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Key Words: Acute Myocardial Infarction, socioeconomic position, meta-analysis.

Word count: 3989

ABSTRACT:

Background: Negative socioeconomic gradient is established for coronary heart disease (CHD) mortality and survival, while socioeconomic pattering of disease incidence is less investigated. To study socioeconomic inequalities in incidence of acute myocardial infarction (AMI), the major component of CHD, we undertook meta-analysis to summarize existing evidence on the issue. **Methods:** A systematic search was performed in PubMed and EMBASE databases for observational studies on AMI incidence and socioeconomic position (SEP), published in English through April 2009. Random-effects model was used to pool the risks estimates from the individual studies. **Results:** Among 1,181 references, 70 studies fulfilled inclusion criteria. An overall increased risk of AMI among the lowest SEP was found for all three indicators: income (pooled RR=1.71, 95% CI 1.43 to 2.05), occupation (pooled RR=1.35, 95% CI 1.19 to 1.53) and education (pooled RR=1.34, 95% CI 1.22 to 1.47). The strongest associations were seen in high-income countries such us US/Canada and Europe, while the results were inconsistent for middle- and low-income regions. **Conclusion:** AMI incidence is associated with low SEP. The nature of social stratification at the level of economic development of a country could be involved in the differences of risk of AMI between social groups.

INTRODUCTION

Acute Myocardial Infarction (AMI) is a major cause of death and disability worldwide.[1] According to an estimate from the WHO, about 40% of all deaths will be related to cardiovascular diseases (CVD) in 2020, with AMI being the main single cause.[2] Projection of global mortality and burden of disease for 2030 presented that despite the decline in mortality due to coronary heart disease (CHD) in high-income countries during the last decades, it will remain the leading cause of mortality in low-and middle-income countries.[3-5] Due to high mortality rate, severe damage to physical and mental health, long rehabilitation periods and a high rate of disability, the burden of AMI is a highly significant social issue.[6]

There is a considerable body of evidence linking socioeconomic position (SEP) with the conventional risk factors for CHD, including AMI as the major component of CHD.[7-9] Lower SEP is often associated with health-damaging lifestyle resulting in the development of poor dietary habits as well as influencing behaviours related to smoking and physical activity.[10] Individuals with low SEP are prone to be exposed to multiple risk factors and, therefore, seem to suffer dramatically from excess burden of disease.[11]

Associations between SEP and CVD mortality and survival have been well discussed in a number of reviews.[12-16] However, quantitative assessment of socioeconomic pattering of CVD incidence and AMI incidence is presented to a lower extent. Use of incidence data generally avoids problems with post-diagnosis SEP changes as well as with different survival by socioeconomic groups.[17] Addressing the issue of social inequality in AMI further, it is important to estimate the individual contribution of each SEP indicator rather than interchangeable SEP measures as they affect health through different pathways and causal mechanisms.[18] We undertook meta-analysis as a quantitative approach to summarize the

existing evidence on the issue[19, 20] to investigate the association between AMI incidence and various SEP measures including educational attainment, income, and occupation categories.

SUBJECTS AND METHODS

Search strategy

To identify eligible studies of associations between socioeconomic determinants and AMI incidence, we conducted a systematic search in PubMed and EMBASE databases for articles published in English-speaking, peer-reviewed journals from 1966 to April 01, 2009. For this search, we used the relevant medical subject heading (MeSH) terms and key words related to socioeconomic determinants combined with specific outcome defined as *"acute myocardial infarction"*. The details of electronic search are reported on-line in Appendix 1. The reference lists were scrutinized to identify additional studies.

Study selection

To be included in this meta-analysis, studies had to 1) use original data; 2) be designed as case-control or cohort studies; 3) consider AMI incidence as an outcome; 4) present risk estimates with 95% confidence intervals (CIs) on the association between incident cases of AMI and at least one measure of SEP, or report sufficient information to compute these for men, women or both.

The articles were selected for inclusion if the study event was originally defined as AMI either nonfatal or in combination with fatal or reported as a composite outcome of AMI and

death attributed to CHD / ischemic heart disease (IHD), including sudden death. We also considered studies where the outcome definition composed AMI with congestive heart failure[21, 22] or unstable angina (UA).[23] In order to avoid the inclusion of chronic ischemic disease, we did not include studies if the outcome of interest was presented as CHD event corresponding to codes 410-414 in ICD-9 or I21-I25 in ICD-10 with no further specification. Neither did we include studies if AMI was combined with angina pectoris, coronary atherosclerosis or stroke with no possibility to extract data on AMI alone. We sought data on the first AMI event to assess the impact of social inequality on development of the disease in people apparently free from acute ischemic disease. Studies focusing exclusively on mortality and survival were not included.

SEP indicators were included only if they were based on income, educational attainment or occupational categories. Studies utilizing a social indicator constructed as a combination of two or more standard socioeconomic indicators were not included. Neither did we include studies where the SEP measure was based on ownership of car/houses/health insurance or presented as categories of deprivation. Only the studies with adult individual-level measure of SEP were included. No restrictions were made by the type of SEP, personal or household.

When overlap was identified from various studies, the original data were included only once, prioritizing datasets providing maximally-adjusted risk estimates. If not, we used the most up-to-date information or studies with greater number of participants. Two co-authors (EM, AS) independently extracted relevant studies following the inclusion criteria. In case of missing data we contacted the corresponding authors. All authors[24-29] from whom the additional information was requested provided us with data we asked for. Discrepancies were resolved by consensus in a panel meeting (TM, EM, AS).

Data extraction

The following information was extracted from each publication: the first author's last name, the year of publication, the country where the study was performed, study design, years of data collection and type of controls (population-based / hospital-based) in case-control studies, duration of follow-up in cohort studies, the sample size, indicators of SEP, source and type of SEP data, definition and status of the outcome, status of event, sex and age along with the risk estimates for AMI associated with SEP with corresponding 95% CIs, and the variables controlled for. The information on country where the study was performed was then classified both according to the geographical area (US/Canada, Europe, Asia, Latin America, Middle East) and country's income level (high-, middle-, or low-income countries).[5] From each study, we extracted the risk estimate both minimally-and maximally-adjusted for the potential confounders. Unless otherwise stated, we included in the analysis the maximally-adjusted estimates in order to overcome inconsistency in handling confounding and mediating variables. We considered the study risk estimates to be minimally-adjusted if unadjusted or adjusted for age, sex and residence, either one or all, by matching, restriction, stratification or statistical adjustment, and to be maximally-adjusted if in addition adjusted for any of the classical well-recognised AMI-specific risk factors. If the original study reported risk estimates in association with more than one measure of SEP, each estimate was extracted and then analysed as its own association with the specific SEP.

Statistical analysis

Relative risk (RR) was used as the measure for summary statistic of associations between SEP and AMI incidence. To simplify the procedure, RRs represented all reported study-specific results derived from cohort studies and odds ratios (ORs) from case-control studies.[30] Due to the initial assumption of between-study heterogeneity, a random-effects model of DerSimonian-Laird,[31] which incorporates both within- and between-study variability, was applied to combine log RRs across the studies. To augment comparability between the studies using different SEP categories, we compared the lowest versus the highest SEP category. If the original study reported the risk estimates not in this order, we back-calculated the point estimate and 95% CIs. For the articles that did not report estimates in form of RRs or ORs, the risk estimates and 95% CIs were recalculated from the presented raw data by using standard equations. If the original study reported separate RRs for different sexes[32-37] or different races[34] or if RRs were reported separately for two subcohorts with rheumatoid arthritis and non-inflammatory rheumatoid disorders within same cohort,[38] the risk estimates were pooled (weighted by inverse of their variance) to obtain a single estimate per SEP from each study.

To evaluate the statistical heterogeneity among studies we used the Cochran's *Q* test.[39] This test examines the null hypothesis that heterogeneity across the study estimates of RRs is due to chance by using a chi-square test with degrees of freedom equal to the number of studies minus one. For *Q* statistic we considered $P<0.1$ as a representative of statistically significant heterogeneity. To describe the proportion of total variance in study estimates explained by heterogeneity between study variation rather than chance, we calculated the I^2 statistic.[40]

Random-effect meta-regression analyses were performed to identify study-level factors contributing to heterogeneity between studies. The explanatory variables included study

design, geographical area, country's income level, publication year (before 2000 / 2000 and after), type of adjustment with respect to AMI-specific risk factors, type of controls in case-control studies, personal or household SEP, and status of the event and the natural logarithm of RR was the dependent variable.[41-43] An univariate meta-regression was performed for each study-level factors for studies on income, education and occupation. A backward stepwise approach was used to select the significant variables to be included in a multivariate analysis. In addition, a series of subgroup analyses were conducted by stratifying the original studies by sex, country's income level and geographical region, study design, adjustment strategy, publication period, personal or household SEP and type of study event. The stability of the results was also evaluated in leave-one-out sensitivity analysis in which the influence of the individual study on the overall pooled RR was estimated by omitting one study at a time.[44]

We assessed publication bias by constructing funnel plots and using the Egger's regression asymmetry test and the Begg-Mazumdar adjusted rank correlation test.[45, 46]. All statistical analyses were performed using STATA version 10 (StataCorp, College Station, TX). *P*-values that were less than 0.05 were considered statistically significant. All statistical tests were two-sided.

RESULTS

Study characteristics

Total search in the electronic databases revealed 2,539 references and among those 1,358 were overlapping between different search categories. The search strategy for the 1,181 unique references is presented on Figure 1 as the QUOROM statement[47] flowchart where

the detailed procedure of the reference identification along with the information on exclusion criteria applied on different stages of the selection is described. Briefly, 855 articles did not address the issue of interest and were excluded after the screening the abstracts leaving us with 326 full-text articles for further examination. Of these, only 64 articles fulfilled the pre-defined inclusion criteria and were selected to be included in the analysis. The reference lists of the selected articles were scrutinized and 19 articles were additionally identified fulfilling the inclusion criteria. To mitigate overlapping in study populations, several studies being initially considered relevant for the analysis[24, 26, 48-63] were excluded and substituted by more recent ones, providing maximally-adjusted risk estimates or with greater number of participants [18, 23, 33, 35, 64-71].

