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## Review Article

# Social Determinants of Myocardial Infarction Risk and Survival: A Systematic Review

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### ABSTRACT

Social determinants of health that have been examined in relation to myocardial infarction incidence and survival include socioeconomic status (income, education), neighbourhood disadvantage, immigration status, social support, and social network. Other social determinants of health include geographic factors such as neighbourhood access to health services. Socioeconomic factors influence risk of myocardial infarction. Myocardial infarction incidence rates tend to be inversely associated with socioeconomic status. In addition, studies have shown that low socioeconomic status is associated with increased risk of poorer survival. There are well-documented disparities in myocardial infarction survival by socioeconomic status, race, education, and census-tract-level poverty. The results of this review indicate that social determinants such as neighbourhood disadvantage, immigration status, lack of social support, and social isolation also play an important role in myocardial infarction risk and survival. To address these social determinants and eliminate disparities, effective interventions are needed that account for the social and environmental contexts in which heart attack patients live and are treated.

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### Introduction

Social determinants of health that have been examined in relation to myocardial infarction incidence and survival include socioeconomic status (income, education), neighborhood disadvantage, immigration status, social support, and social network [1-3]. Other social determinants of health include geographic factors such as neighborhood access to health services. Socioeconomic factors such as lack of education, poverty, and income inequality are among the most important social determinants of cardiovascular health [4]. Low-income people are at increased risk of an array of adverse health outcomes, including myocardial infarction, reinfarction, and CHD mortality [5]. The reasons why low-income persons are at increased risk of myocardial infarction may include differences in cigarette smoking, hypertension and diabetes, although differences persist after adjustment for cardiac risk factors [6]. It is well established that socioeconomic factors influence risk of

myocardial infarction and reinfarction [1, 2, 6-10]. Most studies have shown that low socioeconomic status is associated with increased risk of poorer survival. There are well-documented disparities in myocardial infarction survival by socioeconomic status, race, education, and census-tract-level poverty [11]. However, there is a gap in knowledge about the relationships between social determinants of health (e.g., immigration status, social support/network, and neighborhood access to health services) and myocardial infarction incidence and survival.

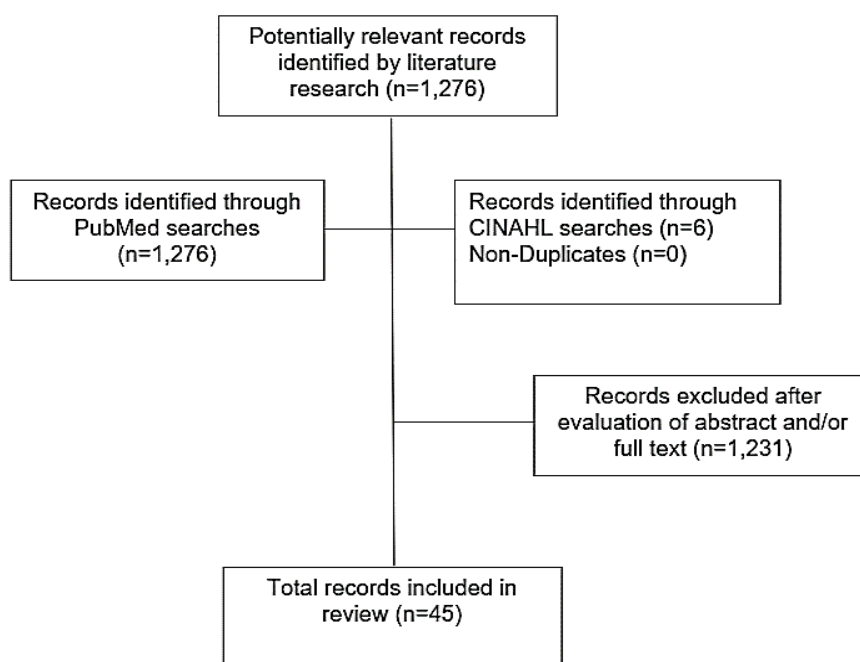
The goal of this review was to examine associations between social determinants of health, such as neighborhood disadvantage, immigration status, social support, and social network and risk of myocardial infarction. Studies were also included that examined risk of reinfarction and mortality among patients who had already suffered an acute myocardial infarction.

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**Methods**

The purpose of this review is to examine the associations between neighborhood deprivation, immigration status, social support and the incidence and survival of myocardial infarction. The neighborhood deprivation refers to community resource deprivation, low-income, lack of education, poor living environment, and crime levels [12]. The social support includes structural support and functional support. The structural support is termed social integration or the social support network (e.g., marital status, single living) [13]. The present review is based upon bibliographic searches in PubMed and CINAHL and relevant search terms. Articles published in English from 1970 through May 1, 2019 were identified using the following MeSH search terms and Boolean algebra commands: (myocardial infarction OR heart attack) AND

(incidence OR mortality OR survival) AND (social determinants OR neighborhood disadvantage OR immigration OR social support OR social network). The searches were not limited to words appearing in the title of an article nor to studies in a particular country or geographic region of the world. The references of review articles were also reviewed. Information obtained from bibliographic searches (title and topic of article, information in abstract, study design, and keywords) was used to determine whether to retain each article identified in this way. Only studies written in English that examined social determinants of myocardial infarction risk and survival were eligible for inclusion. A total of 1,276 articles were identified in the bibliographic searches. Of these, 45 met the study criteria (Figure 1). A variety of study designs were identified, including case-control studies, cohort studies, and population-based studies.



