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Systematic Review/Meta-analysis

Socioeconomic Status, Mortality, and Access to Cardiac Services After Acute Myocardial Infarction in Canada: A Systematic Review and Meta-analysis

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ABSTRACT

Background: Low socioeconomic status (SES) is an important prognosticator for those with acute myocardial infarction (AMI), having previously been described to be associated with increased short-term mortality. Whether this effect persists over time, and whether access to cardiac interventions is equitable within Canada's universal health care system, remains unknown.

Methods: We conducted a systematic review to determine the associations of SES with mortality and access to a spectrum of interventions including cardiac catheterization, revascularization, and cardiac rehabilitation. Electronic databases (EMBASE and MEDLINE) were searched in March 2019 and December 2019. Original studies

RÉSUMÉ

Contexte : Le statut socio-économique (SSE) inférieur est un facteur pronostique important chez les personnes ayant subi un infarctus aigu du myocarde (IAM) qui semble être associé à un risque accru de mortalité à court terme. On ignore si cet effet persiste avec le temps et si l'accès aux interventions cardiaques est équitable au sein du système de soins de santé universel canadien.

Méthodologie : Nous avons réalisé une revue systématique afin de caractériser les associations entre le SSE et la mortalité et l'accès à une gamme d'interventions, y compris le cathétérisme, la revascularisation et la réadaptation cardiaque. Les recherches ont été effectuées dans les bases de données électroniques EMBASE et MEDLINE en mars 2019 et

Cardiovascular disease (CVD) is the leading cause of death worldwide, claiming the lives of 17.9 million people each year—a staggering 31% of global deaths.[1] In 2011, the World Health Organization identified a target of reducing noncommunicable diseases, including CVD, by 25% by 2025.[2] Prior studies have suggested that addressing socioeconomic inequities may be a powerful way by which to reduce the burden of global CVD.[3] Those with lower socioeconomic status (SES) not only bear a greater burden of CVD, but also have disproportionately worse outcomes.[4] For those presenting with acute coronary syndrome, low SES is associated with increased short-term mortality from CVD.[5-7] Data suggest that this increased risk of death persists months to years after the cardiac event, although the evidence is less clear.[8-11]

There is a chain of events that likely leads to such disparities in outcomes. At a patient level, those with lower SES tend to have different atherogenic profiles, with more cardiac risk factors and more severe disease at the time of presentation.[8,10,12] At the care-delivery level, the advent of invasive catheterization and the incorporation of cardiac rehabilitation into standard post–myocardial infarction care has revolutionized cardiovascular health, leading to significant improvements in mortality and quality of life.[4,13-15] However, whether patients across the SES spectrum have equal opportunity to access these therapies remains unclear,[10,16] despite 2 prior systematic reviews on this topic.[17,18] Quatromoni et al. synthesized studies from the United Kingdom and the United States, noting that low-SES patients had reduced rates of coronary revascularization in both countries.[17] Schroder et al., however, noted more variability in the literature.[18] Although they too noted that patients with low SES tended to have lower rates of coronary revascularization, they also found that "the relationship was not consistent for all coronary procedures," with some studies reporting no association between SES and coronary artery bypass grafting.[18] In contrast to the Quatromoni et al.[17] review, they also noted that "access to

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from Canada examining associations between SES and any of the above outcomes in AMI patients were included. Meta-analyses were conducted using random effects models.

Results: Nineteen studies were included, 11 of which could be meta-analyzed. Low SES was associated with a 48% and 34% increase in short-term and intermediate-term mortality, respectively. There was a trend toward increased long-term mortality more than 1-year post-event (pooled odds ratio [OR] 1.34 [95% confidence interval {CI} 0.95-1.88]). Low SES was also associated with lower rates of cardiac catheterization (pooled OR 0.80 [95% CI 0.65-0.99]) and revascularization (pooled OR 0.76 [95% CI 0.63-0.90]) post-AMI. Studies on cardiac rehabilitation showed reduced access and participation in low-SES groups.

Conclusions: Low SES is associated with not only increased mortality post-AMI, but also reduced access to cardiac interventions that have demonstrated benefits for mortality and morbidity. Interventions that improve access to catheterization, revascularization, and cardiac rehabilitation for low-SES populations are needed if true equitable care in Canada is desired.

en décembre 2019. Certaines études originales réalisées au Canada sur les associations entre le SSE et l'un ou l'autre des résultats ci-haut chez des patients ayant subi un IAM ont été incluses. Des méta-analyses à partir de modèles à effets aléatoires ont été réalisées.

Résultats : Dix-neuf études ont été incluses, dont 11 qui ont pu être méta-analysées. Un SSE inférieur était associé à une augmentation de 48 % et de 34 % de la mortalité à court terme et de la mortalité à moyen terme, respectivement. On a observé une tendance à l'augmentation de la mortalité à long terme plus d'un an après l'événement (rapport de cotes [RC] agrégé 1,34 [intervalle de confiance {IC} à 95 % : de 0,95 à 1,88]). Le SSE inférieur était également associé à des taux plus faibles de cathétérisme cardiaque (RC agrégé 0,80 [IC à 95 % : de 0,65 à 0,99]) et de revascularisation (RC agrégé 0,76 [IC à 95 % : de 0,63 à 0,90]) après un IAM. Les études sur la réadaptation cardiaque ont montré une diminution de l'accès et de la participation dans les groupes de SSE inférieur.

Conclusions : Un SSE inférieur est associé, après un IAM, non seulement à une mortalité accrue, mais aussi à un accès réduit aux interventions cardiaques dont les effets positifs sur la mortalité et la morbidité ont été démontrés. Il est nécessaire de mettre en œuvre des interventions qui améliorent l'accès au cathétérisme, à la revascularisation et à la réadaptation cardiaque des populations de SSE inférieur si l'on veut que le système de soins canadien soit réellement équitable.

treatment in countries with universal health coverage was less often associated with SES,"[18] bringing into question whether such disparities are as significant in the Canadian health care system. Schroder et al.[18] also found that the associations between SES and referral, participation, and attendance in cardiac rehabilitation were inconsistent and variable across studies. Both reviews focused on cardiac interventions within the broad scope of coronary artery disease, rather than specifically within the acute myocardial infarction (AMI) population, for whom the benefit of timely intervention is greater and addressing inequity in access is arguably more critical.[15] Furthermore, neither review assessed the quality of constituent studies, nor were meta-analyses conducted to quantify the association between SES and cardiovascular outcomes and interventions.

Clinicians have a responsibility in providing high-quality, equitable care. Identifying disparities along the spectrum of cardiac care provision is essential to inform national health policy and develop targeted interventions to address "wealth-health" disparities in AMI outcomes.[11] We therefore conducted a systematic review and meta-analysis with the objective of determining the associations among SES, mortality, and access to cardiac interventions and cardiac rehabilitation in Canada.