Two risk estimates for educational attainment and AMI incidence presented by Chang C et al.[66] for women from Eastern Europe and whose from non-European countries (Latin America, Asia and Africa) were independently included in the analysis, referred as Chang C (A) and Chang C (B), respectively. Similar to that, two substudies on occupational SEP and AMI described in the article by Mattila K et al.[27] (series I and series II), were also analysed separately. The same strategy was applied to data derived from the articles by Eaker E et al.[72] and Qureshi A et al.,[73] where occupational and educational SEP were presented among women at the age of 45-54 years (Eaker E (A)) and 55-64 years (Eaker E (B)) and patients younger 50 years (Qureshi A (A)) and older 50 years (Qureshi A (B)), respectively. Substudies from the articles by Bosma H et al.[74] originated from Lithuania (Bosma H (A)) and The Netherlands (Bosma H(B)) were included independently. Therefore, 70 original studies from 65 articles, extending back to the year 1968, were finally included in the analysis.

In total, there were 37 case-control studies in 35 articles[23, 25, 27, 28, 32, 33, 35, 65-67, 75-99] reporting associations with different SEP among 74,056 AMI cases and 619,652 controls and 33 cohort studies, including 2 studies nested in cohort, in 30 articles[18, 21, 29, 34, 36-38, 64, 68-74, 100-114] where association with SEP was studied for 28,629 incident cases among 3,869,270 participants. Supplementary table S1 presents data on detailed study characteristics of the included studies.

Overall result

The overall results of this meta-analysis provided evidence of a significant increase in risk of AMI among the lowest socioeconomic categories for all three socioeconomic indicators (Fig. 2-4). Heterogeneity was observed for all three SEP indicators ($p<0.001$) (Table1).

Table 1 Pooled estimates for the lowest versus the highest socioeconomic category and incidence of acute myocardial infarction in series of subgroup analyses

Subgroup analysis	**n = Number of studies, Pooled RR (95% CI), p-value for *Q* test for heterogeneity, I^2 statistic (%)**								
	n	**Income**	***Q* p-value** **I^2 (%)**	**n**	**Education**	***Q* p-value** **I^2 (%)**	**n**	**Occupation**	***Q* p-value** **I^2 (%)**
Summary pooled estimate	19	1.71 (1.43 to 2.05)	<0.001 95.9	47	1.34 (1.22 to 1.47)	<0.001 77.6	33	1.35 (1.19 to 1.53)	<0.001 81.6
Sex									
Male	7	1.50 (1.31 to 1.72)	0.039 54.8	13	1.24 (1.04 to 1.48)	<0.001 83.7	18	1.34 (1.16 to 1.55)	<0.001 77.3
Female	4	1.87 (1.48 to 2.36)	0.015	15	1.58 (1.25 to 2.00)	<0.001	11	1.87 (1.34 to 2.60)	<0.001

			71.3			66.5			77.6
Country's income group									
High	15	1.76 (1.46 to 2.12)	<0.001	34	1.39 (1.25 to 1.55)	<0.001	30	1.41 (1.25 to 1.59)	<0.001
			96.3			79.3			80.6
Middle or Low	4	1.46 (0.60 to 3.54)	<0.001	13	1.16 (0.97 to 1.39)	0.009	3	0.51 (0.27 to 0.99)	0.205
			81.3			54.9			37.0
Geographical region [a]									
US/Canada	4	1.49 (1.27 to 1.75)	0.350	10	1.42 (1.28 to 1.57)	0.340	6	1.44 (1.22 to 1.70)	0.988
			9.2			10.6			0.0
Europe[b]	11	1.80 (1.46 to 2.21)	<0.001	29	1.33 (1.17 to 1.50)	<0.001	26	1.37 (1.19 to 1.58)	<0.001

			97.0			82.6			84.4
Asia	3	1.52 (0.29 to 7.93)	<0.001	3	1.90 (0.48 to 7.58)	0.001	1	0.67 (0.41 to 1.09)	—
			88.0			86.3			
Latin America	1	1.27 (1.06 to 1.52)	—	3	1.23 (1.03 to 1.47)	0.086	0	—	
						59.2			
Middle East	0	—		1	1.18 (0.27 to 5.15)	—	0	—	
Adjustment strategy [c]									
Unadjusted for AMI risk factors[d]	10	1.79 (1.44 to 2.24)	<0.001	29	1.37 (1.21 to 1.56)	<0.001	19	1.27 (1.05 to 1.54)	<0.001
			97.5			81.3			68.1
Adjusted for AMI risk factors[e]	9	1.58 (1.20 to 2.08)	0.001	16	1.26 (1.06 to 1.49)	<0.001	14	1.41 (1.19 to 1.68)	<0.001
			70.1			68.4			80.5

Design									
Cohort[f]	10	1.59 (1.45 to 1.75)	0.016	23	1.45 (1.27 to 1.66)	<0.001	19	1.39 (1.24 to 1.56)	0.002
			55.8			78.7			55.0
Case-control	9	1.91 (1.37 to 2.66)	<0.001	24	1.23 (1.07 to 1.41)	<0.001	14	1.17 (0.88 to 1.55)	<0.001
			91.3			74.1			82.8
Type of control for case-control studies									
Population[g]	6	2.36 (1.86 to 2.99)	0.005	12	1.41 (1.20 to 1.66)	<0.001	11	1.29 (0.95 to 1.76)	<0.001
			69.9			77.0			80.5
Hospital	3	1.05 (0.41 to 2.69)	0.003	12	0.99 (0.78 to 1.27)	0.001	3	0.84 (0.61 to 1.17)	0.296
			82.8			65.2			17.8

Publication period									
Before 2000	6	2.64 (2.16 to 3.22)	0.738	15	1.43 (1.12 to 1.82)	<0.001	16	1.34 (1.02 to 1.76)	0.005
			0.0			70.7			54.6
2000 or after	13	1.58 (1.29 to 1.93)	<0.001	32	1.31 (1.18 to 1.45)	<0.001	17	1.37 (1.18 to 1.59)	<0.001
			97.2			80.2			87.9
Personal or household SEP									
Personal	13	1.84 (1.49 to 2.26)	<0.001	47	1.34 (1.22 to 1.47)	<0.001	31	1.36 (1.20 to 1.55)	<0.001
			96.4			77.6			81.0
Household[h]	6	1.45 (1.00 to 2.08)	<0.001	0	—		2	1.35 (0.35 to 5.18)	0.002
			89.0						89.1

Event[c]									
Clearly first event ever	15	1.59 (1.30 to 1.94)	<0.001 96.8	38	1.29 (1.16 to 1.43)	<0.001 79.1	26	1.25 (1.09 to 1.43)	<0.001 83.4
Potentially first event[i]	4	2.47 (2.12 to 2.88)	0.447 0.0	7	1.75 (1.14 to 2.67)	0.001 74.4	7	2.04 (1.28 to 3.25)	0.004 68.5

[a] Data from Chang C et al [66] are not included due to presenting combined results from Latin American and Asian countries

[b] Corresponds to data from both Western European and Eastern European countries

[c] On this item data from the study by Qureshi A et al. [73] are not available

[d] Unadjusted or adjusted for age, sex and residence only (either one or all)

[e] Adjusted for at least one AMI-specific risk factors such as smoking, diabetes, hypertension, hypercholesterolemia, physical activity and BMI

[f] Corresponds to cohort studies and case-control studies nested in cohort

[g] Corresponds to either population-based controls or relatives/neighbourhood controls

[h] Corresponds to the family income SEP or husband's occupation for women or combination of women's and husband's occupation SEP

[i] Corresponds to the studies where less than <10% of cases may had had a prior AMI as well as the studies where information on cases' history on AMI was not clarified by the authors

The strongest pattern was seen for the lowest income group where the incidence of AMI increased by 71% compared to high income group (RR=1.71, 95% CI 1.43 to 2.05) (Table 1). Further stratification by sex, adjustment strategy, study design, status of event, personal or household type of SEP or publication years did not alter the overall pooled results. No association was seen for the case-control studies utilizing hospital controls, while studies with population controls revealed statistically significant association between the lowest income group and AMI (Table 1).

We observed a 34% increased risk of AMI for the lowest educational group (RR=1.34, 95% CI 1.22 to 1.47) (Table 1). The increase was apparent in subanalyses after stratifying by the main study characteristics, i.e. sex, adjustment strategy, study design, publication period, and status of event, apart from for the case-control studies with hospital controls (Table 1).

Increased incidence of AMI was observed when studies on occupational categories were pooled (RR=1.35, 95% CI 1.19 to 1.53) (Table 1). The increase persisted for the lowest occupational SEP when pooling studies within subgroups with different sex, status of event, and publication years. Non-significant increase was seen in subanalysis for household SEP measure (husband's occupation for women). The results were less consistent among case-control studies (Table 1).

Increased incidence of AMI was evident for the lowest income-based, educational and occupational SEP in high-income countries and in regional areas such us US/Canada and Europe (Table 1). No significant associations were, however, apparent between any of the SEP determinants and AMI incidence in studies carried out in the middle-or low income countries, particularly in Asian region. In contrary, for middle-or low income countries an inverse association was observed for the results combined across the studies on occupational SEP.

There was a substantial heterogeneity in overall result among the studies on all SEP determinants ($p< 0.001$) that remained significant for the results from most of the subanalyses. However, no or low heterogeneity was present when analyses were restricted to studies originated from US/Canada. There was a low heterogeneity among studies on occupation when results were combined for middle-or low-income countries. Similar pattern was seen when studies on income published before the year 2000 were analysed separately.

