Published in final edited form as:
Health Place. 2010 November ; 16(6): 1196–1205. doi:10.1016/j.healthplace.2010.08.004.

Geographic Issues in Cardiac Rehabilitation Utilization: A Narrative Review

Yvonne W. Leung, MA[1], **Janette Brual, MSc**[2], **Alison Macpherson, PhD**[1], and **Sherry L Grace, PhD**[1,3]

[1]School of Kinesiology and Health Science, York University, Toronto, Canada

[2]Department of Geography, Queen's University, Kingston, Canada

[3]University of Health Network, Toronto, Canada

Abstract

Objective—The purpose of this study was to review the current evidence regarding the relationship between geographic indicators and cardiac rehabilitation (CR) utilization among coronary heart disease (CHD) patients.

Results—Seventeen articles were identified for inclusion, where nine studies assessed rurality, 10 studies assessed travel time/distance, and two of these studies assessed both. Nine of the 17 studies (52.9%) showed a significant negative relationship between geographic barrier and CR use. Four of the 17 studies (23.5%) showed a null relationship, while four studies (23.5%) showed mixed findings. Inconsistent findings identified appeared to be related to restricted geographic range, regional density, and socioeconomic status.

Conclusions—Overall, 52.9% of the identified studies reported a significant negative relationship between geographic indicators and CR utilization. This relationship appeared to be particularly consistent in North American and Australian settings, but somewhat less so in the United Kingdom where there is greater population density and availability of public transport.

Keywords

cardiac rehabilitation; geographic accessibility; barriers; attendance; enrollment; participation

Introduction

Cardiac rehabilitation (CR) is an outpatient chronic disease management program designed to enhance and maintain cardiovascular health through individualized, inter-professional care. CR programs offer medical assessment, structured exercise, client and family education, as well as comprehensive risk factor and behavior modification. It is an effective means for the secondary prevention of coronary heart disease (CHD), as evidenced by the 25% reduction in morbidity and mortality when compared to usual care (Boulay,

Corresponding Author: Sherry L. Grace, York University, Faculty of Health, 368 Bethune, 4700 Keele St, Toronto, ON M3J 1P3, Phone: (416) 736-2100 x.22364, Fax: (416) 736-5774, sgrace@yorku.ca.

Disclosure: There is no conflict of interest to disclose.

Prud'homme 2004, Taylor et al. 2004). Despite its established benefits, CR remains under-utilized, with rates of participation ranging from 13 to 60% in studies conducted in Europe, the United States, Canada and New Zealand (Cooper et al. 2002).

The problem of CR underutilization is multi-factorial in scope, and barriers have been identified at the patient, provider, program, and health-system levels (Cooper et al. 2002, Ades 2001, Grace et al. 2008a). Of particular importance are patient-level logistical and health system factors that are geographic in nature, such as CR site location and distribution, distance, transportation access, parking costs, and patient driving status (Cooper et al. 2002, Ades et al. 1992, Harrison, Wardle 2005, Missik 2001, Suaya et al. 2007, Yates, Braklow-Whitton & Agrawal 2003). For instance, longer distances and drive times have been frequently reported as reasons for CR non-enrollment and drop-out (King, Humen & Teo 1999, King et al. 2001). Moreover, rural patients are shown to be less likely to be utilizing CR (Brady et al. 2005, Johnson, Weinert & Richardson 1998). However, some inconsistent results are reported in the literature (Harrison, Wardle 2005, Johnson, Weinert & Richardson 1998, Curnier, Savage & Ades 2005).

Herein the evidence regarding the relationship between geographic indicators and CR utilization among CHD patients is synthesized and reviewed critically. For the purposes of this review, 'utilization' refers to all phases of the process from referral through enrollment, participation and completion. In particular, the current review investigated the effect of: (1) rural residence, and (2) distance and/or travel time on CR utilization. The latter were grouped together as they are often highly correlated.

Methods

For this narrative review, articles were identified by searching MEDLINE, CINAHL, and SCOPUS from January 1990 to January 2010, and references from key articles. Search terms included the following subject headings and key words*: cardiac rehabilitation, barriers, countryside, distance, travel time, commute, geographic, remote, residence, regional, rurality, underserved, small town, suburban, urban, access, attendance, enrollment, participation,* and *utilization*. English-language papers or abstracts were included if they were published in a peer-reviewed journal and were from primary or secondary observational or interventional studies in which participants were cardiac patients eligible for cardiac rehabilitation. Studies where patients reported geographic factors in relation to CR access were not incorporated into the summary tables, but were considered in the discussion section.

Results

There were 17 unique publications identified for inclusion, in which two of these studies (11.8%) assessed both distance and rurality status as geographic factors in CR utilization (Suaya et al. 2007, Higgins et al. 2008). Table 1 summarizes nine studies (47.4% of all included findings) assessing rurality in relation to CR utilization (Harrison, Wardle 2005, Suaya et al. 2007, King, Humen & Teo 1999, King et al. 2001, Brady et al. 2005, Johnson, Weinert & Richardson 1998, Higgins et al. 2008, Smith, Harkness & Arthur 2006, Sundararajan et al. 2004). Table 2 summarizes 10 studies (52.6% of all findings) which examined distance/travel time to CR (Ades et al. 1992, Missik 2001, Suaya et al. 2007, Yates, Braklow-Whitton & Agrawal 2003, Higgins et al. 2008, Melville et al. 1999, Grace et al. 2008b, De Angelis, Bunker & Schoo 2008, Dunlay et al. 2009, Brual et al. 2010). All studies are presented in chronological order and when necessary, alphabetical order of the first author.

Nine studies (52.9%) out of 17 unique studies were prospective cohort studies, six (35.3%) were retrospective cohort studies, and two (11.8%) were cross-sectional. Sample size ranges from 78–12,821 participants. Participants were diagnosed with a variety of coronary heart diseases (CHD) ranging from angina pectoris, to myocardial infarction (MI) and heart failure, and/or had undergone coronary artery bypass graft (CABG), and percutaneous coronary interventions. Three studies (17.6%) sampled only rural participants (Yates, Braklow-Whitton & Agrawal 2003, Johnson, Weinert & Richardson 1998, De Angelis, Bunker & Schoo 2008). One study (5.8%) sampled solely females (Missik 2001). Most studies defined CR utilization as “attending at least one CR session”. Only three studies (17.6%) distinguished between the effects of geographic barrier on CR enrollment versus level of participation (Harrison, Wardle 2005, Johnson, Weinert & Richardson 1998, Brual et al. 2010). Of these, only one study (5.8%) assessed the impact of geographic issues on CR program completion (Harrison, Wardle 2005).