Methods

Data sources and searches

The systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, adhering to a protocol created by the current study investigators. The electronic databases EMBASE and MEDLINE were searched for relevant studies—initially to March 31, 2018, with an updated search conducted for studies included up until December 4, 2019. There were no limitations placed on date of publication or language. The search strategy was created by both current study investigators, with assistance from a medical librarian, and was comprised of 3 key components: (i) SES; (ii) acute coronary syndrome; and (iii) Key words and subject headings within each of these components were combined with the Boolean operator 'OR'. The 3 themes were combined using the Boolean operator 'AND' (see Supplemental Table S1 for search strategy). Subject headings were adapted to different databases as appropriate.

Study selection

The 2 current study investigators independently performed an initial screen of titles and abstracts of all studies identified from the search strategy, based on relevance to the research question. Both investigators conducted a full-text review of all potentially relevant titles, including studies in which: (i) the sample population included adults aged $\geq$ 18 years with acute coronary syndrome (ie, unstable angina, non−ST segment elevation myocardial infarction, or ST−segment elevation myocardial infarction); (ii) SES (defined by household, individual, or neighbourhood income, education, and/or occupation) was measured as an exposure variable; (iii) at least one primary or secondary outcome of interest was reported (described below); and (iv) outcomes were compared between lower-SES and higher-SES groups. Our main outcome of interest was short-term (up to 30-day), intermediate (31 days to 1 year), and long-term (> 1 year) mortality after AMI. Other outcomes of interest included rates of cardiac catheterization, revascularization (percutaneous coronary intervention or coronary artery bypass graft surgery), and referral to and participation in cardiac rehabilitation post-AMI.

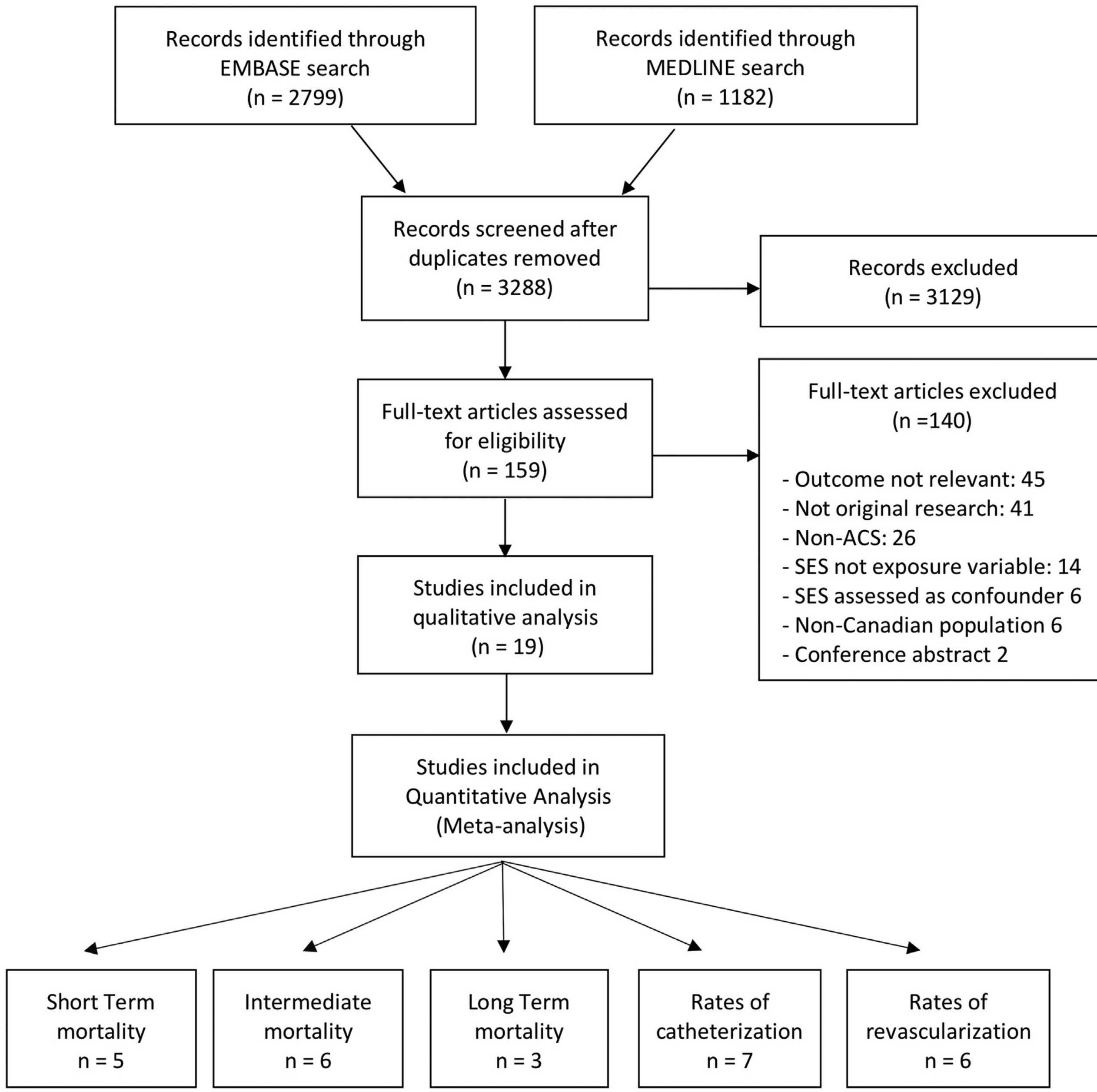

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of study selection. ACS, acute coronary syndrome; SES, socioeconomic status.

Studies were excluded if they were conducted outside of Canada, if they were not original work (ie, reviews, editorials, and commentaries), if the study design was a case study/series, qualitative, or ecological, or if the sample population included nonhuman subjects. Studies of patients with coronary artery disease without an acute myocardial event were not included. Disagreements between the 2 current investigators were resolved by consensus.

Data extraction and study quality assessment

One investigator (AM) completed data extraction for all included studies. Data that were extracted included the following: study design; methods (including sample size and inclusion/exclusion criteria); baseline patient characteristics; SES measure and data source; specific outcomes assessed; and study results. Both investigators independently performed study quality assessments, using the Newcastle-Ottawa assessment scale for cohort studies.[19] The domains of quality assessment included (i) selection (representativeness of both the exposed and non-exposed cohort, ascertainment of exposure, and demonstration that the outcome was not present at study initiation); (ii) comparability of cohorts; and (iii) outcome (length of follow-up, adequacy of follow-up, and assessment method). Disagreements were resolved by consensus.