In random-effect meta-regression analyses the relation between SEP and AMI incidence persisted irrespective to the design of original studies, though in case-control studies multivariate regression indicated the association between type of control (hospital vs. population controls) and RR of AMI for studies on all SEP indicators (for income ß coefficient (ß) = -2.76, 95% CI -4.77 to -0.76, p= 0.007; for education ß = -0.40, 95% CI -0.75 to -0.05, p= 0.02; for occupation ß = -0.51, 95% CI -1.00 to -0.02, p= 0.04). Pooling together the cohort studies and case-control studies with population controls only had no effect on the overall results (pooled RR for income =1.80, 95% CI 1.50 to 2.16; pooled RR for education =1.43, 95% CI 1.30 to 1.58; pooled RR for occupation =1.41, 95% CI 1.24 to 1.60). Type of AMI event (potentially first vs. clearly first event ever) was significantly associated with outcome in multivariate regression analyses in studies on income (ß = 0.24, 95% CI 0.04 to 0.46, p = 0.02) and occupation (ß = 0.54, 95% CI 0.27 to 0.82, p < 0.001). Among other study-level factors only two revealed associations with the outcome. For studies on income SEP the publication period (published in year 2000 and after vs. published before year 2000) reached statistical significance in univariate, but not in multivariate meta-regression analysis (data not shown). For occupational SEP in multivariate analysis country's income group (middle-or low-income countries vs. high-income countries) was associated with RR of AMI (ß = -1.24, 95% CI -1.74 to -0.74, p< 0.001). No other study-level

characteristics for any of studied SEP indicators were found significant in meta-regression analyses.

No publication bias were observed for educational SEP (Egger's test p=0.49) with borderline significant result for occupational SEP (p=0.05), while selection of the studies focusing on income introduced publication bias (p=0.03). The publication bias funnel plots are presented as Supplementary material (Figure S1). No individual studies significantly altered the overall estimates based on the results of the sensitivity analysis.

DISCUSSION

Our results indicated an increased incidence of myocardial infarction among the lowest socioeconomic categories in income (71%), education (34%) and occupation (32%) compared to the highest category of the corresponding SEP. The associations were significant for both males and females and consistent for most of the results from the subgroup analyses. The increased risk of AMI for the lowest categories of all SEP indicators was most evident in high-income countries, while middle-or low-income countries revealed less consistent associations probably due to a limited number of the studies included in the latter strata.

SEP is a surrogate measure for numerous factors that may affect health. There is an increasing awareness that SEP indicators should not be used interchangeably because they may represent different risk factors[115] and relate to different causal pathways.[18, 116] Recent reviews discussed the new approach for health researchers to study the socioeconomic inequalities in health by measuring the respective impact of separate socioeconomic indicators on health outcomes along with the mediating mechanisms and adjustment suggested by each indicator rather than studying an effect of a single composite SEP

313 variable.[18, 117, 118] In our analysis the attempt was made to identify the independent
314 contribution of each SEP indicator to AMI outcome across regions and over time. The results
315 must be interpreted with cautions because of the observational nature of the data.[19, 119,
316 120]

317 Several methodological issues are needed to be taken under consideration. One of the
318 limitations in our study was possible differences in the definition and classification of SEP
319 across studies. It was of particular importance for educational and income SEP categories
320 since differences in countries' general economy, educational systems and cultural issues
321 could cause the variability in the scales used to classify the exposure. The methodological
322 limitations for quantitative comparison of studies on SEP due to the substantial dissimilarity
323 in exposure measures used in different studies over time and geographical regions have been
324 discussed previously.[115] Lack of uniformity in reporting SEP data in original studies have
325 limited our ability to investigate a social gradient in AMI incidence. To reduce the
326 inconsistency in SEP stratification across the original studies and to obtain the meaningful
327 indicator of socioeconomic inequality in health, it has been suggested to measure the
328 difference between the extreme categories of SEP, i.e. to compare the highest and the lowest
329 SEP strata.[117, 118, 121] Studies selected for our analysis varied significantly in presenting
330 SEP categories that prevented us from collapsing the middle-level SEP categories in one. To
331 overcome the problem and to increase the comparability across the studies, we applied the
332 suggested approach and compared the extreme categories that, however, impaired the
333 possibility of studying the social gradient and could be considered as a limitation of the
334 analysis.

335 Due to significant heterogeneity observed across the selected studies, the pooled results
336 should be interpreted with cautions. The nature of observational studies introduces design-

related heterogeneity that basically reflects the disparity in the study characteristics.[122] In our case the heterogeneity was probably boosted by the initial unevenness in study bases as well as in outcome definitions and status of event used in the original studies along with inconsistency in measures of exposure and variability in handling confounding and mediating factors. The incidental manner of reporting SEP data in descriptive tables in a numerous studies, resulted in using estimates adjusted neither by matching nor by statistical adjustment and, probably influenced the completeness of the search. The result-related heterogeneity[122] may be less pronounced in our meta-analysis due to non-substantial variability between the original point estimates and considerable overlaps of the confidence intervals. Meta-regression analyses indicated type of study controls in case-control studies as potential sources of heterogeneity between studies for all SEP indicators. Several meta-analyses discussed the limitations introduced by pooling the results of studies different in study design or type of control groups as in hospital-based case-control studies the choice of controls may affect the representativeness of exposure.[115, 123] In addition, characteristics of hospital catchment area and presence of Berkson's bias, if study exposure is related to the risk of being hospitalized for the control diseases, may jeopardize comparability of studies selected for the analysis even further.[124] Socioeconomic inequalities may influence all above mentioned conditions and, thus, be one of the reasons for type of controls to be a source of heterogeneity. For income-based SEP overall results for studies published before 2000 yielded highly significant association with the outcome along with no heterogeneity between studies, though in multivariable meta-regression the publication year was not recognised as a potential source for heterogeneity. We must, however, acknowledge that in meta-analysis of observational studies the results of multivariable meta-regression can also be confounded by unidentified study-level factors.[41]

Publication bias is a concern in meta-analysis since it might lead to overestimation of the relative risk. Since our meta-analysis was restricted to English-speaking peer reviewed publications, our estimates may have been affected by missing data from the studies performed in the low-or middle-income countries where SEP may be differently associated with AMI. It may explain the presences of publication bias detected in our analysis for combined estimates for studies on income-based SEP. In our study, publication bias may be partially explained by variability in outcome definitions and SEP measures or if studies with relatively smaller sample size and inconsistent results were lacking in the analysis representing significance bias, size bias and suppression publication bias.[119]

Our selection criteria, particularly with respect to study definition, were rather tight that resulted in a limited number of studies. We acknowledge the fact that numerous studies potentially relevant for the analysis were, however, excluded if AMI was reported as a study endpoint in combination with chronic heart diseases. In order to control highly heterogeneous outcome and being mostly interested in social pattering of first acute coronary event, we deliberately narrowed the analysis to AMI only.

Another restraint deals with the variety of confounders and/or mediators across the original studies. It might mainly be crucial for the pooled results if the adjustment strategy differs between the studies with respect to risk factors for myocardial infarction. The complicated interplay between socioeconomic factors and risk factors for cardiovascular diseases must be acknowledged while interpreting the results of meta-analysis. It is well-known that standard risk factors explain more than half of association between SEP and CHD mortality and morbidity and there is a pronounced socioeconomic gradient in CHD-related behavioural and lifestyle factors.[125-128] Therefore, the choice of variables in the original study to adjust for can influence the pooled results. Adjustment for risk factors acting as

intermediate steps in the causal pathways will result in underestimation of the relation between SEP and the disease, while relation will be overstated if genuine confounders left unadjusted. Evidence from the recent studies and reviews indicate that different SEP measures can simultaneously be included in the multivariable models as they do not act as proxy for each other,[117, 118, 129-131] while biological, behavioural and psychological factors can mediate an association between SEP and AMI.[126-128, 131] To reduce the influence of various adjustment we, therefore, performed separate subanalyses for studies minimally-and maximally-adjusted that in our analysis yielded the similar results.

Our findings presented the overall increase in risk of AMI incidence among the lowest SEP that has previously been reported for AMI mortality and CHD morbidity.[13, 16] The aforementioned results corroborated the strong evidence of the relation between socioeconomic deprivation and incidence of acute ischemic events. Further research providing validated information is required to address public health strategies to reduce the risk of AMI among the most vulnerable groups in different countries and among different societies. It is imperative to emphasise the importance of such studies, particularly for the regions with lower level of economic development, where the epidemic of CHD is becoming a public health issue.

Source of financial support: Meta-analysis was supported by grant from the Swedish Council for Working Life and Social Research [FAS, 2006-0230 to Tahereh Moradi]. The study founder had no role in the design, collection, analysis, or interpretation of the data, or in the writing or decision to submit the manuscript.

Competing of interest: None declared.

What is already known?
Adverse socioeconomic position is related to coronary heart disease mortality and survival.
What does this study add?
This meta-analysis reveals an association between low socioeconomic position (SEP) and increased incidence of acute myocardial infarction (AMI). The associations were consistent for both men and women. People from the lowest strata of income-based SEP have a 71% greater risk to develop myocardial infarction compared to those in the highest strata. An increased risk in AMI incidence of 34% and 35% was found for the lowest compared to the highest categories of educational and occupational SEP, respectively. The socioeconomic patterns in myocardial infarction incidence were seen to be most pronounced for high-income countries. The nature of social stratification at the level of economic development of a country could be involved in the differences of risk of AMI between social groups.

Policy Implications
Public health policies aiming at reducing the risk of AMI should address socioeconomic position both in the promotion and the evaluation of preventive measures. The potential for variation in the strength of AMI inequalities between different societies should be acknowledged by national and international policy makers.