Nature and Quality of the Geographic Indicators

Overall, 12 out of 17 unique studies (70.6%) reviewed used objective geographic indicators, while the remaining five studies relied on self-report distance/time (Ades et al. 1992, Missik 2001, Yates, Braklow-Whitton & Agrawal 2003, De Angelis, Bunker & Schoo 2008, Dunlay et al. 2009). All nine studies testing the relationship of “rurality” to CR utilization used different definitions of geographic indicator such as urban versus rural, patients’ location of residence, and degree of rurality or urbanization. For operationalizing rurality or urbanization, four previously-established classification were used: (1) the Montana State University (MSU) Index (Weinert, Boik 1995) which measures the degree of rurality by quantifying physical geography; (2) the Accessibility/Remoteness Index of Australia (ARIA) (The Information and Research Branch, Department of Health and Aged Care 2001), which is an index of remoteness derived from measures of road distance between populated localities and service centers developed using geographic information system (GIS) (The Information and Research Branch, Department of Health and Aged Care 2001); (3) remoteness classifications based on concordances developed and provided by the Australian Bureau of Statistics (ASGC Remoteness Areas) and the Department of Health and Ageing (The Information and Research Branch, Department of Health and Aged Care 2001); and (4) the Oxford-Countryside Agency classification of rural wards (Chandola et al. 2000), which is based on key local characteristics, landscape, settlement, historical and cultural influences. Moreover, three studies used municipal region to determine urbanization or rurality living status (e.g., living within metropolitan area) (King, Humen & Teo 1999, King et al. 2001, Smith, Harkness & Arthur 2006). One study used the Cardiac Care Network Ontario definition of living 30 minutes or greater from emergency care to define urban or rural living (Cardiac Care Network. 2002; Brady et al. 2005). One study used the census data linking to patients' zip code to determine rurality status (Suaya et al. 2007).

In the 10 articles using distance/travel time as a geographic indicator, studies used non-self-report indicators. Three non-self-report tools were used: (1) GIS which calculates distance and drive-time based on geographic and spatial information (Higgins et al. 2008, Melville et al. 1999, Grace et al. 2008b, Brual et al. 2010); (2) the US 2000 Census data and linked zip codes to levels of urbanization in which five quintiles were used to classify distance from CR site (Suaya et al. 2007); (3) as well as the cut-off of 30 minutes drive time to define "Accessible" health care services (Brady et al. 2005).

Rurality

As shown in Table 1, of the nine studies which assessed rurality, five studies (55.6%) showed a significant negative relationship between rurality and CR utilization (King, Humen & Teo 1999, King et al. 2001, Brady et al. 2005, Smith, Harkness & Arthur 2006, Sundararajan et al. 2004), two studies (22.2%) showed no relationship (Harrison, Wardle 2005, Higgins et al. 2008), two studies (22.2%) showed mixed findings (Suaya et al. 2007, Johnson, Weinert & Richardson 1998). One of these studies showed a significant positive relationship between rurality and CR utilization (Suaya et al. 2007).

Distance/Travel Time to CR

As shown in Table 2, of the 10 studies which assessed distance/travel time in relation to CR utilization (Ades et al. 1992, Missik 2001, Suaya et al. 2007, Yates, Braklow-Whitton & Agrawal 2003, Higgins et al. 2008, Melville et al. 1999, Grace et al. 2008b, De Angelis, Bunker & Schoo 2008, Dunlay et al. 2009, Brual et al. 2010), six studies (60%) reported a significant negative relationship (Ades et al. 1992, Suaya et al. 2007, Yates, Braklow-Whitton & Agrawal 2003, Higgins et al. 2008, Grace et al. 2008b, De Angelis, Bunker & Schoo 2008). Three studies (30%) showed no relationship between distance/Travel time to CR use (Missik 2001, Melville et al. 1999, Dunlay et al. 2009). One study (10%) showed a mixed finding (Brual et al. 2010).

Of the five studies which used objective geographic assessment of distance/travel time (Suaya et al. 2007, Higgins et al. 2008, Melville et al. 1999, Grace et al. 2008b, Brual et al. 2010), three studies (60%) found a significant negative association between distance/travel time and CR utilization (Suaya et al. 2007, Higgins et al. 2008, Grace et al. 2008b), while one (20%) study showed null findings (Melville et al. 1999) and one (20%) study showed a mixed findings (Brual et al. 2010).

Discussion

This paper reviewed the literature regarding the relationship between geographic factors and CR utilization among CHD patients. Overall, nine of the 17 (52.9%) studies identified reported a significant negative relationship between CR utilization and geographic indicators. However, four (23.5%) studies showed null effects (Harrison, Wardle 2005, Missik 2001, Melville et al. 1999, Dunlay et al. 2009), and four (23.5%) showed mixed findings (Suaya et al. 2007, Johnson, Weinert & Richardson 1998, Higgins et al. 2008, Brual et al. 2010). With regard to the studies finding mixed results, two studies, specifically found geographic barriers were significantly and negatively associated with enrollment, but that they were not linked to the degree of CR participation once enrolled (Johnson, Weinert & Richardson 1998, Brual et al. 2010). Another study showed that distance but not rurality status was related to utilization (Higgins et al. 2008). Finally, one study reported paradoxically that urban status and distance were positively associated with CR utilization (Suaya et al. 2007).

Self-Report vs Objective Geographic Indicators of Distance and Travel Time

All of the included studies which measured rurality were based on objective means of ascertainment. However, this was not the case in the instance of distance and travel time. This is a limitation given that the validity of self-reported geographic indicators has not been established in the CR literature. Self-reports of distance/travel time may be biased by errors in over- or underestimation, and may be affected by traffic congestion or poor driving conditions. Of the studies which used objective measures of distance/travel time to CR, three out of five studies (60%) showed a significant negative relationship. Of the studies that relied on self-report, three out of five studies (60%) reported a significant negative relationship. Therefore, the means of indicator ascertainment does not impact an overall conclusion that the majority of studies supported a significant negative relationship between geographic indicators and CR utilization.

Studies Showing no Relationship between CR Utilization and Geographic Indicators

Four studies found no association between geographic indicators and CR utilization (Harrison, Wardle 2005, Missik 2001, Melville et al. 1999, Dunlay et al. 2009). Two of these studies were conducted in the United Kingdom (UK) (Harrison, Wardle 2005, Melville et al. 1999). One of these studies involved a women only sample (Missik 2001), while the other study involved a small sample and a restricted range of geographic distance (Dunlay et al. 2009).