**Figure 1:** Flowchart of record selection process.

**Table 1:** Studies of neighborhood disadvantage and myocardial infarction risk and survival.

Author	Design	Outcomes	Sample	Results
Alter <i>et al.</i> , (1999)	Population-based study in Ontario, Canada	Total mortality	51,591 patients with acute myocardial infarction	A strong inverse association was observed with neighborhood income (p<0.001). Each \$10,000 increase in the neighborhood median income was associated with a 10% reduction in the risk of death within one year (hazards ratio [HR] = 0.90, 95% CI 0.86, 0.94).
Tyden <i>et al.</i> , (2002)	Cohort study in Malmo, Sweden	Total mortality	Myocardial infarction patients	The sex- and age-adjusted all-cause mortality rate per 1,000 patient years ranged from 85.5 to 163.6 between residential areas. The area specific relative risk (RR) of death after discharge was associated with a low socioeconomic score (r=0.56, p=0.018).
Stjame <i>et al.</i> , (2004)	Population-based case-control study in Stockholm, Sweden	Incident myocardial infarction	1,631 cases of myocardial infarction and matched controls	The adjusted RR of myocardial infarction was 2.0 (95% CI 1.3, 3.1) for women living in the top quartile of materially deprived areas. For men, the adjusted RR was 1.6 (95% CI 1.2, 2.1).
Stjame <i>et al.</i> , (2006)	Population-based case-control study in Stockholm County, Sweden	Acute myocardial infarction	2,246 cases of myocardial infarction and matched controls	The level of neighborhood socioeconomic resources had a contextual effect on the RR of myocardial infarction. Compared with high-income neighborhoods, the incidence rate ratio in low income neighborhoods was 1.88 (95% CI 1.25, 2.84) for women and 1.52 (95% CI 1.16, 1.99)

				for men.
Chaix <i>et al.</i> , (2007)	Cohort study in the Scania region, Sweden	Incident myocardial infarction and death from IHD	52,084 persons at risk of myocardial infarction	The incidence of myocardial infarction increased with neighborhood socioeconomic deprivation. For high vs. low neighborhood socioeconomic deprivation, the hazard ratio (HR) was 1.7 (95% CI 1.4, 2.0). A similar pattern was seen for IHD mortality.
Beard <i>et al.</i> , (2008)	Population-based study in New South Wales, Australia	Deaths from acute myocardial infarction and hospital admissions for acute coronary syndrome	Persons at risk of acute myocardial infarction or acute coronary syndrome	Area-level socioeconomic disadvantage (defined using Census variables relating to education, occupation, non-English speaking background, indigenous origin, and household economic resources) was related to mortality (RR for highest quartile of disadvantage relative to lowest = 1.40, 95% CI = 1.27, 1.54).
Rose <i>et al.</i> , (2009)	Population-based cohort study in four U.S. communities	Incident hospitalized myocardial infarction	Persons at risk of incident hospitalized myocardial infarction	Within each community, and among all race-gender groups, those living in low neighborhood median household income neighborhoods had an increased risk of myocardial infarction compared to those living in high neighborhood median household income neighborhoods.
Davies <i>et al.</i> , (2009)	Population-based study in Scotland	Incident acute myocardial infarction	5.1 million persons at risk of acute myocardial infarction	The socioeconomic gradient in acute myocardial infarction increased over time ( $p < 0.001$ ). Among males, the gradient across area deprivation categories in 1990-1992 was most pronounced at younger ages. The RR of acute myocardial infarction in the most deprived areas compared to the least was 2.6 (95% CI 1.6, 4.3) for those aged 45-59 years and 1.6 (95% CI 1.1, 2.5) at 60-74 years. A similar pattern was seen in women.
Gerber <i>et al.</i> (2010)	Cohort study of patients discharged from 8 Israeli hospitals	Total mortality and cardiac mortality	1,179 patients with incident myocardial infarction	Patients residing in disadvantaged neighborhoods had higher mortality rates, with 13-year survival estimates of 61%, 74%, and 82% in increasing tertiles ( $p$ -trend $< 0.001$ ). The HRs for death associated with neighborhood socioeconomic status were 1.47 (95% CI 1.05, 2.06) in the lower tertile and 1.19 (95% CI 0.86, 1.63) in the middle tertile compared with the upper tertile ( $p$ -trend = 0.02).
Henriksson <i>et al.</i> , (2010)	Population-based study in Sweden municipalities	Acute myocardial infarction and total mortality	Persons at risk for acute myocardial infarction	Risk for acute myocardial infarction was lower in the municipalities with higher degree of income inequality.
Deguen <i>et al.</i> , (2010)	Population-based study in Strasbourg metropolitan area, France	Myocardial infarction	Persons at risk of myocardial infarction	The risk of myocardial infarction increased with the neighborhood deprivation level. Women appeared to be more susceptible at levels of extreme deprivation.
Blais <i>et al.</i> , (2012)	Population-based study in Quebec	Total mortality	50,242 patients with acute myocardial infarction	Based upon a population deprivation index, the most materially and socially deprived patients had a 16% (95% CI 1.08, 1.25) and 13% (95% CI 1.05, 1.21) relative increased hazard of dying within 1 year, respectively, compared with the most privileged subjects.
Koren <i>et al.</i> , (2012)	Hospital-based cohort study in Israel	Recurrent myocardial infarction	1,164 patients with incident myocardial infarction	The hazards of recurrent myocardial infarction was higher in low socioeconomic status neighborhoods (HR = 1.55, 95% CI 1.13, 2.14).
Koopman <i>et al.</i> , (2012)	Population-based cohort study in The Netherlands.	Incident acute myocardial infarction	Persons at risk of acute myocardial infarction	When comparing the most deprived neighborhood-level socioeconomic quintile with the most affluent quintile, the overall RR for acute myocardial infarction was 1.34 (95% CI 1.32, 1.36) in men and 1.44 (95% CI 1.42, 1.47) in women.