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REFERENCES

1. Thygesen, K, Alpert JS, White HD. Universal definition of myocardial infarction. *J Am Coll Cardiol* 2007;50(22):2173-95.
2. Murray C, Lopez A. Alternative vision of the future: Projecting Mortality and Disability, 1990-2020. In: Murray C, Lopez A, eds. The global burden of disease: a comprehensive assessment of mortality and disability from disease, injuries and risk factors in 1990 and projected to 2020. Cambridge, Mass:Harvard School of Public Health 1996:325-95.
3. Okrainec K, Banerjee DK, Eisenberg MJ. Coronary artery disease in the developing world. *Am Heart J* 2004;148(1):7-15.
4. Pais PS. Early intervention and prevention of myocardial infarction. *J Hypertens Suppl* 2006;24(2):S25-30.
5. Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. *PLoS Med* 2006;**3**(11):e442.
6. Hoit BD, Giplin EA, Henning H, et al. Myocardial infarction in young patients: an analysis by age subsets. *Circulation* 1986;**74**(4):712-21.
7. Levenson JW, Skerrett PJ, Gaziano JM. Reducing the global burden of cardiovascular disease: the role of risk factors. *Prev Cardiol* 2002;5(4):188-99.
8. Tyroler HA. The influence of socioeconomic factors on cardiovascular disease risk factor development. *Prev Med* 1999;29(6 Pt 2):S36-40.
9. Lynch J, Davey Smith G, Harper S. Explaining the social gradient in coronary heart disease: comparing relative and absolute risk approaches. *J Epidemiol Community Health* 2006;60(5):436-41.

10. Kaplan GA, Keil JE. Socioeconomic factors and cardiovascular disease: a review of the literature. *Circulation* 1993;88(4 Pt 1):1973-98.

11. Ruberman W, Weinblatt E, Goldberg JD, et al. Psychosocial influences on mortality after myocardial infarction. *N Engl J Med* 1984;311(9):552-9.

12. Krantz DS, McCeney MK. Effects of psychological and social factors on organic disease: a critical assessment of research on coronary heart disease. *Annu Rev Psychol* 2002;53:341-69.

13. Gonzalez MA, Rodriguez Artalejo F, Calero JR. Relationship between socioeconomic status and ischaemic heart disease in cohort and case-control studies: 1960-1993. *Int J Epidemiol* 1998;27(3):350-8.

14. Brezinka V, Kittel F. Psychosocial factors of coronary heart disease in women: a review. *Soc Sci Med* 1996;42(10):1351-65.

15. Strike PC, Steptoe A. Psychosocial factors in the development of coronary artery disease. *Prog Cardiovasc Dis* 2004;46(4):337-47.

16. Alboni P, Amadei A, Scarfo S, et al. In industrialized nations, a low socioeconomic status represents an independent predictor of mortality in patients with acute myocardial infarction. *Ital Heart J* 2003;4(8):551-8.

17. Devesa SS, Diamond EL. Socioeconomic and racial differences in lung cancer incidence. *Am J Epidemiol* 1983:118(6):818-31.

18. Geyer S, Hemstrom O, Peter P, et al. Education, income, and occupational class cannot be used interchangeably in social epidemiology. Empirical evidence against a common practice. *J Epidemiol Community Health* 2006;60(9):804-10.

19. Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. JAMA 2000;283(15):2008-12.

20. Zwahlen M, Renehan A, Egger M. Meta-analysis in medical research: potentials and limitations. *Urol Oncol* 2008;26(3):320-9.
21. Bosma H, Van Jaarsveld CHM, Tuinstra J, et al. Low control beliefs, classical coronary risk factors, and socio-economic differences in heart disease in older persons. *Soc Sci Med* 2005;60(4):737-45.
22. Pell J, Pell A, Morrison C, et al. Retrospective study of influence of deprivation on uptake of cardiac rehabilitation. *BMJ* 1996;313(7052):267-8.
23. Kontogianni MD, Panagiotakos DB, Chrysohoou C, et al. The impact of olive oil consumption pattern on the risk of acute coronary syndromes: The CARDIO2000 case-control study. *Clin Cardiol* 2007;30(3):125-9.
24. Ahlbom A, Feychting M, Gustavsson A, et al. Occupational magnetic field exposure and myocardial infarction incidence. *Epidemiology* 2004;15(4):403-8.
25. Falger PR, Schouten EG. Exhaustion, psychological stressors in the work environment, and acute myocardial infarction in adult men. *J Psychosom Res* 1992;36(8):777-86.
26. Hallqvist J, Lynch J, Bartley M, et al. Can we disentangle life course processes of accumulation, critical period and social mobility? An analysis of disadvantaged socio-economic positions and myocardial infarction in the Stockholm Heart Epidemiology Program. *Soc Sci Med* 2004;58(8):1555-62.
27. Mattila KJ, Nieminen MS, Valtonen VV, et al. Association between dental health and acute myocardial infarction. BMJ 1989;298(6676):779-81.
28. Pais P, Pogue J, Gerstein H, et al. Risk factors for acute myocardial infarction in Indians: a case-control study. *Lancet* 1996;348(9024):358-63.

29. Vogels EA, Lagro-Janssen AL, van Weel C. Sex differences in cardiovascular disease: are women with low socioeconomic status at high risk? *Br J Gen Pract* 1999;49(449):963-6.
30. Greenland S. Quantitative methods in the review of epidemiologic literature. *Epidemiol Rev* 1987;9:1-30.
31. DerSimonian R, Laird N. Meta-analysis in clinical trials. *Control Clin Trials* 1986;7(3):177-88.
32. Baigi A, Holmen A, Hogstedt B, et al. Birthplace and social characteristics as risk factors for acute myocardial infarction in the province of Halland, Sweden. *Public Health* 2002;116(5):279-84.
33. Ciruzzi M, Pramparo P, Rozosnik J, et al. Diabetes and risk of acute myocardial infarction. *CVD Prevention* 2000;3(1):40-6.
34. Diez Roux, AV, Stein Merkin S, Arnett D, et al. Neighborhood of residence and incidence of coronary heart disease. *N Engl J Med* 2001;345(2):99-106.
35. Ljung R, Hallqvist J. Accumulation of adverse socioeconomic position over the entire life course and the risk of myocardial infarction among men and women: results from the Stockholm Heart Epidemiology Program (SHEEP). *J Epidemiol Community Health* 2006;60(12):1080-4.
36. Rayce SL, Christensen U, Hougaard C, et al. Economic consequences of incident disease: the effect on loss of annual income. *Scand J Public Health* 2008;36(3):258-64.
37. Salomaa V, Niemela M, Miettinen H, et al. Relationship of socioeconomic status to the incidence and prehospital, 28-day, and 1-year mortality rates of acute coronary events in the FINMONICA myocardial infarction register study. *Circulation* 2000;101(16):1913-8.

38. Wolfe F, Michaud K. The risk of myocardial infarction and pharmacologic and nonpharmacologic myocardial infarction predictors in rheumatoid arthritis: A cohort and nested case-control analysis. *Arthritis and Rheumatism* 2008;58(9):2612-21.
39. Cochran WG. The combination of estimates from different experiments. *Biometrics* 1954;8:101-29.
40. Higgins JP, Thompson SG, Deeks JJ, et al. Measuring inconsistency in meta-analyses. BMJ 2003;327(7414):557-60.
41. Baker WL, Michel White C, Cappelleri JC, et al. Understanding heterogeneity in meta-analysis: the role of meta-regression. *Int J Clin Pract* 2009;63(10):1426-34.
42. Thompson SG, Sharp SJ. Explaining heterogeneity in meta-analysis: a comparison of methods. *Stat Med* 1999;18(20): 2693-708.
43. van Houwelingen HC, Arends LR, Stijnen T. Advanced methods in meta-analysis: multivariate approach and meta-regression. *Stat Med* 2002;21(4):589-624.
44. Tobias A. Assessing the influence of a single study in meta-analysis. *Stata Tech Bull* 1999;47:15-7.
45. Begg CB, MazumdarM. Operating characteristics of a rank correlation test for publication bias. *Biometrics* 1994;50(4):1088-101.
46. Egger M, Davey Smith G, Schneider M, et al. Bias in meta-analysis detected by a simple, graphical test. *BMJ* 1997;315(7109):629-34.
47. Moher D, Cook DJ, Eastwood S, et al. Improving the quality of reports of meta-analyses of randomised controlled trials: the QUOROM statement. Quality of Reporting of Meta-analyses. *Lancet* 1999;354(9193):1896-900.
48. Andersen I, Burr H, Kristensen TS, et al. Do factors in the psychosocial work environment mediate the effect of socioeconomic position on the risk of myocardial

infarction? Study from the Copenhagen Centre for Prospective Population Studies. *Occup Environ Med* 2004;61(11):886-92.

49. Appels A, Falger PR, Schouten EG Vital exhaustion as risk indicator for myocardial infarction in women. *J Psychosom Res* 1993;37(8):881-90.

50. Bobak M, Hertzman C, Skodova Z, et al. Association between psychosocial factors at work and nonfatal myocardial infarction in a population-based case-control study in Czech men. *Epidemiology* 1998;9(1):43-7.

51. Chang CL, Marmot M, Fareley T, et al. The influence of economic development on the association between education and the risk of acute myocardial infarction and stroke. *J Clin Epidemiol* 2002;55(8):741-7.

52. Ciruzzi M, Pramparo P, Esteban O, et al. Case-control study of passive smoking at home and risk of acute myocardial infarction. *J Am Coll Cardiol* 1998;31(4):797-803.

53. Ciruzzi M, Pramparo P, Rozlosnik J, et al. Hypertension and the risk of acute myocardial infarction in Argentina. *Prev Cardiol* 2001;4(2):57-64.

54. Ciruzzi M, Schargorodsky H, Rozlosnik J, et al. Frequency of family history of acute myocardial infarction in patients with acute myocardial infarction. *Am J Cardiol* 1997;80(2):122-7.

55. Gustavsson P, Plato N, Hallquist J, et al. A population-based case-referent study of myocardial infarction and occupational exposure to motor exhaust, other combustion products, organic solvents, lead, and dynamite. *Epidemiology* 2001;12(2):222-8.

56. Hallqvist J, Moller J, Ahlbom A, et al. Does heavy physical exertion trigger myocardial infarction? A case-crossover analysis nested in a population-based case-referent study. *Am J Epidemiol* 2000;151(5):459-67.

57. Nyboe J, Jensen G, Appleyard M, et al. Risk factors for acute myocardial infarction in Copenhagen. I: Hereditary, educational and socioeconomic factors. Copenhagen City Heart Study. *Eur Heart J* 1989;10(10):910-6.