The first U.K. study by Melville et al. (1999) consisted of two cohorts of 878 patients who were admitted to hospital with MI who lived within 0–24 km of the CR site. Due to this restricted range, these results may underestimate the role of distance as a barrier to CR, given that all participants lived within the 20 mile or 32 km threshold of “accessible” healthcare services (Cardiac Care Network 1999). The second and more recent study conducted in the UK by Harrison et al. (2005) assessed factors influencing CR enrollment and completion in a predominantly rural locality. Again, the authors acknowledged that within this particular locality, geographic indices were relatively homogenous, which may explain why they were unrelated to CR utilization. Despite the lack of association between distance and CR, access was listed as a major self-reported barrier to CR among 50.8% of respondents. Access issues identified included problems with public transport, parking, and time and location of CR programs. Therefore, the reasons for CR non-utilization went beyond physical distance and were related to infrastructure and system-level barriers. Limitations of this study included not objectively measuring distance from home to CR programs, and focusing on one locality which limits generalizability to other localities where the distribution and availability of CR may differ.

While the lack of association could be attributed to the restricted geographic range in both studies, overall the relationship between geography and CR utilization in the UK may be different than what is evidenced in North America or Australia where much of this research has been conducted. Indeed there were only two studies identified for inclusion in this review from the UK, and both reported null effects. Reasons for this lack of association could be explained by the fact that the UK is more densely populated than North America and Australia, and its' transportation system maybe more developed. Geographic issues in CR access in the UK should perhaps be considered distinct from those in North America and Australia, requiring exploration of context-specific approaches to address CR access barriers. Further investigation is warranted.

The third null study consisted of a solely female sample (Missik 2001). When participants were interviewed about distance and transportation barriers, the latter was identified as a more important issue. In fact, it is well established that lack of transportation is a prominent barrier for female cardiac patients (Oldridge, Rogowski & Gottlieb 1992, Lieberman, Meana & Stewart 1998, Halm et al. 1999, Allen et al. 2004, Grace et al. 2009a). For instance, in a multi-site study of 226 female and 507 male CR non-attendees, participants were asked to rate the importance of transportation problems as a barrier to CR utilization (Grace et al. 2009a). Ratings were made on a five-point Likert scale, with higher scores indicating greater agreement that transportation serves as a CR barrier. Female non-attendees rated transportation problems (2.85±1.49) significantly higher than male non-attendees (2.42±1.35; $p<.05$). Indeed, the unique constellation of characteristics of female cardiac patients such as being more likely to be a widow, have a dependent spouse, live alone, and lack social support when compared to men (Carhart, Ades 1998) may also explain why transportation might be a more important factor than distance in CR under-utilization for women. Future research is needed to explore whether provision of transportation through shuttle buses for instance may have positive effects on women's geographic barriers for CR.

The last null study focused on 179 MI survivors in Olmsted County, Minnesota where there is a single CR program serving all residents (Dunlay et al. 2009). The geographic indicator was defined as < or > five miles distance from home to the CR site. Given this small sample size, short threshold distance chosen, the small number of CR non-attendees (n=64), and the restricted variability due to categorization, it is perhaps not surprising that distance from a CR site was not significantly associated with CR utilization. However, the p-value was .11, suggesting a trend and that with more power a relationship may have been detected. The choice of cut-off at five miles was discordant with the definition of accessible health care as 30 miles (Cardiac Care Network 1999). The authors did find however that ability to drive (OR=6.25) was significantly associated with CR utilization in the multivariate model. Caution is also warranted when interpreting the results considering Olmsted County has a remarkably high rate of CR participation (64.2%) when compared to Minnesota state (42.6%) or the US more broadly (18.7%) (Suaya et al. 2007), which may have affected the results. Overall, these four null studies raise important caveats to the overall association between geographic barriers and CR utilization, which warrant future investigation.

Studies Reporting Mixed Effects on CR Utilization

Four studies assessing rurality and/or distance as geographic indicators to CR utilization showed mixed findings (Suaya et al. 2007, Johnson, Weinert & Richardson 1998, Higgins et al. 2008, Brual et al. 2010). The first study (Johnson, Weinert & Richardson 1998) was one of only two studies to investigate both CR enrollment and degree of participation as outcomes, with the latter being defined as the number of sessions attended. Regression models adjusted for age, social support, intention to attend, and education were computed to determine the correlates of enrollment, and then number of CR sessions attended. Degree of rurality was significantly related to CR enrollment, but not the number of sessions attended**.** These findings suggest that among those who enroll, the role of geography as a barrier may no longer be relevant. Studies assessing CR barriers more broadly have reported similar findings. For example, Moore et al. (1998) reported that among CR program attendees, transportation and travel time had little importance in the decision to participate. Evenson et al. (2000) reported that participants who attended more than one session reported distance and transportation were no longer reasons for dropping-out. Finally, in another study 1222 CHD outpatients were asked to rate the importance of almost 20 CR barriers including distance and transportation problems (Grace et al. 2009a). As outlined above, ratings were made on a 5-point Likert scale, with higher scores indicating greater agreement that the factor serves as a CR barrier. CR non-attendees rated distance (2.74±1.43) and transportation problems (2.55±1.41) much higher than CR attendees (1.82±1.16 and 1.72±1.04, respectively).

These results are replicated in the most recent study by Brual et al (2010), where distance/travel time was significantly related to CR referral and enrollment but not degree of participation in CR. This study additionally investigated what drive time cut-off was significantly related to CR utilization in a Canadian setting. Results revealed that patients are significantly less likely to enroll in CR where drive times exceed 50 minutes.

The study by Suaya et al. (2007) presents the most comprehensive data available on the relationship between geography and CR utilization. In a large sample of 267, 427 U.S. outpatients who were either Medicare beneficiaries or over 65 years of age at the time of hospital discharge, results revealed negative associations consistent with the majority of studies when using a distance indicator, but positive association with CR utilization when using a rural/urban indicator. With regard to the former, outpatients' residence zip codes were used to determine distances to the closest CR site, based on the shortest distance (in miles). Distances were categorized in quintile groupings, with the first quintile group (referent group) ranging from 0.3 to 1.5 miles with a mean distance of one mile. Results revealed that distance was negatively associated with CR utilization. Outpatients in the furthest quintile group, with a mean distance of 31.8 miles and ranging from 15 to 231 miles, were 71% less likely to utilize CR (95% CI: 0.27–0.31). Distance remained a strong correlate of CR utilization even after adjusting for patient and hospital characteristics.