Kim <i>et al.</i> , (2014)	Retrospective cohort study at one referral center in South Korea	Total mortality	2,358 patients hospitalized for acute myocardial infarction	No significant association was seen between a neighborhood socioeconomic status indicator (social deprivation index) and mortality.
Thorne <i>et al.</i> , (2015)	Record linkage study in Wales	30-day mortality following acute myocardial infarction	Patients hospitalized for acute myocardial infarction	Social deprivation was significantly associated with higher mortality for acute myocardial infarction.
Kim <i>et al.</i> , (2018)	Quasi-experimental study in Toronto, Canada area	Incident myocardial infarction and total mortality	Residents of public housing	Living in a public housing project in the second highest neighborhood socioeconomic position was non-significantly associated with lower hazards of acute myocardial infarction (HR = 0.76, 95% CI 0.54, 1.07, p = 0.11) and all-cause mortality (HR = 0.86, 95% CI 0.73, 1.01, p=0.06).

## Results

### I Neighborhood Disadvantage and Myocardial Infarction

Neighborhood disadvantage is defined as overall low neighborhood education, income, living resource deprivation. Alter *et al.* conducted a population-based study of 51,591 patients with acute myocardial infarction in Ontario, Canada (Table 1) [14]. A strong inverse association was observed with neighborhood income ( $p < 0.001$ ). Each \$10,000 increase in the neighborhood median income was associated with a 10% reduction in the risk of death within one year (hazard ratio [HR] = 0.90, 95% CI 0.86, 0.94). Stjerne *et al.* examined the relation between area material deprivation and risk of myocardial infarction in a population-based case-control study in Stockholm, Sweden [15]. The adjusted relative of myocardial infarction was 2.0 (95% CI 1.3, 3.1) for women living in the top quartile of materially deprived areas. For men, the adjusted relative risk was 1.6 (95% CI 1.2, 2.1).

In a population-based case-control study in Stockholm County, Sweden, Stjerne *et al.* examined the relation between neighborhood socioeconomic resources and risk of acute myocardial infarction [16]. The level of neighborhood socioeconomic resources had a contextual effect on the relative risk of myocardial infarction. Compared with high-income neighborhoods, the incidence rate ratio in low-income neighborhoods was 1.88 (95% CI 1.25, 2.84) for women and 1.52 (95% CI 1.16, 1.99) for men. Chaix *et al.* examined the relation between neighborhood socioeconomic deprivation and risk of myocardial infarction in a cohort study of 52,084 persons in the Scania region of Sweden [17]. The incidence of myocardial infarction increased with neighborhood socioeconomic deprivation. For high vs. low neighborhood socioeconomic deprivation, the hazard ratio was 1.7 (95% CI 1.4, 2.0). A similar pattern was seen for ischaemic heart disease mortality.

In a population-based study in New South Wales, Australia, Beard *et al.* examined the relation between area socioeconomic disadvantage and death from acute myocardial infarction [18]. Area-level socioeconomic disadvantage (defined using Census variables relating to education, occupation, non-English speaking background, indigenous origin, and household economic resources) was related to mortality (relative risk for highest quartile of disadvantage relative to lowest = 1.40, 95% CI = 1.27,

1.54). In a population-based cohort study in four U.S. communities, Rose *et al.* examined the relation between neighborhood median household income and risk of myocardial infarction [19]. Within each community, and among all race-gender groups, those living in low neighborhood median household income neighborhoods had an increased risk of myocardial infarction compared to those living in high neighborhood median household income neighborhoods.

Davies *et al.* conducted a population-based study of area deprivation and risk of acute myocardial infarction in Scotland [20]. The socioeconomic gradient in acute myocardial infarction increased over time ( $p < 0.001$ ). Among males, the gradient across area deprivation categories in 1990-1992 was most pronounced at younger ages. The relative risk of acute myocardial infarction in the most deprived areas compared to the least was 2.6 (95% CI 1.6, 4.3) for those aged 45-59 years and 1.6 (95% CI 1.1, 2.5) at 60-74 years. A similar pattern was seen in women. Gerber *et al.* conducted a cohort study of 1,179 myocardial infarction patients discharged from 8 Israeli hospitals [21]. Patients residing in disadvantaged neighborhoods had higher mortality rates, with 13-year survival estimates of 61%, 74%, and 82% in increasing tertiles ( $p$ -trend  $< 0.001$ ). The hazard ratios for death associated with neighborhood socioeconomic status were 1.47 (95% CI 1.05, 2.06) in the lower tertile and 1.19 (95% CI 0.86, 1.63) in the middle tertile compared with the upper tertile ( $p$ -trend = 0.02).