58. Panagiotakos DB, Pitsavos C, Chrysohoou C, et al. Risk stratification of coronary heart disease in Greece: final results from the CARDIO2000 Epidemiological Study. *Prev Med* 2002;35(6):548-56.

59. Peter R, Gassler H, Geyer S. Socioeconomic status, status inconsistency and risk of ischaemic heart disease: a prospective study among members of a statutory health insurance company. *J Epidemiol Community Health* 2007;61(7):605-11.

60. Rosengren A, Wedel H, Wilhelmsen L. Coronary heart disease and mortality in middle aged men from different occupational classes in Sweden. *BMJ* 1988;297(6662):1497-500.

61. Rosenlund M, Berglind N, Gustavsson A, et al. Environmental tobacco smoke and myocardial infarction among never-smokers in the Stockholm Heart Epidemiology Program (SHEEP). *Epidemiology* 2001;12(5):558-64.

62. Van Lenthe FJ, Gevers E, Joung I, et al. Material and behavioral factors in the explanation of educational differences in incidence of acute myocardial infarction: the Globe study. *Ann Epidemiol* 2002;12(8):535-42.

63. Weinehall L, Johnson O, Jahsson J-H, et al. Perceived health modifies the effect of biomedical risk factors in the prediction of acute myocardial infarction. An incident case-control study from northern Sweden. *J Intern Med* 1998;243(2):99-107.

64. Andersen I, Gamborg M, Osler M, et al. Income as mediator of the effect of occupation on the risk of myocardial infarction: does the income measurement matter? *J Epidemiol Community Health* 2005;59(12):1080-5.

584 65. Bobak M, Hertzman C, Marmot M. Own education, current conditions, parental
585 material circumstances, and risk of myocardial infarction in a former communist
586 country. *J Epidemiol Community Health* 2000;54(2):91-6.
587 66. Chang CL, Shipley MJ, Marmot MG, et al. Can cardiovascular risk factors explain the
588 association between education and cardiovascular disease in young women? *J Clin*
589 *Epidemiol* 2002;55(8):749-55.
590 67. Collijn DH, Appels A, Nijhuis F. Psychosocial risk factors for cardiovascular disease
591 in women: the role of social support. *Int J Behav Med* 1995;2(3):219-32.
592 68. Hippe M, Vestbo J, Hein HO, et al. Familial predisposition and susceptibility to the
593 effect of other risk factors for myocardial infarction. *J Epidemiol Community Health*
594 1999;53(5):269-76.
595 69. Huisman M, Van Lenthe F, Avendano M, et al. The contribution of job characteristics
596 to socioeconomic inequalities in incidence of myocardial infarction. *Soc Sci Med*
597 2008;66(11):2240-52.
598 70. Schaufelberger M, Rosengren A. Heart failure in different occupational classes in
599 Sweden. *Eur Heart J* 2007;28(2):212-8.
600 71. Wennberg P, Lindahl B, Hallmans G, et al. The effects of commuting activity and
601 occupational and leisure time physical activity on risk of myocardial infarction. *Eur J*
602 *Cardiovasc Prev Rehabil* 2006;13(6):924-30.
603 72. Eaker ED, Pinsky J, Castelli WP. Myocardial infarction and coronary death among
604 women: psychosocial predictors from a 20-year follow-up of women in the
605 Framingham Study. *Am J Epidemiol* 1992;135(8):854-64.
606 73. Qureshi AI, Suri M, Saad M, et al. Educational attainment and risk of stroke and
607 myocardial infarction. *Med Sci Monit*, 2003;9(11):CR466-73.

74. Bosma H, Appels A, Sturmans F, et al. Educational level of spouses and risk of mortality: the WHO Kaunas-Rotterdam Intervention Study (KRIS). *Int J Epidemiol* 1995;24(1):119-26.
75. Alfredsson L, Karasek R, Theorell T. Myocardial infarction risk and psychosocial work environment: an analysis of the male Swedish working force. *Soc Sci Med* 1982;16(4):463-7.
76. Altieri A, Tavani A, Gallus S, et al. Occupational and leisure time physical activity and the risk of nonfatal acute myocardial infarction in Italy. *Ann Epidemiol* 2004;14(7):461-66.
77. Burr ML, Sweetnam PM. Family size and paternal unemployment in relation to myocardial infarction. *J Epidemiol Community Health* 1980;34(2):93-5.
78. Danesh J, Youngman L, Clark S, et al. Helicobacter pylori infection and early onset myocardial infarction: case-control and sibling pairs study. *BMJ* 1999;319(7218):1157-62.
79. Hebert PR, Buring JE; O'Connor GT, et al. Occupation and risk of nonfatal myocardial infarction. *Arch Intern Med* 1992;152(11):2253-7.
80. Ising H, Babisch W, Gunther T. Work noise as a risk factor in myocardial infarction. *J Clin Basic Cardiol* 1999;2(1):64-8.
81. Ismail J, Jafar TH, Jafary FH, et al. Risk factors for non-fatal myocardial infarction in young South Asian adults. *Heart* 2004;90(3):259-63.
82. Janszky I, Ahlbom A, Hallquist J, et al. Hospitalization for depression is associated with an increased risk for myocardial infarction not explained by lifestyle, lipids, coagulation, and inflammation: the SHEEP Study. *Biol Psychiatry* 2007;62(1):25-32.

631 83. Kabagambe EK, Baylin A, Ruiz-Navares E, et al. Decreased consumption of dried
632 mature beans is positively associated with urbanization and nonfatal acute myocardial
633 infarction. *J Nutr* 2005;135(7):1770-5.
634 84. Kono S, Handa K, Kawano T, et al. Alcohol intake and nonfatal acute myocardial
635 infarction in Japan. *Am J Cardiol* 1991;68(10):1011-4.
636 85. Lind E, Theorell T. Sociological characteristics and myocardial infarctions. *J*
637 *Psychosom Res* 1973;17(1):59-73.
638 86. Lovasi GS, Vernez Moudon A, Smith NL, et al. Evaluating options for measurement
639 of neighborhood socioeconomic context: evidence from a myocardial infarction case-
640 control study. *Health Place* 2008;14(3):453-67.
641 87. Malinauskiene V, Grazuleviciene R, Azaraviciene A. Socioeconomic differences in
642 myocardial infarction risk among 35-64 year old women in Kaunas, Lithuania. *Przegl*
643 *Lek* 2003;60 Suppl 6:86-8.
644 88. Malinauskiene V, Grazuleviciene R, Nieuwenhuijsen MJ, et al. Myocardial infarction
645 risk and occupational categories in Kaunas 25-64 year old men. *Occup Environ Med*
646 2002;59(11):745-50.
647 89. Malinauskiene V, Theorell T, Grazuleviciene R, et al. Low job control and
648 myocardial infarction risk in the occupational categories of Kaunas men, Lithuania. *J*
649 *Epidemiol Community Health* 2004;58(2):131-5.
650 90. Martinez-Gonzalez MA, Fernandez-Jarne E, Serrano-Martinez M, et al.
651 Mediterranean diet and reduction in the risk of a first acute myocardial infarction: an
652 operational healthy dietary score. *Eur J Nutr* 2002;41(4):153-60.
653 91. Netterstrom B, Nielsen FE, Kristensen TS, et al. Relation between job strain and
654 myocardial infarction: a case-control study. *Occup Environ Med* 1999;56(5):339-42.

92. Ostlin P, Klerdal K, Hammar N. Time trends in incidence of myocardial infarction in male and female dominated occupations in Stockholm, Sweden. *Scand J Public Health* 2008;36(5):546-54.
93. Patil SS, Joshi R, Gupta G, et al. Risk factors for acute myocardial infarction in a rural population of central India: a hospital-based case-control study. *Natl Med J India* 2004;17(4):189-94.
94. Piegas LS, Avezum A, Pereira JCR, et al. Risk factors for myocardial infarction in Brazil. *Am Heart J* 2003;146(2):331-8.
95. Rosenlund M, Bellander T, Nordquist T, et al. Traffic-generated air pollution and myocardial infarction. *Epidemiology* 2009;20(2):265-71.
96. Sarraf-Zadegan N, Amiri M, Maghsoudloo S. Helicobacter pylori relation to acute myocardial infarction in an Iranian sample. *Coronary Health Care* 2001;5(4):202-7.
97. Wardwell WI, Hyman M, Bahnson CB. Socio-environmental antecedents to coronary heart disease in 87 white males. *Soc Sci Med* 1968;2(2):165-83.
98. Wielgosz AT, Wielgosz M, Biro E, et al. Risk factors for myocardial infarction: the importance of relaxation. *Br J Med Psychol* 1988;61 (Pt 3):209-17.
99. Vitullo F, Marchioli R, Di Mascio R, et al. Family history and socioeconomic factors as predictors of myocardial infarction, unstable angina and stroke in an Italian population. PROGETTO 3A Investigators. *Eur J Epidemiol* 1996;12(2):177-85.
100. Chaix B, Rosvall M, Merlo J. Neighborhood socioeconomic deprivation and residential instability: effects on incidence of ischemic heart disease and survival after myocardial infarction. *Epidemiology* 2007;18(1):104-11.
101. Croft P, Hannaford PC. Risk factors for acute myocardial infarction in women: evidence from the Royal College of General Practitioners' oral contraception study. BMJ 1989;298(6667):165-8.