However, when outpatients' zip codes were used to create five quintile groups of rurality through urbanization based on claims files and census data, they found paradoxical results. Results revealed that when compared to those living in rural areas, outpatients living in the most urbanized areas were 36% less likely to utilize CR. Unfortunately, the authors did not address their paradoxical finding. It could be speculated that this highest quintile group is situated in an inner-city context of social deprivation. This would imply a curvilinear relationship between geography and CR utilization. Alternatively, the results could be explained by increased traffic congestion with increasing urbanization. This contention is not testable however, as travel time was not assessed. Further study to explore whether a curvilinear or linear association exists should be undertaken. If a curvilinear relationship is exposed, this would suggest that different approaches to geographic barriers would need to be applied in the context of great rurality or greater urbanization.

Lastly, the study by Higgins et al (2008) also presented mixed findings. They investigated both travel time and rurality status as correlates of CR utilization in 184 patients who underwent CABG at one hospital in Australia. Of the 170 (92%) patients followed-up, 122 patients (72%) attended CR. This is a much higher rate of CR enrollment than was evidenced in any other study included in this review, and is much higher than what is reported in other jurisdictions around the world. Indeed, the focus of the study was on optimizing CR referral strategies. Location of residence was used to categorize patients as rural/remote vs. metropolitan using remoteness classifications (The Information and Research Branch, Department of Health and Aged Care 2001). Results showed that rurality was not related to utilization. In multivariate analysis however, results showed that shorter travel time was significantly and positively associated with CR utilization. The authors unfortunately did not address their contradictory findings. This study was limited by a small sample size, limited to a single centre, and a low response rate (46%), which may explain the contradictory findings. However, it could also be speculated that given the best practices instituted regarding CR access in Australia, that rural patients were provided some alternative CR program delivery models such as home-based services. Indeed the role of alternative models of CR provision in overcoming CR barriers deserves much more study and application.

Other Geographic Barriers to CR Utilization

Through the literature search for this review, quantitative and qualitative studies which queried patients directly about their perceived geographic barriers to CR utilization were identified. Other than distance/travel time and rurality status, the following barriers were often self-reported: heavy traffic (Stokes 2008), parking problems, inconvenient program locations (Grace et al. 2002), cost of traveling, not having a driver's license or inability to drive (Dunlay et al. 2009, Winberg 2002, Jones et al. 2007, Dalal, Evans 2003, Wingham et al. 2006), and inclement weather leading to hazardous or congested traffic conditions (Blanchard et al. 2003, Fleury et al. 2004). Indeed, for rural patients, factors other than proximity to a program may influence attendance, such as the quality of roads and harsh weather in particular for northern-residing outpatients (Curnier, Savage & Ades 2005, Pell, Morrison 1998). Finally, heart failure patients reported that one of the reasons for non-attendance was anxiety over travel (Austin et al. 2005).

As raised earlier, several measures of CR barriers, including geographic ones have recently been developed and psychometrically-validated, enabling patients to rate the relative importance of a comprehensive list of barriers identified in the literature. Notably, the Cardiac Rehabilitation Barriers Scale (CRBS) (Shanmugasegaram et al. 2010) developed by our group, the Cardiac Rehabilitation Enrolment Obstacles scale (CREO) (Fernandez et al. 2008), the Cardiac Rehabilitation Preferences Form (CRPF) (Fernandez et al. 2007), and the Beliefs About Cardiac Rehabilitation scale (BACR) (Cooper et al. 2007) all include geographic barriers to CR utilization. With regard to the former, factor analysis of the CRBS has consistently revealed a 'logistical barriers' factor, where distance, transportation problems, cost (which would be related to travel in the Canadian context where it has been administered because CR services are paid through provincial health insurance), and severe weather have been consistently shown to be significantly and negatively associated with CR utilization (Shanmugasegaram et al. 2010, Grace et al. 2004). Overall, in a sample 1278 CHD outpatients of which 55% attended CR, the mean importance rating of distance as a barrier was 2.3±1.4, and transportation problems was 2.1±1.3, suggesting that both of these geographic barriers play an important role in CR utilization (Grace et al. 2009b). However, already exercising at home did appear to be a greater barrier than geography (highest mean rating at 3.0±1.4). In another sample of 1803 CHD outpatients, the mean importance rating of distance as a barrier was 2.2±1.1, and transportation problems was 1.9±1.1 on the CRBS. In fact, distance was the third most strongly-endorsed barrier after already exercising at home and personal or business travel (Shanmugasegaram et al. 2010). Mean individual item scores have not been published for the other barrier scales.

Implications for Health Policy and Practice

Overall, a negative and significant relationship between geographic barriers and CR utilization in the context of moderate population sizes and densities in North America was generally supported in this review. Thus, where a CR site is not available in proximity to a patient's home, referral to a home-based CR program would be indicated to ensure equitable access to these proven services. Studies comparing the efficacy of home-based versus traditional hospital-based CR found that it is just as effective (Dalal et al. 2007, Jolly et al. 2006), and may even be more cost-effective (Taylor et al. 2007). Indeed, patients frequently state that drive time and distance are important factors influencing their decisions to choose home-based over hospital-based CR (Grace et al. 2005). Innovative and alternative models of CR delivery in the literature also include developing 'satellite' support facilities (Fitchet et al. 2003), use of the internet to deliver services (Miller 1996), home visits by healthcare professionals, use of mail and fax to return completed activity logs, video recording, and transtelephonic electrocardiogram (ECG) monitoring of exercise progress (Dollard et al. 2004).

Several solutions to mitigate geographic barriers to on-site CR utilization were also proposed in the literature. Indeed, some patients are not safe candidates for unmonitored CR services. Healthcare officials may consider increasing access to CR by offering car pooling, free parking, or transportation such as shuttle buses in dense suburban areas. They may also consider offering more convenient scheduling of sessions that avoid peak rush-hour traffic.

Overall, public health officials and health policy decision-makers need to be more systematic in planning, delivering, and siting CR programs based on density of prevalent

CHD and CHD risk factors. Moreover, CR program staff should ensure that patients are referred to the site nearest home not the site nearest where they received acute care services. Where no programs are available in proximity to a patient's home or place or work, home of community-based services should be offered, or innovative modes of delivery adopted. Indeed, the results of the study by Higgins et al. in Australia raises some promising practices in optimizing CR access in the context of geographic barriers. Systematic CR referral strategies where patients are referred to the site closest to home and offered home-based services where a clinic-based program is not available within an acceptable driving distance for the patient could ensure the great majority of cardiac outpatients access CR services.