Table 1. Characteristics of included studies

Study	Province	Study design	Sample size at analysis	Duration of follow-up	Data source used to identify cohort	Inclusion criteria	Exclusion criteria
Alter 1999[30]	Ontario	Retrospective cohort	51,591	1 year	OMID	"Most responsible diagnosis" of AMI April 1, 1994 to March 31, 1997	Admitted with AMI in year prior to index admission; invalid ON health card; age < 20 y or > 105 y; not ON resident, hospital stay < 4 d; AMI coded as a complication of hospital stay, transferred from other acute care facility
Alter 2003a[35]	Ontario	Retrospective cohort	47,036	90 days	OMID	Admitted to hospital with AMI between April 1, 1994 and March 31, 1997	NR
Alter 2003b[37]	Ontario	Retrospective cohort	15,166	1 year	OMID	"Most responsible diagnosis" of AMI between April 1, 1994 and March 31, 1998 who received revascularization within 12 months of AMI	Admitted to institutions with on-site angiography-only facilities; no information on attending physician; patients receiving revascularization on same day as AMI admission
Alter 2004[21]	Ontario	Prospective cohort	2256	30 days	SESAMI study	Admitted for AMI between December 1, 1999 and June 1, 2002	Age < 19 y or > 101 y; no valid ON health care number; transferred into recruiting site; died within 24 h; severe illness (ventilatory support); language barrier precluding completion of survey; discharged or transferred early after presentation
Alter 2005[16]	All provinces except Newfoundland/ Labrador, Yukon, Northwest Territories, Nunavut	Retrospective cohort	139,484	1 year	CIHI database	"Most responsible diagnosis" of AMI between April 1, 1997 and March 31, 2000	Age < 20 y or > 105 y; no valid health card; length of stay < 3 d; previous AMI admission in preceding year; AMI coded as in-hospital complication
Alter 2006a[31]	Ontario	Prospective cohort	2800	6 months	SESAMI study	Admitted for AMI between December 1, 1999 and February 28, 2003	Age < 19 y or > 101 y; no valid ON health care number; transferred into recruiting site; severe illness (ventilatory support); language barrier precluding completion of survey; discharged or transferred early after presentation; died during index hospitalization
Alter 2006b[11]	Ontario	Prospective cohort	3407	2 years	SESAMI study	Admitted for AMI between December 1, 1999 and February 26, 2003	Age < 19 y or > 101 y; no valid ON health care number; transferred into recruiting site; died within 24 h; severe illness (ventilatory support); language barrier precluding completion of survey; discharged or transferred early after presentation

Continued

Table 1. Continued.

Study	Province	Study design	Sample size at analysis	Duration of follow-up	Data source used to identify cohort	Inclusion criteria	Exclusion criteria
Alter 2013[32]	Ontario	Prospective cohort	1368	Mean: 9.6 y (as of December 31, 2010)	SESAMI study	AMI between December 1, 1999 and February 28, 2003	Age < 19 y or > 101 y; no valid ON health card; transferred to recruiting hospital; non−English speaking; death within 1 y after AMI; no participation in 1-y follow-up interview
Blais 2012[26]	Quebec	Retrospective cohort	50,242	1 y	Administrative databases (discharge & mortality databases)	Admitted between January 1, 1997 and December 31, 2001 with principal diagnosis of AMI in hospital database	AMI coded as a complication; 1-d procedures; age < 20 y or > 105 y; discharged alive with hospital stay < 3 d; history of AMI (including in secondary diagnoses) from April 1, 1993 to December 31, 1996
Chan 2008[33]	Ontario	Prospective cohort	1801	2 y	SESAMI study	NR	NR
Chang 2003[34]	Alberta	Retrospective cohort	31,408	5 y	Administrative database (hospital discharge abstracts)	Discharged April 1, 1993 to March 31, 2000 with "most responsible diagnosis" AMI or unstable angina	Age < 18 y
Chang 2007[25]	Alberta	Retrospective cohort	5622	1 y	Administrative database (Ambulatory Care Classification System)	Alberta resident, presenting to acute care hospital emergency department with "initial episode of care" of AMI as "most responsible diagnosis," between April 1, 1998 and March 31, 2001	Age < 18 y
Fabreau 2014[27]	Alberta	Retrospective cohort	14,012	1 y	APPROACH registry	Age 18-99 y; Alberta residents, admitted to any cardiac service in the 2 southern Alberta health zones between April 18, 2004 and Dec 31, 2011 with principal diagnosis of ACS at time of discharge or admission (if discharge diagnosis was missing)	Canadian Census data unavailable; residents residing outside of 2 southern-Alberta health zones
Fabreau 2016[28]	Alberta	Retrospective cohort	14,012	1 y	APPROACH registry	Age 18-99 y; Alberta residents, admitted to any cardiac service in the 2 southern Alberta health zones between April 18, 2004 and December 31, 2011 with principal diagnosis of ACS at time of discharge or admission (if discharge diagnosis was missing)	Canadian Census data unavailable; residents residing outside of 2 southern-Alberta health zones
Grace 2002[38]	Ontario	Prospective cohort	541	6 mo	Survey data from patients from 12 coronary intensive care units across south-central Ontario	Diagnosis of AMI or unstable angina, age ≥ 18 y	Too ill or confused to participate; unable to read/speak English.

Khaykin 2002[24]	Ontario	Retrospective cohort	14,365	1 y	OMID	"Most responsible diagnosis" of AMI between April 1, 1992 and March 31, 1999	Hospitalized with AMI within 1 y prior to index admission; not residents of ON; invalid ON health card number; age < 20 y or > 105 y; discharged alive with hospital stay < 3 d; AMI coded as in-hospital complication; transferred from another acute care facility
Oldridge 1983[39]	Ontario	Prospective cohort (subanalysis of a randomized controlled trial)	618	≥ 3 y	Ontario Exercise-Heart Collaborative Study	Documented episode of AMI; male sex; age < 54 y at time of AMI; if diabetic then controlled via diet; diastolic blood pressure < 110 mm Hg; no heart failure; consent of family doctor, < 1 y from time of infarction, FEV1/FVC > 60%	Presence of any medical condition that may pose unacceptable risk for rehabilitation or result in an inability to become physically active, or orthopedic disability that would limit exertion
Pilote 2003[36]	Quebec	Retrospective cohort	62,364	90 d	Administrative database (discharge summary database)	Hospitalized for first occurrence of AMI as main diagnosis between January 1, 1985 and December 31, 1995 ("first occurrence" based on absence of AMI hospitalization for at least previous 3 y)	Missing or invalid postal codes; socioeconomic data not available in 1991 Canadian Census
Pilote 2007[29]	Quebec, Ontario, British Columbia	etrospective cohort	145,882	From date of admission until March 31, 2001	Administrative databases (hospital discharge summary databases)	Admitted to acute care hospitals between January 1, 1996 and March 31, 2000 (QC) or March 31, 2001 (ON and BC) with first occurrence of AMI as main diagnosis (with 1-y exclusion period), and discharged alive	AMI coded as in-hospital complication; transferred from another hospital; total length of hospitalization < 2 d; discharged to long-term care or rehabilitation center; moved out of province; health care number invalid

ACS, acute coronary syndrome; AMI, acute myocardial infarction; APPROACH, Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease; BC, British Columbia; CIHI, Canadian Institute for Health Information; FEV1, forced expiratory volume; FVC, forced vital capacity; NR, not reported; OMID, Ontario Myocardial Infarction Database; ON, Ontario; QC, Quebec; SESAMI, Socio-Economic Status and Acute Myocardial Infarction Study.