102. Engstrom G, Tyden P, Berglund G, et al. Incidence of myocardial infarction in women. A cohort study of risk factors and modifiers of effect. *J Epidemiol Community Health* 2000;54(2):104-7.
103. Hedblad B, Jonsson S, Nilsson P, et al. Obesity and myocardial infarction - Vulnerability related to occupational level and marital status. A 23-year follow-up of an urban male Swedish population. *J Intern Med*, 2002;252(6):542-50.
104. Kuper H, Adami H-O, Theorell T, et al. Psychosocial determinants of coronary heart disease in middle-aged women: a prospective study in Sweden. *Am J Epidemiol* 2006;164(4):349-57.
105. Lang T, Ducimetiere P, Arveiler D, et al. Incidence, case fatality, risk factors of acute coronary heart disease and occupational categories in men aged 30-59 in France. *Int J Epidemiol* 1997;26(1):47-57.
106. Lapidus L, Bengtsson C. Socioeconomic factors and physical activity in relation to cardiovascular disease and death. A 12 year follow up of participants in a population study of women in Gothenburg, Sweden. *Br Heart J* 1986;55(3):295-301.
107. Lynch JW, Kaplan GA, Cohen RD, et al. Do cardiovascular risk factors explain the relation between socioeconomic status, risk of all-cause mortality, cardiovascular mortality, and acute myocardial infarction? *Am J Epidemiol* 1996;144(10):934-42.
108. Marmot MG, Shipley MJ, Hemingway H, et al. Biological and behavioural explanations of social inequalities in coronary heart disease: The Whitehall II study. *Diabetologia* 2008;51(11):1980-88.
109. Orth-Gomer K, RosengrenA, Wilhelmsen L. Lack of social support and incidence of coronary heart disease in middle-aged Swedish men. *Psychosom Med* 1993;55(1):37-43.

110. Rosvall M, Engstrom G, Hedblad B, et al. The role of preclinical atherosclerosis in the explanation of educational differences in incidence of coronary events. *Atherosclerosis* 2006;187(2):251-6.
111. Rosvall M, Gerward S, Engstrom G, et al. Income and short-term case fatality after myocardial infarction in the whole middle-aged population of Malmo, Sweden. *Eur J Public Health* 2008;18(5):533-8.
112. Shekelle RB, Ostfeld AM, Paul O. Social status and incidence of coronary heart disease. *J Chronic Dis* 1969;22(6):381-94.
113. Weikert C, Stefan N, Schulze M, et al. Plasma fetuin-A levels and the risk of myocardial infarction and ischemic stroke. *Circulation* 2008;118(24):2555-62.
114. Wolinsky FD, Wyrwich KW, Jung SC, et al. The risk of hospitalization for acute myocardial infarction among older adults. *J Gerontol A Biol Sci Med Sc*, 1999;54(5):M254-61.
115. Poole C, Greenland S, Luetters C, et al. Socioeconomic status and childhood leukaemia: a review. *Int J Epidemiol* 2006;35(2):370-84.
116. Lahelma E, Martikainen P, Laaksonen M, et al. Pathways between socioeconomic determinants of health. *J Epidemiol Community Health* 2004;58(4):327-32.
117. Braveman PA, Cubbin C, Egerter S, et al. Socioeconomic status in health research: one size does not fit all. JAMA 2005;294(22):2879-88.
118. Shavers VL. Measurement of socioeconomic status in health disparities research. *J Natl Med Assoc* 2007;99(9):1013-23.
119. Greenland S, O'Rourke K. Meta-Analysis. In: Rothman K, ed. Modern Epidemiology. Lippincott Williams and Williams: Philadelphia, PA 2008: 652-83.

120. Oreopoulos A, Padwal R, Norris CM, et al. Effect of obesity on short- and long-term mortality postcoronary revascularization: a meta-analysis. *Obesity (Silver Spring)* 2008;16(2):442-50.
121. Conway DI, Petticrew M, Marlborough H, et al. Socioeconomic inequalities and oral cancer risk: a systematic review and meta-analysis of case-control studies. *Int J Cancer* 2008;122(12):2811-9.
122. Engberg S. Systematic reviews and meta-analysis: studies of studies. *J Wound Ostomy Continence Nurs* 2008;35(3):258-65.
123. Key J, Hodson S, Omar RZ, et al. Meta-analysis of studies of alcohol and breast cancer with consideration of the methodological issues. *Cancer Causes Control* 2006;17(6):759-70.
124. Wacholder S, Silverman DT, McLaughlin JK, et al. Selection of controls in case-control studies. II. Types of controls. *Am J Epidemiol* 1992;135(9):1029-41.
125. Blair AS, Lloyd-Williams F, Mair FS. What do we know about socioeconomic status and congestive heart failure? A review of the literature. *J Fam Pract* 2002;51(2):169.
126. Kilander L, Berglund L, Boberg M, et al. Education, lifestyle factors and mortality from cardiovascular disease and cancer. A 25-year follow-up of Swedish 50-year-old men. *Int J Epidemiol* 2001;30(5):1119-26.
127. Steptoe A, Marmot M. The role of psychobiological pathways in socio-economic inequalities in cardiovascular disease risk. *Eur Heart J* 2002;23(1):13-25.
128. Suadicani P, Hein HO, Gyntelberg F. Strong mediators of social inequalities in risk of ischaemic heart disease: a six-year follow-up in the Copenhagen Male Study. *Int J Epidemiol* 1997;26(3):516-22.
129. Georgiades A, Janszky I, Blom M, et al. Financial strain predicts recurrent events among women with coronary artery disease. *Int J Cardiol* 2008;135:175-83.

130. Pollack CE, Chideya S, Cubbin C, et al. Should health studies measure wealth? A systematic review. *Am J Prev Med* 2007;33(3):250-64.

131. Wilkinson RG, Pickett KE. Income inequality and population health: a review and explanation of the evidence. *Soc Sci Med* 2006;62(7):1768-84.

FIGURE LEGENDS

Figure 1. The QUOROM[a] statement [47] flowchart for study selection.

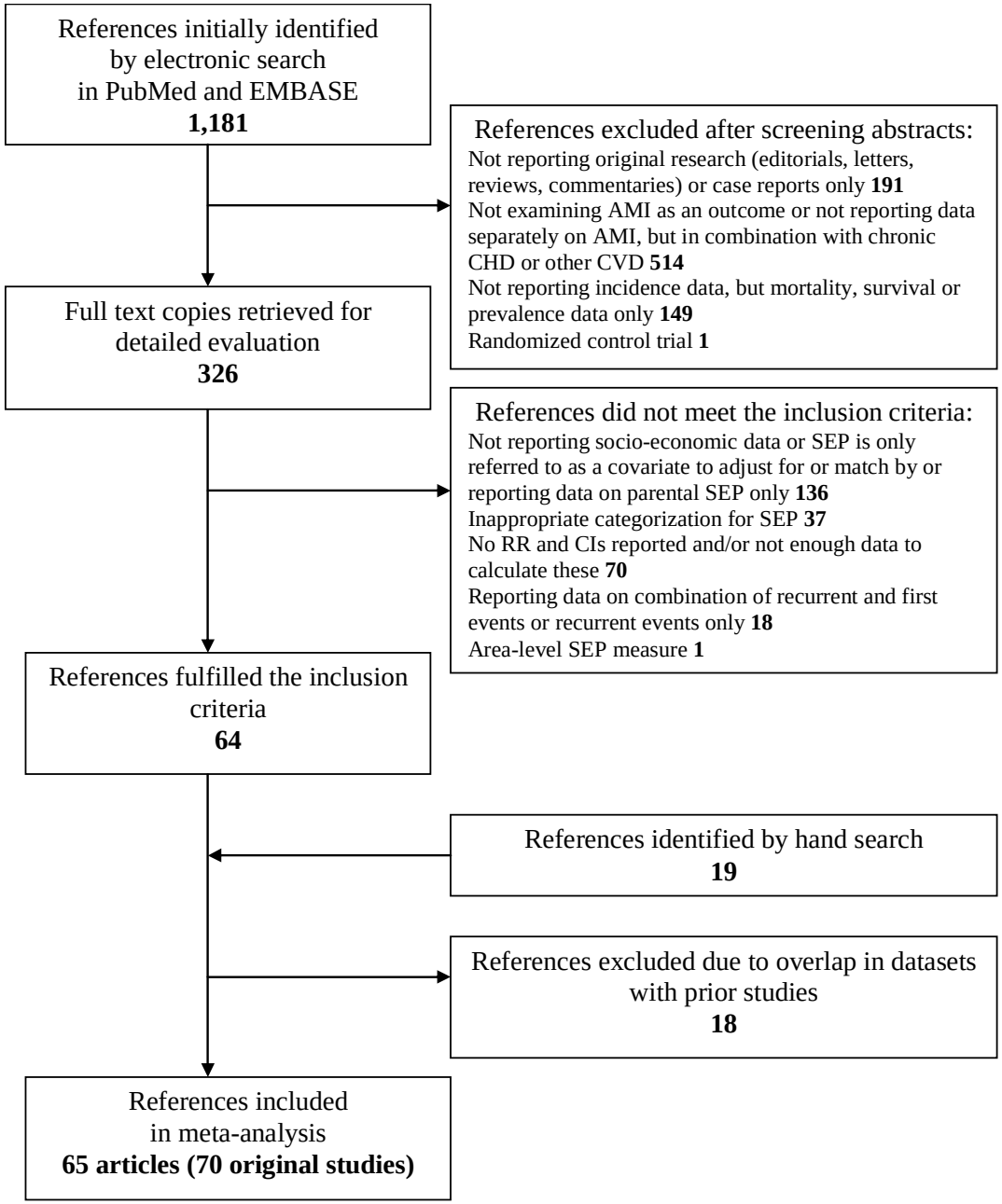
[a] Quality of Reports of Meta-Analyses of Randomised Controlled Trials