Henriksson *et al.* examined the relation between municipality income inequality and risk of acute myocardial infarction in a population-based study in Sweden [22]. Risk for acute myocardial infarction was lower in the municipalities with higher degree of income inequality. In a population-based study in Strasbourg metropolitan area in France, Deguen *et al.* examined the relation between level of neighborhood deprivation and risk of myocardial infarction [23]. The risk of myocardial infarction increased with the neighborhood deprivation level. Women appeared to be more susceptible at levels of extreme deprivation. Blais *et al.* conducted a population-based study of 50,242 patients with acute myocardial infarction in Quebec, Canada [24]. Based upon a population deprivation index, the most materially and socially deprived patients had a 16% (95% CI 1.08, 1.25) and 13% (95% CI 1.05, 1.21) relative increased hazard of dying within 1 year, respectively, compared with the most privileged subjects.

In a hospital-based cohort study in Israel, Koren *et al.* examined the relation between neighborhood socioeconomic status and risk of recurrent myocardial infarction [25]. The hazards of recurrent myocardial infarction were higher in low socioeconomic status neighborhoods (hazard ratio = 1.55, 95% CI 1.13, 2.14). Koopman *et al.* examined the relation between neighborhood deprivation and risk of acute myocardial infarction in a population-based cohort study in The Netherlands [26]. When comparing the most deprived neighborhood-level socioeconomic quintile with the most affluent quintile, the overall relative risk for acute myocardial infarction was 1.34 (95% CI 1.32, 1.36) in men and 1.44 (95% CI 1.42, 1.47) in women. Kim *et al.* conducted a retrospective cohort study of acute myocardial infarction patients as one referral center in South Korea [27]. No significant association was seen between a neighborhood socioeconomic status indicator (social deprivation index) and mortality.

In a record linkage study in Wales, Thorne *et al.* examined the relation between area social deprivation and 30-day mortality following acute myocardial infarction [28]. Social deprivation was significantly associated with higher mortality for acute myocardial infarction. In a quasi-experimental study in the Toronto, Canada area, Kim *et al.* examined the relation between neighborhood socioeconomic position and risk of myocardial infarction and total mortality [29]. Living in a public housing project in the second highest neighborhood socioeconomic position was non-significantly associated with lower hazards of acute myocardial infarction (hazard ratio = 0.76, 95% CI 0.54, 1.07,  $p = 0.11$ ) and all-cause mortality (hazard ratio = 0.86, 95% CI 0.73, 1.01,  $p = 0.06$ ).

**Table 2:** Studies of immigration status and myocardial infarction risk and survival.

Author	Design	Outcomes	Sample	Results
Alfredsson <i>et al.</i> , (1982)	Case-control study in Stockholm County, Sweden	Incident myocardial infarction	356 cases and matched controls	The overall RR for Finnish immigrants compared to native Swedes was 1.7. For the group of Finnish immigrants who had been in Sweden for 20 years or more the RR was 1.3.
Hedlund <i>et al.</i> , (2007)	Case-control study in Stockholm County, Sweden	Incident myocardial infarction	46,366 cases of incident myocardial infarction and stratified controls	Foreign-born subjects had a higher incidence of myocardial infarction than those born in Sweden (RR for men = 1.17, 95% CI 1.13, 1.21; RR for women = 1.15, 95% CI 1.09, 1.21). An increased incidence was present primarily in subjects born in Finland, other Nordic countries, Poland, Turkey, Syria and South Asia in both genders, from the Netherlands among men, and from Iraq among women.
Hedlund <i>et al.</i> , (2008)	Population-based cohort study in Stockholm, Sweden	Total mortality	Incident cases of myocardial infarction	After adjustment for socioeconomic status, male immigrants had a lower mortality within 28 days after a first myocardial infarction compared to Sweden-born (OR = 0.84, 95% CI 0.76, 0.94). Among women, there was a weak similar relationship (OR = 0.92, 95% CI 0.76, 1.10). There were no important differences between foreign-born and Sweden-born in 1-year mortality.
Saposnik <i>et al.</i> , (2010)	Population-based, matched, retrospective cohort study in Ontario, Canada	Hospitalization for acute myocardial infarction	Persons at risk for myocardial infarction	The incidence rate of acute myocardial infarction was 4.14 per 10,000 persons among new immigrants and 6.61 per 10,000 person-years among long-term residents (HR = 0.66, 95% CI 0.63, 0.69).
Hempler <i>et al.</i> , (2011)	Registry-based follow-up study in Denmark	Incident acute myocardial infarction	Persons at risk of acute myocardial infarction	Immigrant men and women from Turkey and Pakistan had an increased incidence of acute myocardial infarction. No notable differences were observed between former Yugoslavians and native Danes.
Deckert <i>et al.</i> , (2013)	Retrospective cohort study in Germany	Total mortality and acute myocardial infarction incidence	Persons at risk for acute myocardial infarction	Acute myocardial infarction incidence was higher in male repatriates (standardized incidence ratio = 1.30, 95% CI 1.02, 1.65) than in the general German population.
van Oeffelen <i>et al.</i> , (2014)	Population-based cohort study in The Netherlands	Acute myocardial infarction and total mortality	Persons hospitalized for acute myocardial infarction	Mortality and acute myocardial infarction readmission rates were higher among immigrants as compared with ethnic Dutch.