Table 2. Sample characteristics

Study	Age (y)	Female (%)	Household Income (median $, IQR): %	Rural (%)	Comorbidities				
					HTN (%)	DYS (%)	DM (%)	Prior MI/CAD (%)	CVA/TIA (%)
Alter 1999[30]	Median 69	33.8-39 [*]	Q1: 16,621 (15,652-17,302) Q2: 19,136 (18,434-19,683) Q3: 21,255 (20,376-21,765) Q4: 24,628 (23,946-25,301) Q5: 28,988 (26,916-30,469)	10.2-52.6[*]	NR	NR	1.7-2.2[*]	NR	3.4-4.4[*]
Alter 2003a[35]	Mean 67.1	36.3	NR	NR	NR	NR	NR	NR	NR
Alter 2003b[37]	Mean 60.5-61.3[†]	26.1-26.2[†]	Mean 21,049-21,762[†]	NR	NR	NR	1.4-2.1[†]	NR	1.4-1.6[†]
Alter 2004[21]	Median 64	30	Low (< 30,000[c]): 34.5 Middle (30,000-59,999): 33.1 High (≥ 60,000): 32.4	7.4	49.3	45.2	24.0	40.0	NR
Alter 2005[16]	Median 69	35.3	38,629 (33,120-46,248)	24.1	NR	NR	NR	NR	NR
Alter 2006a[31]	Mean 63.8	30.5	Low (< 40,000): 53.6 High (≥ $40,000): 46.4	NR	NR	NR	NR	24.2	NR
Alter 2006b[11]	Median 64	29.6	Low (< 30,000[‡]): 29.3 Middle (30,000-59,999): 34.3 High (≥ 60,000): 36.4	NR	35.9-49.5[*]	29.2-32.0[*]	19.4-33.0[*]	23.0- 32.6[*] Prior CABG: 2.8-3.8 Prior PCI: 3.2-3.6	4.1-6.4[*]
Alter 2013[32]	Mean 60.5-65.1[*]	19.8-47.4[*]	Low (< 30,000[c]): 24.2 Middle (30,000-59,999): 34.5 High (≥ 60,000): 41.3	3.2-8.5[*]	43.9-53.5[*]	37.5-43.6[*]	17.0-30.2[*]	20.0-28.1[*]	3.0-4.2[*]
Blais 2012[26]	Mean 65.8	34.9	NR	25.3	NR	NR	2.9	NR	6.6
Chan 2008[33]	Mean 62.6	28.2	Low (< 30,000[c]): 25.7 Middle (30,000-59,999): 34.4 High (≥ 60,000): 39.9	NR	NR	NR	NR	NR	NR
Chang 2003[34]	Median 64-73[§]	33.7	Mean > 45,000: 49.0-55.3[§]	47.0-62.4[§,‖]	28.7-40.8[§]	15.4-18.7[§]	15.8-21.9[§]	10.0-23.0[§] Prior PCI: 1.8-5.3[§] Prior CABG: 1.7-7.3[§]	NR
Chang 2007[25]	Median 62-70[*]	25.8-37.4[*]	Q1 (≤ 38,796): 25.0 Q2 (38,797-49,347): 25.0 Q3 (49,348-62,839): 25.0 Q4 (≥ 62,840): 25.0	32.4-53.5[*,‖]	52.6-56.0[*]	29.6-36.5[*]	18.6-24.7[*]	26.3-29.4[*]	NR
Fabreau 2014[27]	Mean 63.0-68.4[§]	28.7	58,570-63,878[§]	22.4-23.2[14]	67.2-74.3[§]	69.6-75.9[§]	25.3-25.8[§]	19.2-23.9[§] Prior PCI: 17.4-23.1[§] Prior CABG: 5.8-9.2[§]	7.3-9.6[§]
Fabreau 2016[28]	Mean 64.4-65.2[¶]	28.5-29.4[¶]	49,799-67,760[¶]	22.6[‖]	68.5-71.9[¶]	72.8-78.4[¶]	25.4-25.9[¶]	22.5-22.9[¶] Prior PCI: 17.4-23.0[¶] Prior CABG:7.8-8.3[¶]	7.8-8.3[‖]

Grace 2002[38]	Mean 61.9	NR	> 50,000: 45.0	NR	NR	NR	NR	NR	NR
Khaykin 2002[24]	Median 66.9-68.2**	35.8-37.1**	20,009-20,054**	NR	NR	NR	1.6-3.8**	NR	3.7-4.4**
Oldridge 1983[39]	Mean 45.5-46.7††	NR	NR	NR	NR	NR	NR	91.0-95.0††	NR
Pilote 2003[36]	Mean 64.0	35.0	44,610	NR	NR	NR	NR	NR	NR
Pilote 2007[29]	Median 65-69‡‡	31.0- 38.0‡‡	42,096-50,708‡‡	NR	18.0-28.0‡‡	NR	17.0-25.0‡‡	NR	3.0-7.0

Values are %, unless otherwise indicated.

CABG, coronary artery bypass grafting; CAD, coronary artery disease; CVA, cerebrovascular accident; DM, diabetes mellitus; DYS, dyslipidemia; HTN, hypertension; IQR, interquartile range; MI, myocardial infarction; NR, not reported; PCI, percutaneous coronary intervention; Q, quartile; TIA, transient ischemic attack.

* Stratified by income.

† Stratified by invasive vs noninvasive hospitals.

‡ Income categories for patients age < 65 years. For patients ≥ 65 years of age, low income: < $20,000; middle income: $20,000-$39,999; high income: ≥ $40 000

§ Stratified by sex.

‖ Rural defined as a Canadian Census nonmetropolitan area.

¶ Stratified by metropolitan vs nonmetropolitan residence.

** Stratified by year of hospital admission.

†† Stratified by rehabilitation attendance.

‡‡ Stratified by province.

Data analysis

The majority of studies reported odds ratios (ORs) of an outcome for the lower-SES group compared with the higher-SES group, or presented results for which an OR could be calculated. When hazard ratios were reported, these were converted to an OR using the formula [20] $OR = (RR[1-P_0]) / (1-RR^* P_0)$, where the hazard ratio was approximated to be the relative risk (RR), and P_0 was the prevalence of the outcome in the reference group. One study reported relative risks,[21] which were approximated as ORs.

