the metabolic syndrome: prospective study. BMJ 2006;332:521–5.

26. Hemingway H, Shipley M, Brunner E, Britton A, Malik M, Marmot M. Does autonomic function link social position to coronary risk? The Whitehall II study. Circulation 2005;111:3071–7.

27. LaPar DJ, Stukenborg GJ, Guyer RA, et al. Primary payer status is associated with mortality and resource utilization for coronary artery bypass grafting. Circulation 2012;126:S132–9.

28. Sada MJ, French WJ, Carlisle DM, et al. Influence of payor on use of invasive cardiac procedures and patient outcome after myocardial infarction in the United States. Participants in the National Registry of Myocardial Infarction. J Am Coll Cardiol 1998;31:1474–80.

29. Zacharias A, Schwann TA, Riordan CJ, et al. Operative and late coronary artery bypass grafting outcomes in matched African-American versus Caucasian patients: evidence of a late survival-Medicaid association. J Am Coll Cardiol 2005;46:1526–35.

30. Ford ES, Ajani UA, Croft JB, et al. Explaining the decrease in U.S. deaths from coronary disease, 1980–2000. N Engl J Med 2007;356:2388–98.

31. Sjölander M, Eriksson M, Glader EL. Social stratification in the dissemination of statins after stroke in Sweden. Eur J Clin Pharmacol 2013;69:1173–80.

KEY WORDS cardiovascular disease, risk factors, socioeconomic status, universal coverage

APPENDIX For supplemental tables and figures, please see the online version of this article.