Dzayee <i>et al.</i> , (2014)	Nationwide cohort study in Sweden	Recurrent myocardial infarction	518,503 patients diagnosed with first myocardial infarction	Foreign-born men and women had a slightly increased HR than Sweden-born men and women. Foreign-born who had lived in Sweden for less than 35 years had a higher risk than those who had lived there for 35 years or longer.
Shvartsur <i>et al.</i> , (2018)	Retrospective cohort study in Israel	Total mortality	11,143 Israeli-born and immigrant acute myocardial infarction patients	10-year mortality rates were 65% lower in Israeli-born patients compared with immigrants.

## II Immigration Status and Myocardial Infarction

In a case-control study in Stockholm County, Sweden, Alfredsson *et al.* examined the relation between immigration status and risk of myocardial infarction, as shown in (Table 2) [30]. The overall relative risk for Finnish immigrants compared to native Swedes was 1.7. For the group of Finnish immigrants who had been in Sweden for 20 years or more, the relative risk was 1.3. Hedlund *et al.* examined the relation between immigration status and risk of myocardial infarction in a case-control study in Stockholm County, Sweden [31]. Foreign-born subjects had a higher incidence of myocardial infarction than those born in Sweden (relative risk for men = 1.17, 95% CI 1.13, 1.21; relative risk for women = 1.15, 95% CI 1.09, 1.21). An increased incidence was present primarily in subjects born in Finland, other Nordic countries, Poland, Turkey, Syria and South Asia in both genders, from the Netherlands among men, and from Iraq among women.

In a population-based cohort study of myocardial infarction patients in Stockholm, Sweden, Hedlund *et al.* examined the relation between immigration status and total mortality [32]. After adjustment for socioeconomic status, male immigrants had a lower mortality within 28 days after a first myocardial infarction compared to Sweden-born (odds ratio = 0.84, 95% CI 0.76, 0.94). Among women, there was a weak similar relationship (odds ratio = 0.92, 95% CI 0.76, 1.10). There were no important differences between foreign-born and Sweden-born in 1-year mortality. In a population-based, matched, retrospective cohort study in Ontario, Canada, Saposnik *et al.* examined the relation between immigration and hospitalization for acute myocardial infarction [33]. The incidence rate of acute myocardial infarction was 4.14 per 10,000 persons among new immigrants and 6.61 per 10,000 person-years among long-term residents (hazard ratio = 0.66, 95% CI 0.63, 0.69). Hempler *et al.* examined the relation between immigration status and risk of acute myocardial infarction in a registry-based follow-up study in Denmark [34]. Immigrant men and women from Turkey and Pakistan had an increased incidence of acute myocardial infarction. No notable differences were observed between former Yugoslavians and native Danes.

In a retrospective cohort study in Germany, Decker *et al.* examined the relation between repatriation status and risk of acute myocardial infarction [35]. Acute myocardial infarction incidence was higher in male repatriates (standardized incidence ratio = 1.30, 95% CI 1.02, 1.65) than in the general German population. In a population-based cohort study in The Netherlands, Van Oeffelen *et al.* examined the relation between immigration status and myocardial infarction readmission rates and mortality [36]. Mortality and acute myocardial infarction readmission rates were higher among migrants as compared with ethnic Dutch. Dzayee *et al.* examined the relation between immigration status and recurrent myocardial infarction in a nationwide cohort study in Sweden [37]. Foreign-born men and women had a slightly increased hazard ratio than Sweden-born men and women. Foreign-born who had lived in Sweden for less than 35 years had a higher risk than those who had lived there for 35 years or longer. Shvartsur *et al.* examined the relation between immigration status and total mortality in a retrospective cohort study of acute myocardial infarction patients in Israel [38]. Ten-year mortality rates were 65% lower in Israeli-born patients compared with immigrants.

## III Social Support and Myocardial Infarction

Berkman *et al.* examined the relation between emotional support and total mortality in a cohort study of patients hospitalized for acute myocardial infarction in New Haven, CT (Table 3) [39]. Lack of emotional support was significantly associated with mortality (odds ratio = 2.9, 95% CI 1.2, 6.9). In a cohort study in England, Jenkinson *et al.* examined the relation between social isolation and mortality among 1,376 patients hospitalized for acute myocardial infarction [40]. Socially isolated patients were 49% more likely to die after an infarction than patients who were not socially isolated. Friedmann and Thomas examined the relation between social support and total mortality in a follow-up study of patients with myocardial infarction [41]. High social support tended to predict survival independently of demographic and other psychosocial variables ( $p < 0.068$ ).

**Table 3:** Studies of social support and myocardial infarction risk and survival.

Author	Design	Outcomes	Sample	Results
Berkman <i>et al.</i> , (1992)	Cohort study in New Haven, CT	Total mortality	194 patients hospitalized for acute myocardial infarction	Lack of emotional support was significantly associated with mortality (OR = 2.9, 95% CI 1.2, 6.9).
Jenkinson <i>et al.</i> , (1993)	Cohort study in England	Total mortality	1,376 patients hospitalized for acute myocardial infarction	Socially isolated patients were 49% more likely to die after an infarction than patients who were not socially isolated.