Meta-analyses were performed separately for each outcome using Stata version 14 (Stata Corp. LP, College Station, TX). DerSimonian and Laird random effects models were used to pool ORs across studies, and forest plots were generated. Heterogeneity of effect estimates was assessed using Cochran's Q test and the I^2 statistic. No stratified analyses or meta-regression could be conducted due to the small number of studies. In circumstances in which 2 or more studies reported on the exact same cohort, only the original (first) study was included in the main meta-analysis. In circumstances in which multiple studies reported on overlapping cohorts, the study with the largest sample size was used. If multiple effect estimates were provided with varying levels of statistical adjustment, the most-adjusted estimate was used for the main meta-analysis. If multiple outcomes were reported for revascularization/catheterization, varying only by time to procedure, the outcome representing the shortest time interval was used in the meta-analysis. For revascularization, the combined outcome (rates of either percutaneous coronary intervention or coronary artery bypass grafting) was used if available. If only stratified results were provided (for percutaneous coronary intervention alone or coronary artery bypass grafting alone), the effect estimate for rate of percutaneous coronary intervention was used due to its higher prevalence in clinical practice. Sensitivity analyses were conducted, substituting each study that was not included into the main meta-analysis for the above reasons, to assess whether this changed the pooled-effect estimates.[22] Additional sensitivity analyses were conducted, including only adjusted effect estimates (removing crude effect estimates).

Publication bias was not assessed, owing to the small number of studies included in the meta-analysis. With fewer than 10 studies, power to detect publication bias using statistical tests for funnel plot asymmetry and regression methods is limited, and these tests are therefore not recommended.[23]

Results

The initial search strategy identified a total of 3981 citations—2799 from EMBASE, and 1182 from MEDLINE (Fig. 1). A total of 3288 titles and abstracts were screened after 693 duplicates were removed. Of these, 3129 were excluded as they were not relevant to the research objective, leaving 159 studies for full-text screening. A total of 19 studies met inclusion criteria for this systematic review from the initial search. With the updated search conducted for studies up to December 2019, an additional 475 titles and abstracts were

Table 3. Study exposure and outcome measures

	Socioeconomic status (exposure)			Outcome measures						
Study	Measures	Comparison‡	Data source	Short-term mortality (within 30 d)	Intermediate mortality (31 d-1 y)	Long-term mortality (> 1 y)	Catheterization	Revascularization	Referral to rehabilitation	Participation in rehabilitation
Alter 1999[30]	Personal income*	Q1 vs Q5†; Per $10,000 increase in income	1996 Census	X	✓	X	✓	✓	X	X
Alter 2003a[35]	Personal income*	Q1 vs Q5†	1996 Census	X	X	X	✓	X	X	X
Alter 2003b[37]	Household income*	Q1 vs others; Q5 vs others	1996 Census	X	X	X	X	✓	X	X
Alter 2004[21]	Household income; education	T1 vs T3†	Self-report	X	✓	X	✓	X	✓	X
Alter 2005[16]	Household income*	Per $10,000 increase in income; 10% increase in poverty; 10% increase in patients with < grade 9 education	2001 Census	✓	X	X	✓	✓	X	X
Alter 2006a[31]	Household income; education	Low vs high income (> $40,000/y); Low vs high education (completed high school or higher)	Self-report	X	✓	X	X	X	X	X
Alter 2006b[11]	Household income; education	T1 vs T3; T2 vs T3	Self-report	✓	✓	✓	✓	✓	X	X
Alter 2013[32]	Household income; education	T1 vs T3†	Self-report	X	X	✓	X	✓	✓	✓
Blais 2012[26]	Deprivation index (incorporates education, employment, income)*	Q1 vs Q5†	Canadian Census	✓	✓	X	✓	✓	X	X
Chan 2008[33]	Household income; education level	T1 vs T3; T2 vs T3	Self-report	X	X	✓	X	X	X	X
Chang 2003[34]	Household income*	Low vs high income (> $45,000)	Statistics Canada 1995	X	X	✓	X	X	X	X
Chang 2007[25]	Household income*	Qr1 vs Qr4†; Per $10,000 increase in income	2001 Census	✓	✓	X	✓	✓	X	X
Fabreau 2014[27]	Household income*	Q1 vs Q5†	2006 Census	✓	✓	X	✓	X	X	X
Fabreau 2016[28]	Household income*	Q1 vs Q5†	2006 Census	✓	✓	X	✓	X	X	X
Grace 2002[38]	Family income	NR	Self-report	X	X	X	X	X	X	✓
Khaykin 2002[24]	Personal income*	Below vs above median income	1996 Census	✓	✓	X	✓	X	X	X
Oldridge 1983[39]	Occupation	Blue collar or white collar	NR	X	X	X	X	X	X	✓

Pilote 2003[36]	Family income*; education; employment; rent	Q1 vs Q5[†]	1991 Census	X	X	X	✓	✓	X	X
Pilote 2007[29]	Family income*; education; employment; rent	T1 vs T3	1996 Census	✓	✓	X	✓	✓	X	X

NR, not reported; Q, quintile; Qr, quartile; T, tertile.
* Using neighbourhood-level data.
† Comparison also made across all socioeconomic groups (tertiles/quartiles/quintiles).
‡ Where "1" (eg, "T1," "Qr1," and "Q1") indicates the highest-income group.

screened, of which 13 underwent full-text screening; none met criteria for further inclusion in the systematic review.

Of the 19 included studies, 8 reported short-term (within 30 days of AMI) mortality,[11,16,22-27] 10 reported on intermediate (31 days to 1 year) mortality,[11,21,24-31] and 4 reported on long-term mortality (> 1 year) post AMI.[11,32-34] Twelve studies reported on catheterization post-AMI,[11,16,21,24-30,35,36] and 9 on revascularization.[11,16,25,26,29,30,32,36,37] Four studies examined referral to or participation in cardiac rehabilitation.[21,32,38,39]

Study characteristics

Eleven studies included Ontario populations,[11,21,24,30-33,35,37-39] 4 were from Alberta,[25,27,28,34] 2 were from Quebec[26,36] and 2 included patients from more than 4 provinces[16,29] (Table 1). Several patient cohorts overlapped across studies. Four studies used the Ontario Myocardial Infarction Database (OMID).[24,30,35,37] Five studies used data from the Socio-Economic and Acute Myocardial Infarction (SESAMI) study.[11,21,31-33] Two study cohorts were obtained through Alberta administrative data with overlapping dates,[25,34] and another 2 study cohorts were identical, from the **A**lberta **P**rovincial **Pr**oject for **O**utcome **A**ssessment in **C**oronary **H**eart Disease (APPROACH) database.[27,28] All studies were cohort studies (n = 19), although one was a subanalysis of a larger randomized control trial.[39] The sample size at analysis ranged from 541 to 145,882. Baseline characteristics of patients are represented in Table 2. Most patients were in their sixties, and approximately 20% to 40% of the sample populations were female across most studies. The proportion of patients living in a rural vs urban environment ranged from 3% to 64% across studies. The degree of cardiovascular comorbidities was also variable across studies. Eighteen of 19 studies used income information for SES determination. The majority of these (n = 12) used neighbourhood area census data, and 6 used self-reported income through survey data. Seven studies integrated education level into measures of SES, and 2 included occupation (Table 3). Most studies used income tertiles, quartiles, or quintiles to group SES into categories (Table 3).