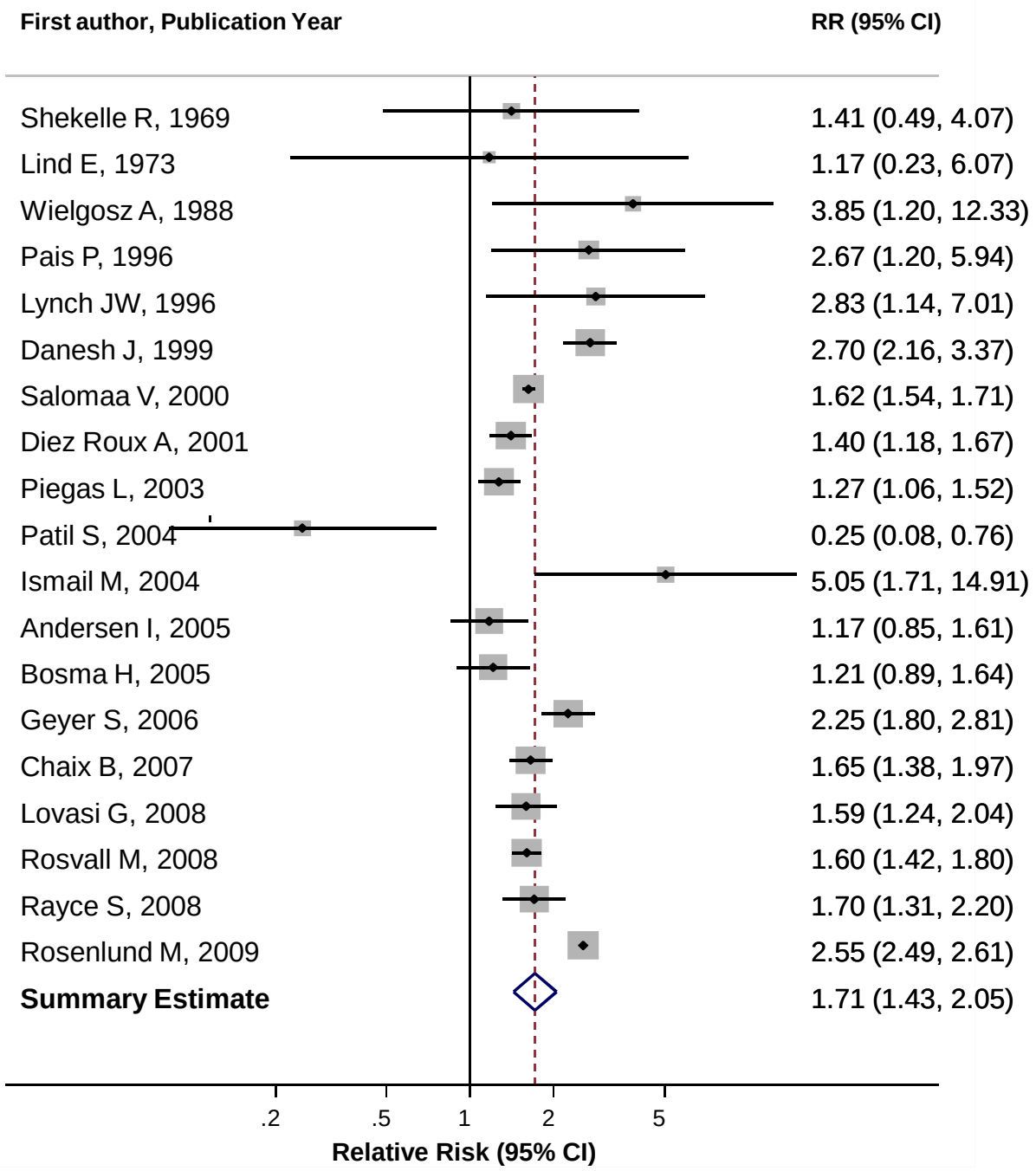
Figure 2. Relative Risk (RR) and 95% confidence intervals (CIs) for acute myocardial infarction incidence and income categories (the lowest vs. the highest socioeconomic position category) in individual studies and for all studies combined. RRs from the individual studies are indicated by squares and the size of the squares represents the statistical weight that each study contributed to the random-effect summary estimate. Horizontal lines indicate the study-specific 95% CIs. Diamond represents the overall summary RR and its 95% CIs.

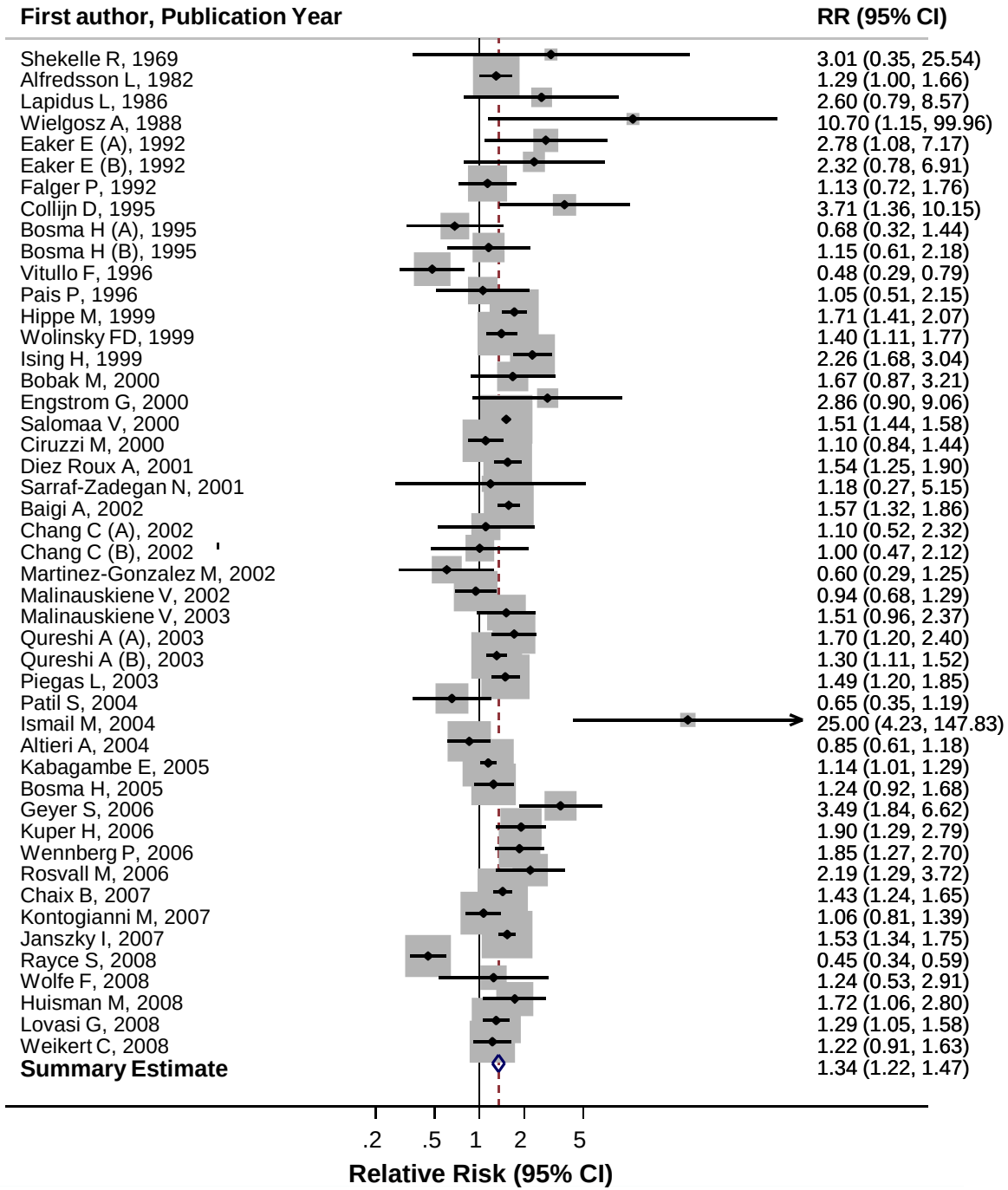
Figure 3. Relative Risk (RR) and 95% confidence intervals (CIs) for acute myocardial infarction incidence and educational attainment (the lowest vs. the highest socioeconomic position category) in individual studies and for all studies combined. RRs from the individual studies are indicated by squares and the size of the squares represents the statistical weight that each study contributed to the random-effect summary estimate. Horizontal lines indicate the study-specific 95% CIs. Diamond represents the overall summary RR and its 95% CIs.

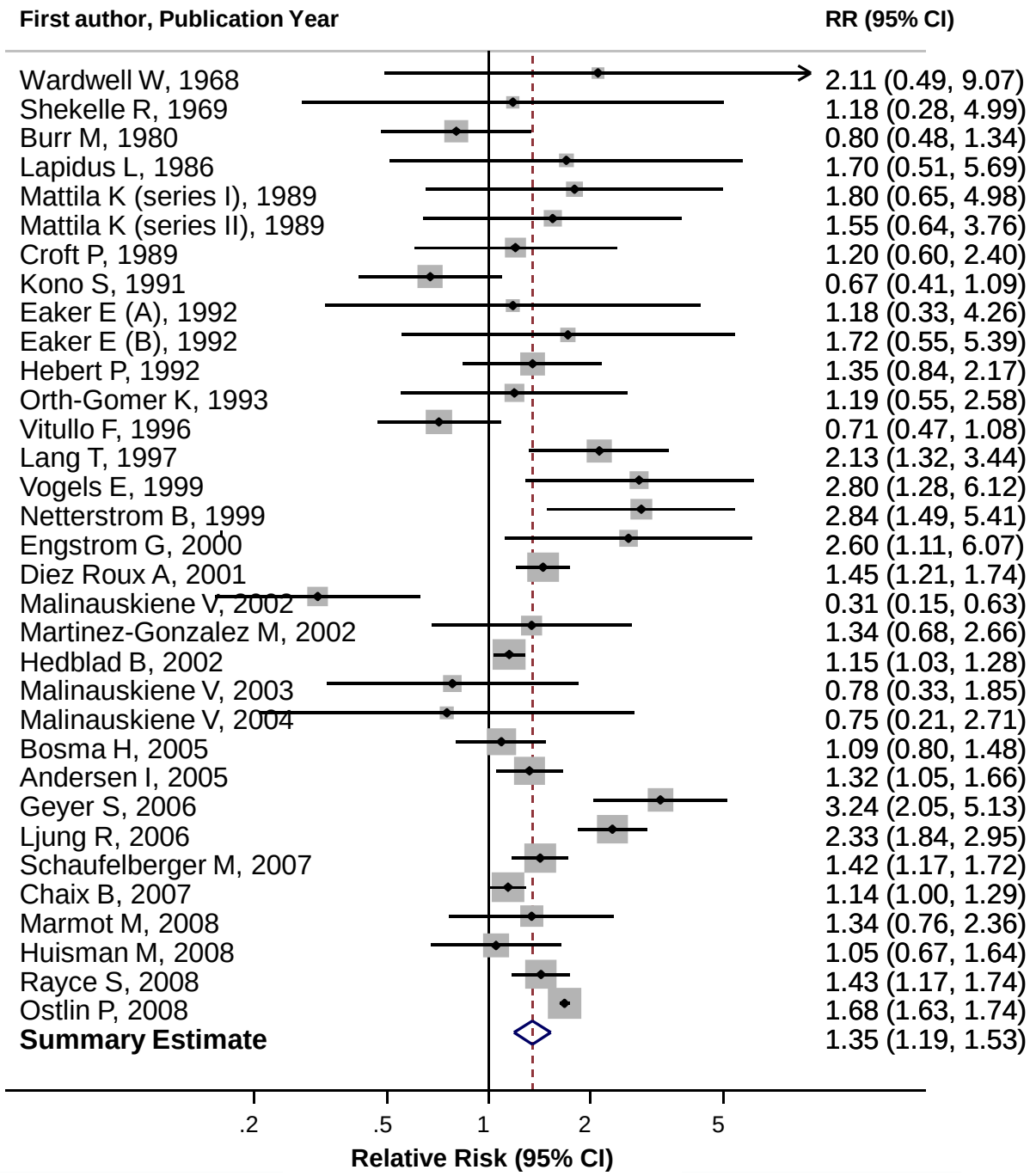
Figure 4. Relative Risk (RR) and 95% confidence intervals (CIs) for acute myocardial infarction incidence and occupational categories (the lowest vs. the highest socioeconomic position category) in individual studies and for all studies combined. RRs from the individual