Friedmann & Thomas, (1995)	Follow-up study of randomized controlled trial participants	Total mortality	368 myocardial infarction patients	High social support tended to predict survival independently of demographic and other psychosocial variables ( $p < 0.068$ ).
Greenwood <i>et al.</i> , (1995)	Cohort study in England	Total mortality	1,701 patients hospitalized for acute myocardial infarction	Lack of social contacts or being unmarried were not significantly associated with survival.
Farmer <i>et al.</i> , (1996)	Cohort study in Corpus Christi, TX	Total mortality	596 patients with myocardial infarction	Survival following myocardial infarction was greater for those with high or medium social support than for those with low social support. The RR of mortality was 1.89 (95% CI 1.20, 2.97) for those with low social support.
Hammer <i>et al.</i> , (1998)	Population-based case-control study in five Swedish counties	Incident myocardial infarction	Men and women in five counties in Sweden who were at risk of myocardial infarction	Younger men (30-54 years of age) in occupations with both high job strain and low social support at work had a RR of 1.79 (95% CI 1.22, 2.65) compared with subjects in low strain and high social support jobs.
Pederson <i>et al.</i> , (2004)	Follow-up study of patients 4-6 weeks post-myocardial infarction and at 9 months	Recurrent cardiac events	112 myocardial infarction patients treated at two hospitals in Denmark	Lower social support at baseline was associated with an increased risk of recurrent cardiac events at follow-up (OR = 0.90, 95% CI 0.84, 0.97).
Andre-Petersson <i>et al.</i> , (2006)	Cohort study of men in Malmo, Sweden	Incident myocardial infarction and total mortality	Men born in Malmo, Sweden who were at-risk of myocardial infarction	Low levels of social support was associated with an increased risk of incident myocardial infarction (HR = 2.40, 95% CI 1.36, 4.25, $p = 0.003$ ) and premature death (HR = 1.99, 95% CI 1.32, 3.00, $p = 0.001$ ).
Schmaltz <i>et al.</i> , (2007)	Study of all patients discharged with a primary diagnosis of acute myocardial infarction from three medical centers in Calgary, Alberta, Canada	Mortality	Patients with acute myocardial infarction	Living alone was independently associated with mortality (adjusted HR = 1.6, 95% CI 1.0, 2.5), but interacted with patient sex. Men living alone had the highest mortality risk (HR = 2.0, 95% CI 1.1, 3.7), followed by women living alone, men living with others, and women living with others.
Chaix <i>et al.</i> , (2006)	Cohort study of men in Malmo, Sweden	Acute myocardial infarction and death due to chronic IHD	498 men at risk of acute myocardial infarction or death due to IHD	Low neighborhood-based social support was associated with increased risk of acute myocardial infarction and IHD mortality. The hazard ratios for IHD death associated with neighborhood social support were 2.50 (95% CI 1.06, 5.91) in the lower tertile and 1.66 (95% CI 0.70, 3.93) in the middle tertile compared with the upper tertile. The hazard ratios for incident myocardial infarction associated with neighborhood social support were 1.87 (95% CI 1.02, 3.43) in the lower tertile and 1.60 (95% CI 0.89, 2.86) in the middle tertile compared with the upper tertile.
Andre-Petersson <i>et al.</i> , (2007)	Cohort study in Malmo, Sweden	Incident myocardial infarction	7,770 men and women at risk of myocardial infarction	Among women, low levels of social support at work was associated with an increased risk of myocardial infarction. No association was observed among men.
Lett <i>et al.</i> , (2007)	Prospective study of randomized controlled trial participants	Total mortality and non-fatal reinfarction	1,481 acute myocardial infarction patients	Higher levels of perceived social support were associated with improved outcome for patients without elevated depression but not for patients with high levels of depression. The relation between perceived social support and mortality or nonfatal infarction did not reach statistical significance.
Nielsen & Mard, (2010)	Cohort study in Denmark	Total mortality	242 patients with acute myocardial infarction	Single living was an independent predictor of death (HR = 2.55, 95% CI 1.52, 4.30).