Study quality

Assessment of study quality results can be found in Figure 2. Most studies had appropriate ascertainment of exposure, comparability of cohorts, and outcome assessment. However, 8 of 19 study samples were not representative of either the Canadian population or the AMI population (for example, by excluding severely ill patients or those who could not speak English).

Association between SES and outcomes

Five studies reporting short-term mortality, comprising a total of 219,165 patients, were meta-analyzed.[11,25-27,29] Low SES was associated with increased short-term mortality, with a pooled OR of 1.48 (95% confidence interval [CI] 1.19-1.84; Fig. 3). Six studies reporting intermediate mortality, comprising a total of 270,149 patients, were meta-analyzed.[25-27,29-31] Low SES was associated with increased intermediate mortality, with a pooled OR of 1.34 (95% CI

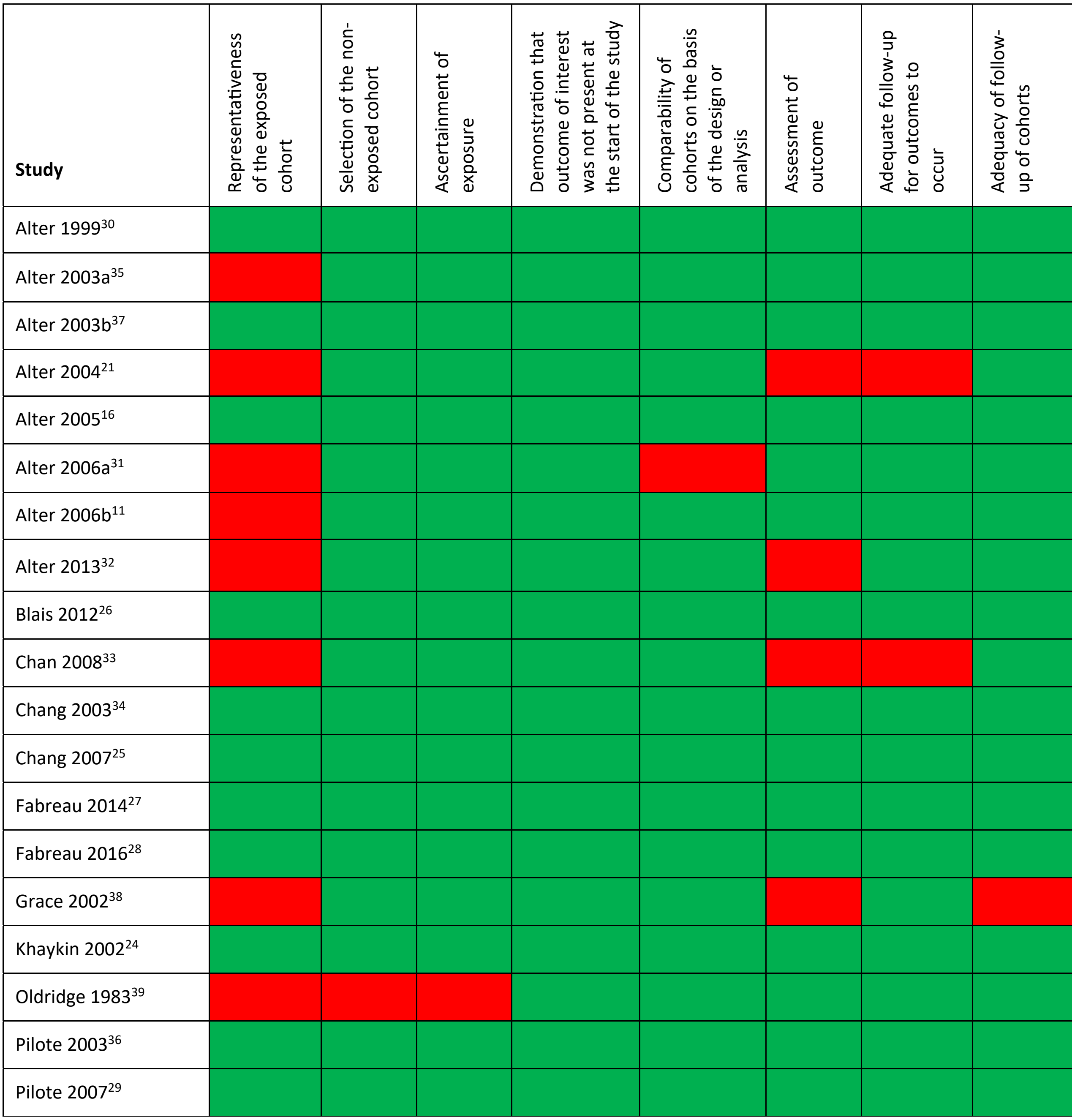

Figure 2. Assessment of study quality. **Red** = high or unclear risk of bias; **green** = low risk of bias.

1.16-1.54). When considering only the 4 studies that provided adjusted ORs, the effect was slightly attenuated, although the OR was still significantly greater than 1, at 1.13 (95% CI 1.02-1.25).[20,24,32,35] Three studies reporting mortality at more than 1-year post-AMI were meta-analyzed, all of which reported adjusted effect estimates.[11,33,34] The total number of patients included in this meta-analysis was 36,616. The association between low SES and increased mortality persisted, although it no longer reached statistical significance (pooled OR 1.34 [95% CI 0.95-1.88]). There was significant statistical heterogeneity for all 3 mortality outcomes, with I^2 values ranging from 78% to 91%.