Gaps in Literature and Directions for Future Research

The studies reviewed herein originated from Australia, Canada, the US, and the UK. Therefore, the association of geographic indicators in other regions of the world such as Asia, South Asia, and other Eastern European countries is currently unknown. Moreover, the economics of CR provision in urban and rural environments and of alternative delivery models deserve much more research attention.

Several questions were raised for future study by this review through the process of critically appraising discrepant findings in the literature. First, there are unanswered questions as to the role geographic barriers play in the UK, where greater density and availability of public transportation may mitigate the negative relations to CR utilization which was evidenced in the North American setting. Second, the relative importance of geographic barriers included in CREO, BACR and CRPF scales should be considered. Third, these CR barriers scales should be administered in matched samples of urban and rural CHD outpatients in jurisdictions with different geographic characteristics to more comprehensively understand the role of geographic barriers to CR utilization.

Limitations

Caution is warranted when interpreting the current findings. This narrative review was not undertaken following a comprehensive and systematic literature search. In addition, the methodological quality of included studies was not rigorously assessed. These limitations introduce the potential of bias.

Conclusions

Geographic disparities as indicated by rurality and greater travel time and distance are a significant barrier to CR referral and enrollment in North American settings. This relationship may be less significant in the UK where greater density and availability of public transit may mitigate this effect. Geographic indicators appear to be unrelated to degree of CR participation once patients enroll. With regard to special populations, transportation access deserves consideration for female cardiac outpatients when promoting CR utilization, and social deprivation and traffic density deserves consideration when referring inner-city patients.

CR referral strategies being developed in Australia should be further tested for their potential to ensure cardiac inpatients are systematically referred to the most appropriate CR program model at the site closest to home. Indeed, plausible, low-cost interventions to overcome geographic barriers to CR access have long been identified in the literature. This synthesis of the literature provides the foundation for randomized controlled trials testing the effectiveness of these approaches.

Acknowledgments

Thank you to York University information specialist Mr. Rajiv Nariani for conducting the electronic database searches. Y Leung is supported by a CIHR Canada Graduate Scholarships Doctoral Award. J Brual was supported by a Heart and Stroke Foundation Master's Scholarship. S Grace is supported by a CIHR New Investigator Award.

References

Ades PA. Cardiac rehabilitation and secondary prevention of coronary heart disease. New England Journal of Medicine. 2001; 345(12):892–902. [PubMed: 11565523]

Ades PA, Waldmann ML, McCann WJ, Weaver SO. Predictors of cardiac rehabilitation participation in older coronary patients. Archives of Internal Medicine. 1992; 152(5):1033–1035. [PubMed: 1580707]

Allen JK, Scott LB, Stewart KJ, Young DR. Disparities in women's referral to and enrollment in outpatient cardiac rehabilitation. Journal of general internal medicine : official journal of the Society for Research and Education in Primary Care Internal Medicine. 2004; 19(7):747–753.

Austin J, Williams R, Ross L, Moseley L, Hutchison S. Randomised controlled trial of cardiac rehabilitation in elderly patients with heart failure. European Journal of Heart Failure. 2005; 7(3): 411–417. [PubMed: 15718182]

Blanchard CM, Courneya KS, Rodgers WM, Fraser SN, Murray TC, Daub B, Black B. Is the theory of planned behavior a useful framework for understanding exercise adherence during phase II cardiac rehabilitation? Journal of cardiopulmonary rehabilitation. 2003; 23(1):29–39. [PubMed: 12576910]

Boulay P, Prud'homme D. Health-care consumption and recurrent myocardial infarction after 1 year of conventional treatment versus short- and long-term cardiac rehabilitation. Preventive Medicine. 2004; 38:586–593. [PubMed: 15066361]

Brady, S., Thomas, S., Nolan, R., Brooks, D. Pre-coronary artery bypass graft measures and enrollment in cardiac rehabilitation. Lippincott Williams Wilkins; Philadelphia, PA: 2005.

Brual J, Gravely-Witte S, Suskin N, Stewart DE, Grace SL. Drive Time to Cardiac Rehabilitation: At What Point Does it Affect Enrolment Patterns. International Journal of Health Geographics. 2010; 9:27–37. [PubMed: 20525345]

Cardiac Care Network. The Ontario cardiac rehabilitation pilot project: Report and recommendations. Cardiac Care Network; Toronto, ON: 2002.

Cardiac Care Network. Consensus Panel on Cardiac Rehabilitation and Secondary Prevention Services in Ontario: Final report and recommendations. Cardiac Care Network; Toronto, ON: 1999.

Carhart RL Jr, Ades PA. Gender differences in cardiac rehabilitation. Cardiology clinics. 1998; 16(1): 37–43. [PubMed: 9507779]

Chandola, T., Lloyd, M., Wright, M., Wigglesworth, R. Rural deprivation: an analysis of the indices of deprivation 2000 for rural areas. Department of Social Policy and Social Work, Oxford University; Oxford: 2000.

Cooper AF, Jackson G, Weinman J, Horne R. Factors associated with cardiac rehabilitation attendance: a systematic review of the literature. Clinical rehabilitation. 2002; 16(5):541–552. [PubMed: 12194625]

Cooper AF, Weinman J, Hankins M, Jackson G, Horne R. Assessing patients' beliefs about cardiac rehabilitation as a basis for predicting attendance after acute myocardial infarction. Heart (British Cardiac Society). 2007; 93(1):53–58. [PubMed: 16905630]

Curnier, DY., Savage, PD., Ades, PA. Geographic distribution of cardiac rehabilitation programs in the United States. Lippincott Williams Wilkins; Philadelphia, PA: 2005.

Dalal HM, Evans PH. Achieving national service framework standards for cardiac rehabilitation and secondary prevention. BMJ (Clinical research ed). 2003; 326(7387):481–484.