781 studies are indicated by squares and the size of the squares represents the statistical weight
782 that each study contributed to the random-effect summary estimate. Horizontal lines indicate
783 the study-specific 95% CIs. Diamond represents the overall summary RR and its 95% CIs.


References initially identified by electronic search in PubMed and EMBASE **1,181**
References excluded after screening abstracts:
Not reporting original research (editorials, letters, reviews, commentaries) or case reports only **191**
Not examining AMI as an outcome or not reporting data separately on AMI, but in combination with chronic CHD or other CVD **514**
Not reporting incidence data, but mortality, survival or prevalence data only **149**
Randomized control trial **1**
Full text copies retrieved for detailed evaluation **326**
References did not meet the inclusion criteria:
Not reporting socio-economic data or SEP is only referred to as a covariate to adjust for or match by or reporting data on parental SEP only **136**
Inappropriate categorization for SEP **37**
No RR and CIs reported and/or not enough data to calculate these **70**
Reporting data on combination of recurrent and first events or recurrent events only **18**
Area-level SEP measure **1**
References fulfilled the inclusion criteria **64**
References identified by hand search **19**
References excluded due to overlap in datasets with prior studies **18**
References included in meta-analysis **65 articles (70 original studies)**


First author, Publication Year
RR (95% CI)
Shekelle R, 1969
1.41 (0.49, 4.07)
Lind E, 1973
1.17 (0.23, 6.07)
Wielgosz A, 1988
3.85 (1.20, 12.33)
Pais P, 1996
2.67 (1.20, 5.94)
Lynch JW, 1996
2.83 (1.14, 7.01)
Danesh J, 1999
2.70 (2.16, 3.37)
Salomaa V, 2000
1.62 (1.54, 1.71)
Diez Roux A, 2001
1.40 (1.18, 1.67)
Piegas L, 2003
1.27 (1.06, 1.52)
Patil S, 2004
0.25 (0.08, 0.76)
Ismail M, 2004
5.05 (1.71, 14.91)
Andersen I, 2005
1.17 (0.85, 1.61)
Bosma H, 2005
1.21 (0.89, 1.64)
Geyer S, 2006
2.25 (1.80, 2.81)
Chaix B, 2007
1.65 (1.38, 1.97)
Lovasi G, 2008
1.59 (1.24, 2.04)
Rosvall M, 2008
1.60 (1.42, 1.80)
Rayce S, 2008
1.70 (1.31, 2.20)
Rosenlund M, 2009
2.55 (2.49, 2.61)
Summary Estimate
1.71 (1.43, 2.05)
.2
.5
1
2
5
Relative Risk (95% CI)


First author, Publication Year
RR (95% CI)
Shekelle R, 1969
3.01 (0.35, 25.54)
Alfredsson L, 1982
1.29 (1.00, 1.66)
Lapidus L, 1986
2.60 (0.79, 8.57)
Wielgosz A, 1988
10.70 (1.15, 99.96)
Eaker E (A), 1992
2.78 (1.08, 7.17)
Eaker E (B), 1992
2.32 (0.78, 6.91)
Falger P, 1992
1.13 (0.72, 1.76)
Collijn D, 1995
3.71 (1.36, 10.15)
Bosma H (A), 1995
0.68 (0.32, 1.44)
Bosma H (B), 1995
1.15 (0.61, 2.18)
Vitullo F, 1996
0.48 (0.29, 0.79)
Pais P, 1996
1.05 (0.51, 2.15)
Hippe M, 1999
1.71 (1.41, 2.07)
Wolinsky FD, 1999
1.40 (1.11, 1.77)
Ising H, 1999
2.26 (1.68, 3.04)
Bobak M, 2000
1.67 (0.87, 3.21)
Engstrom G, 2000
2.86 (0.90, 9.06)
Salomaa V, 2000
1.51 (1.44, 1.58)
Ciruzzi M, 2000
1.10 (0.84, 1.44)
Diez Roux A, 2001
1.54 (1.25, 1.90)
Sarraf-Zadegan N, 2001
1.18 (0.27, 5.15)
Baigi A, 2002
1.57 (1.32, 1.86)
Chang C (A), 2002
1.10 (0.52, 2.32)
Chang C (B), 2002
1.00 (0.47, 2.12)
Martinez-Gonzalez M, 2002
0.60 (0.29, 1.25)
Malinauskiene V, 2002
0.94 (0.68, 1.29)
Malinauskiene V, 2003
1.51 (0.96, 2.37)
Qureshi A (A), 2003
1.70 (1.20, 2.40)
Qureshi A (B), 2003
1.30 (1.11, 1.52)
Piegas L, 2003
1.49 (1.20, 1.85)
Patil S, 2004
0.65 (0.35, 1.19)
Ismail M, 2004
25.00 (4.23, 147.83)
Altieri A, 2004
0.85 (0.61, 1.18)
Kabagambe E, 2005
1.14 (1.01, 1.29)
Bosma H, 2005
1.24 (0.92, 1.68)
Geyer S, 2006
3.49 (1.84, 6.62)
Kuper H, 2006
1.90 (1.29, 2.79)
Wennberg P, 2006
1.85 (1.27, 2.70)
Rosvall M, 2006
2.19 (1.29, 3.72)
Chaix B, 2007
1.43 (1.24, 1.65)
Kontogianni M, 2007
1.06 (0.81, 1.39)
Janszky I, 2007
1.53 (1.34, 1.75)
Rayce S, 2008
0.45 (0.34, 0.59)
Wolfe F, 2008
1.24 (0.53, 2.91)
Huisman M, 2008
1.72 (1.06, 2.80)
Lovasi G, 2008
1.29 (1.05, 1.58)
Weikert C, 2008
1.22 (0.91, 1.63)
Summary Estimate
1.34 (1.22, 1.47)
.2
.5
1
2
5
Relative Risk (95% CI)


First author, Publication Year
RR (95% CI)
Wardwell W, 1968
2.11 (0.49, 9.07)
Shekelle R, 1969
1.18 (0.28, 4.99)
Burr M, 1980
0.80 (0.48, 1.34)
Lapidus L, 1986
1.70 (0.51, 5.69)
Mattila K (series I), 1989
1.80 (0.65, 4.98)
Mattila K (series II), 1989
1.55 (0.64, 3.76)
Croft P, 1989
1.20 (0.60, 2.40)
Kono S, 1991
0.67 (0.41, 1.09)
Eaker E (A), 1992
1.18 (0.33, 4.26)
Eaker E (B), 1992
1.72 (0.55, 5.39)
Hebert P, 1992
1.35 (0.84, 2.17)
Orth-Gomer K, 1993
1.19 (0.55, 2.58)
Vitullo F, 1996
0.71 (0.47, 1.08)
Lang T, 1997
2.13 (1.32, 3.44)
Vogels E, 1999
2.80 (1.28, 6.12)
Netterstrom B, 1999
2.84 (1.49, 5.41)
Engstrom G, 2000
2.60 (1.11, 6.07)
Diez Roux A, 2001
1.45 (1.21, 1.74)
Malinauskiene V, 2002
0.31 (0.15, 0.63)
Martinez-Gonzalez M, 2002
1.34 (0.68, 2.66)
Hedblad B, 2002
1.15 (1.03, 1.28)
Malinauskiene V, 2003
0.78 (0.33, 1.85)
Malinauskiene V, 2004
0.75 (0.21, 2.71)
Bosma H, 2005
1.09 (0.80, 1.48)
Andersen I, 2005
1.32 (1.05, 1.66)
Geyer S, 2006
3.24 (2.05, 5.13)
Ljung R, 2006
2.33 (1.84, 2.95)
Schaufelberger M, 2007
1.42 (1.17, 1.72)
Chaix B, 2007
1.14 (1.00, 1.29)
Marmot M, 2008
1.34 (0.76, 2.36)
Huisman M, 2008
1.05 (0.67, 1.64)
Rayce S, 2008
1.43 (1.17, 1.74)
Ostlin P, 2008
1.68 (1.63, 1.74)
Summary Estimate
1.35 (1.19, 1.53)
.2
.5
1
2
5
Relative Risk (95% CI)