Seven studies reporting rates of cardiac catheterization (with timing of catheterization ranging from within 1 day to 6 months post-event) were meta-analyzed.[11,25-27,29,30,36] These 7 studies comprised of a total of 333,120 patients. Low SES was associated with lower odds of catheterization, with a pooled OR of 0.80 (95% CI 0.65-0.99). When conducting meta-analysis for only the 4 studies that provided adjusted effect estimates, the overall trends remained the same, but they no longer reached statistical significance (pooled OR

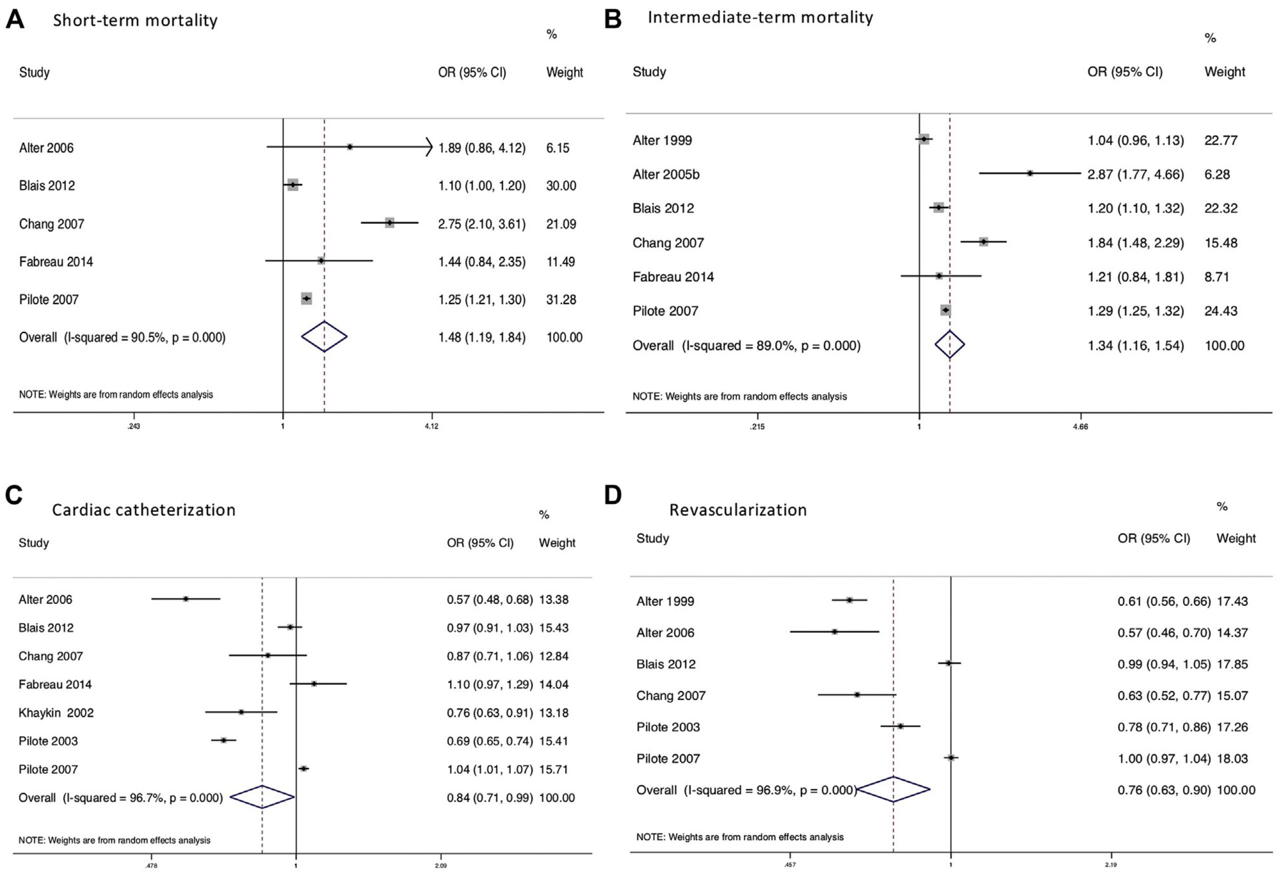

Figure 3. Forest-plots of odds ratios for (**A**) short-term mortality, (**B**) intermediate-term mortality, (**C**) cardiac catheterization and (**D**) revascularization for lower-SES compared to higher-SES groups. SES, socioeconomic status.

0.78 [95% CI 0.54-1.12]).[24,28,33,35] Meta-analysis of the 6 studies that reported revascularization outcomes (with timing of revascularization ranging from within the index hospitalization to 1 year post-event), comprising a total of 319,108 patients, showed that low SES was associated with significantly reduced odds of revascularization (pooled OR 0.76 [95% CI 0.63-0.90]).[11,25,26,29,30,36] The I^2 for catheterization and revascularization were 97%-98%.

Studies reporting cardiac rehabilitation outcomes could not be meta-analyzed due to insufficient data. Low SES was associated with reduced referral in both studies that explored this outcome[21,32] (although one study did not report whether this reduction was statistically significant).[32] A statistically significant reduction in participation in cardiac rehabilitation was found in all 3 studies reporting this outcome.[32,38,39]

Sensitivity analysis

A series of sensitivity analyses were conducted, but none changed the trends seen. For short-term mortality, when a later-published study[33] substituted the original study[27] that used the same cohort for meta-analysis, there were no changes to the results (both pooled ORs 1.48 [95% CI 1.19-1.83]). Similarly, lower SES was significantly associated with increased intermediate mortality, even when studies with larger cohorts[31] were substituted by studies with overlapping, but smaller cohorts.[21] For long-term mortality, when the study with the larger cohort (but shorter follow-up duration at 2 years)[11] was substituted for the study with a smaller but overlapping cohort (with a longer follow-up duration, mean 9.6 years),[32] the association between low SES and mortality became statistically significant (pooled OR 1.13 [95% CI 1.08, 1.19]).[31,32] There were no changes to the results with the series of sensitivity analyses conducted for the outcomes of cardiac catheterization (pooled OR range 0.81-0.87) and revascularization (pooled OR range 0.70-0.78). Similarly, sensitivity analyses were conducted to exclude studies with unclear bias or high risk of bias in the domain of representativeness of the sample population. There were no changes to our findings, although ORs for access to cardiac catheterization were no longer statistically significant (pooled OR 0.85 [95% CI 0.68-1.05]). This source of bias also likely does not explain heterogeneity across studies, as the I^2 were minimally changed with these sensitivity analyses (I^2 88.3%-98.5%).

Discussion

It is widely recognized that low SES is associated with poor outcomes. However, to adequately inform clinical practice and health policy, one must also explore potential areas for intervention, including inequities in access to critical cardiac services. We have conducted the first systematic review to assess not only the associations between SES and mortality outcomes in AMI patients in Canada, but also those between SES and access to interventions along a continuum of care for these patients.

In our meta-analyses, which utilize data from 1985 to 2011, we show that lower SES is associated with higher short-term mortality after AMI (pooled OR 1.48, 95% CI 1.19-1.84) in Canada. In addition, we have demonstrated that this association persists months, to perhaps years, after the initial cardiac event, highlighting the deep-seated and lasting effects of health inequities. Furthermore, despite the presence of a universal health care system in Canada, our systematic review and meta-analysis suggests that disparities exist along a continuum of care for AMI patients—those with lower SES have reduced rates of cardiac catheterization (pooled OR 0.80, 95% CI 0.65-0.99) and revascularization (pooled OR 0.76, 95% CI 0.63-0.90). There is minimal evidence regarding the effect of SES on access to cardiac rehabilitation, but the available data suggest that both referral and attendance at these programs are lower for low-SES populations. These findings all represent junctures at which interventions could be designed to improve access to care for patients with low SES, to improve their health and life expectancy after an AMI event.