Dalal HM, Evans PH, Campbell JL, Taylor RS, Watt A, Read KL, Mourant AJ, Wingham J, Thompson DR, Pereira Gray DJ. Home-based versus hospital-based rehabilitation after myocardial infarction: A randomized trial with preference arms--Cornwall Heart Attack Rehabilitation Management Study (CHARMS). International journal of cardiology. 2007; 119(2):202–211. [PubMed: 17196274]

De Angelis C, Bunker S, Schoo A. Exploring the barriers and enablers to attendance at rural cardiac rehabilitation programs. The Australian Journal of Rural Health. 2008; 16(3):137–142. [PubMed: 18471183]

Dollard J, Smith J, Thompson DR, Stewart S. Broadening the reach of cardiac rehabilitation to rural and remote Australia. European Journal of Cardiovascular Nursing. 2004; 3(1):27–42. [PubMed: 15053886]

Dunlay SM, Witt BJ, Allison TG, Hayes SN, Weston SA, Koepsell E, Roger VL. Barriers to participation in cardiac rehabilitation. American Heart Journal. 2009; 158(5):852–859. [PubMed: 19853708]

Evenson KR, Fleury J. Barriers to outpatient cardiac rehabilitation participation and adherence. Journal of Cardiopulmonary Rehabilitation. 2000; 20(4):241–246. [PubMed: 10955265]

Fernandez RS, Salamonson Y, Juergens C, Griffiths R, Davidson P. Development and preliminary testing of the Cardiac Rehabilitation Enrolment Obstacles (CREO) scale: Implications for service development. European Journal of Cardiovascular Nursing. 2008

Fernandez RS, Salamonson Y, Juergens C, Griffiths R, Davidson P. Validation of the Revised Cardiac Rehabilitation Preference Form in Patients With Post-Percutaneous Coronary Intervention. J Cardiopulm Rehabil Prev. 2007; 27(6):390–394. [PubMed: 18197074]

Fitchet A, Doherty PJ, Bundy C, Bell W, Fitzpatrick AP, Garratt CJ. Comprehensive cardiac rehabilitation programme for implantable cardioverter-defibrillator patients: a randomised controlled trial. Heart (British Cardiac Society). 2003; 89(2):155–160. [PubMed: 12527665]

Fleury J, Lee SM, Matteson B, Belyea M. Barriers to physical activity maintenance after cardiac rehabilitation. Journal of cardiopulmonary rehabilitation. 2004; 24(5):296–305. quiz 306–7. [PubMed: 15602147]

Grace SL, Evindar A, Kung TN, Scholey PE, Stewart DE. Automatic referral to cardiac rehabilitation. Med Care. 2004; 42(7):661–669. [PubMed: 15213491]

Grace SL, Gravely-Witte S, Brual J, Monette G, Suskin N, Alter DA, Higginson L, Stewart DE. Contribution of Patient and Physician Factors to Cardiac Rehabilitation Enrollment: A Prospective Multi-Level Study. European Journal of Cardiovascular Prevention and Rehabilitation. 2008a; 15(5):548–556–556. [PubMed: 18830085]

Grace SL, Gravely-Witte S, Brual J, Suskin N, Higginson L, Alter D, Stewart DE. Contribution of patient and physician factors to CR referral: A prospective multi-level study. Nat Clin Pract Cardiovasc Med. 2008b; 5(10):653–662. [PubMed: 18542104]

Grace SL, Gravely-Witte S, Kayaniyil S, Brual J, Suskin N, Stewart DE. A multi-site examination of sex differences in cardiac rehabilitation barriers by participation status. Journal of Women's Health. 2009a; 18(2):209–216.

Grace SL, Shanmugasegaram S, Gravely-Witte S, Brual J, Suskin N, Stewart DE. Barriers to cardiac rehabilitation: Does age make a difference? Journal of cardiopulmonary rehabilitation and prevention. 2009b; 29:183–187. [PubMed: 19471138]

Grace SL, Abbey SE, Shnek ZM, Irvine J, Franche RL, Stewart DE. Cardiac rehabilitation II: referral and participation. General hospital psychiatry. 2002; 24(3):127–134. [PubMed: 12062136]

Grace SL, McDonald J, Fishman D, Caruso V. Patient preferences for home-based versus hospital-based cardiac rehabilitation. Journal of Cardiopulmonary Rehabilitation. 2005; 25(1):24–29. [PubMed: 15714108]

Halm M, Penque S, Doll N, Beahrs M. Women and cardiac rehabilitation: referral and compliance patterns. The Journal of cardiovascular nursing. 1999; 13(3):83–92. [PubMed: 10098008]

Harrison WN, Wardle SA. Factors affecting the uptake of cardiac rehabilitation services in a rural locality. Public health. 2005; 119(11):1016. [PubMed: 16085152]

Higgins RO, Murphy BM, Goble AJ, Le Grande MR, Elliott PC, Worcester MU. Cardiac rehabilitation program attendance after coronary artery bypass surgery: overcoming the barriers. The Medical journal of Australia. 2008; 188(12):712–714. [PubMed: 18558894]

Johnson JE, Weinert C, Richardson JK. Rural residents' use of cardiac rehabilitation programs. Public Health Nursing. 1998; 15(4):288–296. [PubMed: 9682622]

Jolly K, Taylor RS, Lip GY, Stevens A. Home-based cardiac rehabilitation compared with centre-based rehabilitation and usual care: a systematic review and meta-analysis. International journal of cardiology. 2006; 111(3):343–351. [PubMed: 16316695]

Jones M, Jolly K, Raftery J, Lip GY, Greenfield S. BRUM Steering Committee . 'DNA' may not mean 'did not participate': a qualitative study of reasons for non-adherence at home- and centre-based cardiac rehabilitation. Family practice. 2007; 24(4):343–357. [PubMed: 17630271]

King KM, Humen DP, Smith HL, Phan CL, Teo KK. Predicting and explaining cardiac rehabilitation attendance. The Canadian journal of cardiology. 2001; 17(3):291–296. [PubMed: 11264562]

King KM, Humen DP, Teo KK. Cardiac rehabilitation: the forgotten intervention. The Canadian Journal of Cardiology. 1999; 15(9):979–985. [PubMed: 10504179]

Lieberman L, Meana M, Stewart D. Cardiac rehabilitation: gender differences in factors influencing participation. Journal of Women's Health. 1998; 7(6):717–723.

Melville MR, Packham C, Brown N, Weston C, Gray D. Cardiac rehabilitation: socially deprived patients are less likely to attend but patients ineligible for thrombolysis are less likely to be invited. Heart (British Cardiac Society). 1999; 82(3):373–377. [PubMed: 10455092]

Miller NH. The Use of the Telephone in Cardiac and Pulmonary Rehabilitation. Journal of Cardiopulmonary Rehabilitation. 1996; 16(6):349–52. [PubMed: 8985791]

Missik E. Women and cardiac rehabilitation: accessibility issues and policy recommendations. Rehabilitation nursing: the official journal of the Association of Rehabilitation Nurses. 2001; 26(4):141–147. [PubMed: 12035581]

Moore SM, Ruland CM, Pashkow FJ, Blackburn GG. Women's patterns of exercise following cardiac rehabilitation. Nursing research. 1998; 47(6):318–324. [PubMed: 9835487]

Oldridge NB, Rogowski B, Gottlieb M. Use of outpatient cardiac rehabilitation services: Factors associated with attendance. Journal of Cardiopulmonary Rehabilitation. 1992; 12:25–31.