Buchholz <i>et al.</i> , (2011)	Registry-based cohort study at 19 U.S. medical centers	Acute myocardial infarction and 4-year mortality	Patients hospitalized for acute myocardial infarction	Patients who lived alone had a comparable risk of mortality (HR = 0.99, 95% CI 0.76, 1.28) as patients who lived with others.
Kitamura <i>et al.</i> , (2013)	Cohort study in Osaka region of Japan	Major adverse cardiovascular events and total mortality	5,845 patients with acute myocardial infarction	Living alone was associated with a higher risk of composite endpoint consisting of major adverse cardiovascular events and total deaths (HR = 1.32, 95% CI 1.11, 1.58).
Gafarov <i>et al.</i> , (2013)	Cohort study	Incident myocardial infarction	870 women in Novosibirsk, Russia	The rate of myocardial infarction was higher in married women with fewer close contacts and smaller social networks.
Quinones <i>et al.</i> , (2014)	Registry-based cohort study in Augsburg, Germany	Total mortality	3,766 patients with incident myocardial infarction	Overall, marital status showed a statistically non-significant inverse association (HR = 0.76, 95% CI 0.47, 1.22). Stratified analyses revealed strong protective effects only among men and women aged < 60 years who were diagnosed with hyperlipidemia.
Kilpi <i>et al.</i> , (2015)	Population-based cohort study in Finland	Myocardial infarction incidence and mortality	302,885 persons at risk of myocardial infarction	Men who were married had a lower risk of myocardial infarction as compared with those who were unmarried, even after adjusting for socioeconomic factors. Among women, the associations of living arrangements with myocardial infarction were explained by socioeconomic factors. Living arrangements were strong predictors of survival after myocardial infarction.
Weiss-Faratici <i>et al.</i> , (2016)	Cohort study in Israel	Total mortality at two time points	Patients with incident myocardial infarction	Higher perceived social support was associated with lower mortality at both time points (HR = 0.85, 95% CI 0.75, 0.96; HR = 0.74, 95% CI 0.66, 0.83, respectively).
Hakulinen <i>et al.</i> , (2018)	Cohort study in the United Kingdom	Incident acute myocardial infarction and total mortality	479,054 persons at risk of myocardial infarction	Social isolation was associated with higher risk of acute myocardial infarction (HR = 1.43, 95% CI 1.3-1.55).

In a cohort study of patients hospitalized for acute myocardial infarction in England, Greenwood *et al.* examined the relation between lack of social contacts or being unmarried and total mortality [42]. Lack of social contacts or being unmarried was not significantly associated with survival. In a cohort study of 596 patients with myocardial infarction in Corpus Christi, TX, Farmer *et al.* examined the relation between social support and total mortality [43]. Survival following myocardial infarction was greater for those with high or medium social support than for those with low social support. The relative risk of mortality was 1.89 (95% CI 1.20, 2.97) for those with low social support. In a population-based case-control study in five Swedish counties, Hammer *et al.* examined the relation between social support and risk of myocardial infarction [44]. Younger men (30-54 years of age) in occupations with both high job strain and low social support at work had a relative risk of 1.79 (95% CI 1.22, 2.65) compared with subjects in low strain and high social support jobs.

In a follow-up study of 112 myocardial infarction patients treated at two hospitals in Denmark, Pederson *et al.* examined the relation between social support and recurrent cardiac events [45]. Lower social support at baseline was associated with an increased risk of recurrent cardiac events at follow-up (odds ratio = 0.90, 95% CI 0.84, 0.97). Andre-Petersson *et al.* examined the relation between social support and risk of myocardial infarction and total mortality in a cohort study in Malmo, Sweden [46]. Low levels of social support was associated with an increased risk of incident myocardial infarction (hazard ratio = 2.40, 95% CI 1.36, 4.25,

$p = 0.003$ ) and premature death (hazard ratio = 1.99, 95% CI 1.32, 3.00,  $p = 0.001$ ). In a study of all patients discharged with a primary diagnosis of acute myocardial infarction from three medical centers in Calgary, Alberta, Canada, Schmaltz *et al.* examined the relation between living alone and mortality [47]. Living alone was independently associated with mortality (adjusted hazard ratio = 1.6, 95% CI 1.0, 2.5), but interacted with patient sex. Men living alone had the highest mortality risk (hazard ratio = 2.0, 95% CI 1.1, 3.7), followed by women living alone, men living with others, and women living with others.

In a cohort study in Malmo, Sweden, Chaix *et al.* examined the relation between neighborhood-based social support and risk of acute myocardial infarction and death due to chronic ischaemic heart disease (IHD) [48]. Low neighborhood-based social support was associated with increased risk of acute myocardial infarction and IHD mortality. The hazard ratios for IHD death associated with neighborhood social support were 2.50 (95% CI 1.06, 5.91) in the lower tertile and 1.66 (95% CI 0.70, 3.93) in the middle tertile compared with the upper tertile. The hazard ratios for incident myocardial infarction associated with neighborhood social support were 1.87 (95% CI 1.02, 3.43) in the lower tertile and 1.60 (95% CI 0.89, 2.86) in the middle tertile compared with the upper tertile.

In a cohort study in Malmo, Sweden, Andre-Petersson examined the relation between social support and risk of myocardial infarction [49]. Among women, low levels of social support at work was associated with an increased risk of myocardial infarction. No association was observed



among men. In a prospective study of acute myocardial infarction patients, Lett *et al.* examined the relation between perceived social support and total mortality and non-fatal reinfarction [50]. Higher levels of perceived social support were associated with improved outcome for patients without elevated depression but not for patients with high levels of depression. The relation between perceived social support and mortality or non-fatal infarction did not reach statistical significance. In a cohort study of 242 patients with acute myocardial infarction in Denmark, Nielsen and Mard examined the relation between single living and total mortality [51]. Single living was an independent predictor of death (hazard ratio = 2.55, 95% CI 1.52, 4.30).