Reasons for the differential access to cardiac interventions (ie, catheterization and revascularization) —which are covered by the Canadian universal health care system—remain unclear and require further study. There is some evidence that physicians tailor their clinical decision-making based on patient factors, including SES. For example, physicians describe choosing treatment options that they perceive to be more acceptable, feasible, or affordable for low-SES patients.[40] Although some physicians believe that this tailoring of clinical decisions based on SES does not lead to disparities in outcomes, others acknowledge that this type of practice is not ideal but may be necessary to mitigate even worse outcomes in low-SES patients.[40] That is, physicians may provide what they feel is "appropriate care" (which often is less aggressive in nature) rather than the standard of care for low-SES patients, feeling that this is in the patient's best interest in light of the perceived lack of understanding, financial limitations, and/or potential nonadherence to recommendations and therapy in this population.[40] Catheterization and revascularization are evidence-based interventions that have a proven mortality benefit in the setting of AMI.[41,42] Our findings of low-SES patients having reduced rates of cardiac interventions may account, at least in part, for higher rates of mortality in this population.

Access to cardiac rehab similarly appears to be lower for Canadians with low SES, compared with that for their high-SES counterparts. Although the Canadian Cardiovascular Society recommends a benchmark of 85% rate of referral to cardiac rehabilitation,[43] only 39%-52% of patients who undergo revascularization are referred in actuality,[44] with likely an even lower proportion of SES patients being referred. Low SES poses multiple barriers to access to both referral and participation in cardiac rehabilitation, both at the patient level (transportation and financial barriers, and lack of understanding for the need for cardiac rehabilitation) and the provider level (perceived patient lack of motivation and their inability to afford cardiac rehabilitation).[44,45] At a system level, coverage for cardiac rehabilitation varies widely across Canada, with patients generally bearing a significant cost. On average, the direct cost to patients is $275.29 (standard deviation: $194.68), which equates to about one-third of the program costs.[46] It is no surprise, then, that cost-related barriers are cited as the greatest barriers to access to cardiac rehabilitation, which disproportionately affects those with low SES.[45]

Although our review has important strengths, including a comprehensive search strategy, meta-analyses of a wide set of outcomes, and extensive sensitivity analyses, we acknowledge several caveats and limitations. First, we note that the included studies are relatively old; only 2 studies (representing one study cohort) included data beyond 2010, with their data being from 2004-2011.[27,28] With increasing expertise and availability of cardiac catheterization, it is unclear whether data from the late 1990s to early 2000s fully represent recent practice patterns. However, Alter et al. noted that although overall coronary angiography rates increased from 1992 to 2001, higher-income groups experienced a disproportionately higher increase compared to lower-income groups.[47] The persistence of health inequities over time has been repeatedly demonstrated across different areas of medicine, with lower-SES groups not benefiting equally from improved population health, medical advances, and access to care.[48–51] In 2016, the Canadian Institutes of Health Information reported that nationally, inequities for the vast majority of the 16 studied health indicators either persisted or increased over the past decade.[52] This finding is in spite of a national commitment to reduce health inequities in Canada[52] and the presence of both established and developing interventions meant to address exactly this problem. Therefore, despite the lack of recent studies included in this systematic review, the wider body of literature suggests that our findings still hold.

A second limitation is the high clinical and statistical heterogeneity across the included studies. Baseline characteristics of patients were variable across studies, particularly with respect to rural residency. Due to the limited number of studies for each outcome that could be meta-analyzed, and due to insufficient data (for example, lack of stratification by urban vs rural residency even within primary studies), we were unable to explore sources of heterogeneity using stratified meta-analysis and meta-regression. Similarly, there was heterogeneity with respect to outcomes. For example, different studies examined rates of cardiac catheterization and revascularization over different time periods, ranging from in-hospital interventions during the index admission for AMI[11] to 6 months post-hospitalization.[26,30] Despite this heterogeneity, studies demonstrated remarkably homogeneous results, suggesting a consistent effect between SES and outcomes across studies. Lastly, many included studies had similar or overlapping patient cohorts, although we accounted for this in our meta-analysis by using only the original (first) study in the main meta-analysis if 2 or more studies reported on the exact same cohort, and by using only the study with the largest sample size, in cases with multiple studies reporting on overlapping cohorts. Sensitivity analyses, replacing studies that reported on the same or overlapping cohorts, did not change our findings.

Addressing disparities in the wealth-health gradient will require multi-domain collaboration. Although complex biological and psycho-social factors have been demonstrated to influence cardiovascular health,[11] we have demonstrated that there also exist disparities in the provision of evidence-based life-prolonging interventions, based on SES. Health care providers and the health care system have a responsibility to remediate this. First, given the poorer prognosis in low-SES patients with AMI, health care providers should consider integrating SES into clinical assessment and risk stratification. Prior studies have explored alternate risk stratification tools (ASSIGN and QRISK algorithms) that incorporate postal code income with traditional CVD risk factors and improve prediction of CVD events in patients whose risk may otherwise be underestimated.[4] Second, health care providers may also consider more frequent follow-up visits for low-SES patients, particularly in the short-term and intermediate post-AMI period, given the increased risk of mortality during this time. Third, clinicians should consider, on both an individual and departmental level, why patients with low SES have lower rates of cardiac catheterization and revascularization—whether this is due to tailoring of therapy due to patient constraints (and whether such tailoring is justified), and the extent to which unconscious bias may play a role. Lastly, under-utilization of cardiac rehabilitation is a widely recognized problem, although we show that patients with low SES are disproportionately affected.[44] There are multiple potential strategies to equalize opportunities to access cardiac rehabilitation and to improve access, particularly for low-SES patients who are at greatest risk of poor outcomes. These approaches include coverage of cardiac rehabilitation for this population to minimize out-of-pocket expenses, and automatic referral to cardiac rehabilitation post-AMI, to mitigate patient-level barriers and referral biases, respectively.[44]

Conclusion

Patients with low SES have an increased mortality post-AMI, most pronounced in the short-term, but demonstrating these same trends after 1-year post-infarct. Even in Canada's universal health care system, there is evidence of reduced access to standard-of-care interventions post-AMI, including cardiac catheterization, revascularization, and rehabilitation, for low-SES patients. These junctures represent important opportunities for individual-level and system-level changes to improve care for those who are most vulnerable and at greatest risk of poor outcomes post-AMI.

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Disclosures

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Supplementary Material

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