Pell JP, Morrison CE. Factors associated with low attendance at cardiac rehabilitation. British Journal of Cardiology. 1998; 5:152–154.

Shanmugasegaram, S., Gagliese, L., Oh, P., Stewart, DE., Brister, S., Chan, V., Grace, SL. Psychometric validation of the cardiac rehabilitation barriers scale. 2010. Manuscript submitted for publication (copy on file with author)

Smith KM, Harkness K, Arthur HM. Predicting cardiac rehabilitation enrollment: the role of automatic physician referral. European journal of cardiovascular prevention and rehabilitation : official journal of the European Society of Cardiology, Working Groups on Epidemiology & Prevention and Cardiac Rehabilitation and Exercise Physiology. 2006; 13(1):60–66.

Stokes H. Reasons for non-adherence to cardiac rehabilitation programmes included lack of motivation, domestic duties, and other health problems. Evidence-based nursing. 2008; 11(2):63. [PubMed: 18364433]

Suaya JA, Shepard DS, Normand SL, Ades PA, Prottas J, Stason WB. Use of cardiac rehabilitation by Medicare beneficiaries after myocardial infarction or coronary bypass surgery. Circulation. 2007; 116(15):1653–1662. [PubMed: 17893274]

Sundararajan V, Bunker SJ, Begg S, Marshall R, McBurney H. Attendance rates and outcomes of cardiac rehabilitation in Victoria, 1998. The Medical journal of Australia. 2004; 180(6):268–271. [PubMed: 15012563]

Taylor RS, Brown A, Ebrahim S, Jolliffe J, Noorani H, Rees K, Skidmore B, Stone JA, Thompson DR, Oldridge N. Exercise-based rehabilitation for patients with coronary heart disease: systematic review and meta-analysis of randomized controlled trials. The American Journal of Medicine. 2004; 116(10):682–692. [PubMed: 15121495]

Taylor RS, Watt A, Dalal HM, Evans PH, Campbell JL, Read KL, Mourant AJ, Wingham J, Thompson DR, Pereira Gray DJ. Home-based cardiac rehabilitation versus hospital-based rehabilitation: a cost effectiveness analysis. International journal of cardiology. 2007; 119(2):196–201. [PubMed: 17084927]

The Information and Research Branch, Department of Health and Aged Care. Measuring Remoteness: Accessibility/Remoteness Index of Australia (ARIA). 2001. [Homepage of Commonwealth of Australia], [Online]. Available: http://www.health.gov.au/internet/main/publishing.nsf/Content/7B1A5FA525DD0D39CA25748200048131/$File/ocpanew14.pdf [2010, 1/28/2010]

Weinert C, Boik RJ. MSU Rurality Index: development and evaluation. Montana State University. Research in nursing & health. 1995; 18(5):453–464. [PubMed: 7676078]

Winberg B. Self-reported behavioural and medical changes in women after their first myocardial infarction: A 4-year comparison between participation and non-participation in a cardiac rehabilitation programme. European journal of cardiovascular nursing. 2002; 1(2):101. [PubMed: 14622762]

Wingham J, Dalal HM, Sweeney KG, Evans PH. Listening to patients: Choice of cardiac rehabilitation. European Journal of Cardiovascular Nursing. 2006; 5:289–294. [PubMed: 16545616]

Yates BC, Braklow-Whitton JL, Agrawal S. Outcomes of cardiac rehabilitation participants and nonparticipants in a rural area. Rehabilitation Nursing. 2003; 28(2):57. [PubMed: 12673978]

Table 1

Articles Examining Rurality as a Geographic Indicator of Cardiac Rehabilitation Utilization, N = 9