In a registry-based cohort study of patients hospitalized for acute myocardial infarction at 19 U.S. medical centers, Bucholz *et al.* examined the relation between living alone and reinfarction and mortality [52]. Patients who lived alone had a comparable risk of mortality (hazard ratio = 0.99, 95% CI 0.76, 1.28) as patients who lived with others. In a cohort study of 5,845 patients with acute myocardial infarction in the Osaka region of Japan, Kitamura *et al.* examined the relation between living alone and major adverse cardiovascular events and total mortality [53]. Living alone was associated with a higher risk of composite endpoint consisting of major adverse cardiovascular events and total deaths (hazard ratio = 1.32, 95% CI 1.11, 1.58). In a cohort study in Novosibirsk, Russia, Gafarov *et al.* examined social support and social networks in relation to risk of myocardial infarction [54]. The rate of myocardial infarction was higher in married women with fewer close contacts and smaller social networks.

In a registry-based study of 3,766 patients with incident myocardial infarction in Augsburg, Germany, Quinones *et al.* examined the relation between marital status and total mortality [55]. Overall, marital status showed a statistically non-significant inverse association (HR = 0.76, 95% CI 0.47, 1.22). Stratified analyses revealed strong protective effects only among men and women aged < 60 years who were diagnosed with hyperlipidemia. Kipli *et al.* examined the relation between marital status and risk of myocardial infarction incidence and mortality in a cohort of 302,885 persons in Finland [56]. Men who were married had a lower risk of myocardial infarction as compared with those who were unmarried, even after adjusting for socioeconomic factors. Among women, the associations of living arrangements with myocardial infarction were explained by socioeconomic factors. Living arrangements were strong predictors of survival after myocardial infarction.

In a cohort study of patients with incident myocardial infarction in Israel, Weiss-Farati *et al.* examined the relation between social support and mortality [57]. Higher perceived social support was associated with lower mortality at both time points (hazard ratio = 0.85, 95% CI 0.75, 0.96; hazard ratio = 0.74, 95% CI 0.66, 0.83, respectively). Hakulinen *et al.* examined the relation between social isolation and risk of acute myocardial infarction in a cohort study of 479,054 persons in the United Kingdom [58]. Social isolation was associated with higher risk of acute myocardial infarction (hazard ratio = 1.43, 95% CI 1.3-1.55).

## Discussion

The results of this review indicate that social determinants such as neighborhood disadvantage (e.g., resource deprivation, poverty, lack of

education), immigration status, lack of social support, and social isolation play an important role in myocardial infarction risk and survival. Residing in areas with fewer economic resources may delay care for acute illness or adversely impact the ability to receive follow-up care [1]. Population differences in cardiovascular risk factors such as cigarette smoking, hypertension, and diabetes may partly account for associations between area-based measures of socioeconomic status and neighborhood disadvantage are associated with increased risk of adverse health outcomes. Some but not all studies have shown that myocardial infarction incidence rates are lower among immigrants. The healthy immigrant effect diminishes over several generations. Studies have shown that country of origin is associated with myocardial infarction survival. These differences may be due to environmental exposures such as diet, smoking, or physical activity.

Several factors may account for the inverse association between social support and myocardial infarction survival. First, lack of social support and depression are interrelated. Social isolation provokes anxiety and depression, activating neuroendocrine, immune responses, and hemodynamic alterations via the renin-angiotensin-aldosterone system [59]. These deleterious biological processes are known to damage arterial walls and the myocardium itself [59]. Like other major risk factors of MI (e.g., elevated cholesterol level, tobacco use, and hypertension), the evidence showed social isolation related anxiety and depression elevated the same biomarkers that mediate the effects of elevated cholesterol level or tobacco use [13]. Second, the treatment of acute MI is costly. Adequate social support may help patients gain other supportive resources, such as medical referral networks, group therapy, or informational opportunities relating to financial support [13]. Individuals with adequate social support may also have better access to the appropriate treatment [13]. Third, social support was found as the mediator between self-care behaviours and disease progression [60]. Social support may offer protection against the negative health consequences by enhancing health-promoting behaviours and discouraging negative behaviours. Finally, cardiac rehabilitation programs and other prevention strategies are effective to prevent and reduce mortality post-MI [13]. The cardiac rehabilitation, a group setting program, provides three types of peer support. They are emotional, informational, and affirmational [13]. Peer support has been found effective to relieve anxiety and depression, promote positive coping strategies, improve outlook and confidence in post-MI management, therefore enhance recovery and survival [13].

Rehabilitation provides an opportunity to offer peer support to patients who have a low social support. Based on our review, we recommend to modify rehabilitation program into a more social activity with boosted peer support system in which individuals with low social support can be partnered with volunteers who have well-established social support and experienced in MI management. In addition, social support is not routinely assessed by general practitioners, and even less by cardiovascular specialists. Therefore, screening for social support and depression may be useful to identify high risk individual and reduce mortality. Although extensive research has shown a consistent relationship between low social support and MI, the mechanism of social support is not clearly identified. The challenge remains to plan and evaluate interventions that target social support. Much more research is required to explicate strategies for modifying the negative effects of this

relationship, particularly at the public health level.

To address these social determinants and eliminate myocardial infarction disparities, effective interventions are needed that account for the social and environmental contexts in which patients live and are treated. Of particular concern are access to health care among immigrant populations and health communication about the early detection and treatment of cardiovascular disease risk factors for patients who are unmarried or socially isolated.

### Conflicts of Interest

None.

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