Study, Country	Design	Sample	Geographic Indicator	CR Utilization	Covariate Adjustment	Results
Johnson et al., 1998, United States	Prospective cohort. 3 assessment points: i) time of hospital discharge, ii) two weeks post-discharge, iii) one week after estimated completion of a 12-week with 3 sessions/week CR program, multi-centre.	N=254 rural residents hospitalized for MI, CABG, or PCI in four hospitals. Mean age 64, no SD or range available, 67% male, 98% white.	Degree of rurality based on location of residence. using the MSU Rurality Index. Grouped into 3 categories: 35% (N=89) of participants were classified as living on a farm/ranch or rural area; 34% (N=86) were classified as living in small towns, and 31% (N=79) were living in a city or suburban area.	Attended at least 1 of 36 sessions in a formal CR program. 72 (28%) self-report CR participation. 14 (19%) self-reported completing 1–18 sessions, 15 (21%) completed 19–35 sessions, 43 (60%) completed all 36 available sessions.	Model of Participation (N=254): Age, social support, intention to attend, & education. Model of Session Attended (N=74): Emotional health, social support, employment status, locus of control, functional abilities, economic adequacy, & health beliefs	Degree of rurality was significantly associated with utilization (β=−.649, p=0.005; N=254), but not associated with number of sessions attended.
King et al., 1999, Canada	Retrospective cohort of patients identified using health records between September 1, 1996 and August 31, 1997, multi-centre.	N=1245 outpatients following MI, PCI and/or CABG. Age range = 27–93 years Mean age: 63±11, 76.7% male, 98% English-speaking, 81% European origin	Location of residence: i) city (N=595; 47.8%), ii) metro area (N=133; 10.7%), iii) within 1 h of the tertiary care city (N=192; 15.4%), iv) within province (N=266; 21.4%), v) out of province (N=55; 4.4%), vi) out of country (N=4; 0.3%). Data was obtained via health records.	Attending at least 1 CR session, which was ascertained through health records. Program reported attendance rate was 28% (N=354).	English speaking; current smoker; sex; history of COPD/ Asthma; age; PCI; Neurological/Cognitive impairment	Living in the city of the tertiary care centre was associated with a greater likelihood of attending CR (OR=3.97, 95%CI= [2.97 – 5.31]).
King et al., 2001, Canada	Prospective cohort. Telephone interview at two time points: 2 weeks and approx. 6 months after hospital discharge, multi-centre.	N=304 outpatients following acute MI and/or CABG. 69.1% < 70 years of age, 76% male.	Location of residence: i) city or metropolitan (N=192; 53%), ii) within 1 hour of the closest CR program (N=50; 16.4%), iii) within the province (N=70, 23%) e, iv) out of province or country (N=22, 7.2%). Data was obtained via health records.	Attending at least 1 CR session. 96 (32%) self-reported CR attendance.	Age; sex; hypertension; diabetes; dyslipidemia; family history; smoking status; body mass index; number of risk cardiac? factors; NYHA class; previous cardiac event; self-efficacy; motivation; depression; social support; behavioural performance-health maintenance & role resumption	Participants living in the city were 4.5 times more likely to attend CR (OR=4.48, p<0.001).
Smith et al., 2005, Canada	Retrospective study of patients between 1 April 1996 and 31 March 2000, multi-centre.	N=3536 patients who underwent CABG, mean age=64.4±9.87; 79.1% male.	Geographic proximity was defined as to CR site was defined as living within Greater city region which was confirmed by postal code. 43.4% living within the city area. Data was obtained via health records.	Attending at least 1 CR service. 2121 (60%) patients attended the CR intake appointment. Of those who attended their intake appointment, 1466 (69.1%) enrolled in at least one session.	Preoperative CR; Sex; Hyperlipidemia; English Speaking; Previous CABG; Living with spouse; Age; Urgent surgery; Obesity; Diabetes.	Geographic proximity was a significant correlate of CR utilization (OR=2.85; 95%CI [2.44–3.33]).
*Suaya et al., 2007, United States	Retrospective design using Medicare claims files. Medicare beneficiaries hospitalized in 1997 with “a qualifying coronary discharge diagnosis” and aged	N=267,427 AMI and CABG outpatient Medicare beneficiaries aged ≥ 65 years at time of qualifying hospital admission. 56% male, 92% white.	Patient’s zip codes were linked with the US 2000 Census data to determine levels of urbanization. Five quintiles were used to classify levels of urbanization, with Q1 being high and Q5 being low level of urbanization.	18.7% (n=49,877) attended at least 1 session of outpatient CR, and attended an average of 24 of 36 sessions. Data obtained via database linkage.	sociodemographic; comorbid conditions; characteristics of the index hospitalization and inpatient facility; socioeconomic and disability characteristics of the patient’s zip code; state indicators; clustering of patients within their index hospital	Patients with the highest levels of urbanization were 36% less likely to utilize CR than those living in the most rural quintile (p<0.001).

Study, Country	Design	Sample	Geographic Indicator	CR Utilization	Covariate Adjustment	Results
	≥ 65 years at time of admission, multi-centre.					
Sundararajan et al., 2004, Australia	Retrospective cohort study from January to December 1998, multi-centre.	N=12,821 MI, CABG or PCI patients, age range 40–90 or up; 70.1% male.	Accessible geographic place of residence (yes/no) was indicated by Accessibility/Remoteness Index of Australia. N=2,477 (19.3%) living in inaccessible geographic place of residence; N=10,344 (80.7%) living in accessible geographic place of residence.	Attending at least 1 CR session. 23.7% participated in the CR program. 75% of these attendees completed a full 6–8-week program. Data was reported by 66 CR programs.	Age; Sex; Marital status; Cardiac diagnosis/procedure; Number of comorbid conditions; heart failure; Index admission to intensive care unit; Index admission classified as emergency; Type of hospital; quartile of economic resources	N=2552 (25%) patients living in accessible vs. N=489 (20%) living in inaccessible geographic place of residence were more likely to attend CR (OR=1.28; 95%CI [1.13–1.45]).
Brady et al., 2005, Canada	Prospective cohort. Two assessment time points: 1–2 weeks prior to surgery and 10–12 weeks post surgery, multi-centre.	N=78 patients undergoing CABG surgery in 1 of 2 tertiary hospitals in the same city. Age range = 43–79 years; Mean age 62±9, 95% male, 60% urban, 90% able to drive self.	Location of residence: urban (as defined as < 30 minutes from emergency care, N=46; 60%) or rural (≥ 30 minutes from emergency care, N=31; 40%). Data obtained via self-report survey.	No definition for enrollment. Self-report CR enrollment rate was 46%.	Exercise capacity, self-efficacy, depressive symptoms, stage of change	N=26 (57%) of urban participants enrolled in CR, compared to only N=9 (29%) of rural participants ($p<0.02$). Location of residence was a significant predictor of CR enrollment.
Harrison et al., 2005, United Kingdom	Retrospective cohort between January 2000 and December 2001, multi-centre.	N=236 patients w/ diagnoses included angina pectoris, MI, Subsequent MI, chronic ischemic heart disease, MI with heart failure, CABG, & Angioplasty of coronary artery. Mean age 67±1. 69% male, 83% rural.	Patients' location of residence was classified as rural (n=196, 84.1%) or urban (n=37, 15.9%) using the Oxford-Countryside classification of rural wards.	No definition for attendance. Overall, self-report CR utilization rate was 39%, with 23% completing the program.	Age; sex; deprivation; attended one of the three local main CR providers.	N=10 (27%) urban participants and N=80 (40.8%) rural participants participated in CR. N=7 (18.9%) urban participants and N=46 (23.5%) rural participants completed the program. Urban/rural locality was not associated with program completion.
Higgins et al., 2008, Australia	Prospective cohort between July 2001 and April 2004, single-site.	N=184 patients undergoing CABG, mean age=66±10; range, 42–88, 79.4% male.	170 patients were tracked. Patient's residence was classified as rural/remote (n=80, 47.1%) or metropolitan (n=90, 52.9%) using the Australian Institute of Health and Welfare guide.	Attending at least one CR session. 123 (72%) attended. Most patients (90/123, 73%) of these patients completed the full program. Data obtained via self-report & confirmed by CR programs.	None	66 (54%) urban participants and 24 (51%) rural participants attended CR. Location of residence was not related to utilization.

2MWT, Two Minute Walk Test, CABG, CAD, Coronary Artery Disease, coronary artery bypass graft, CHD, Coronary Heart Disease, COPD, Chronic Obstructive Pulmonary Disease, CR, cardiac rehabilitation, GIS, geographic information system, GPS, Global Positioning System, Km, Kilometers, CESEI, Cardiac Exercise Self-Efficacy Instrument, HADS-D, Hospital Anxiety and Depression scale-Depression subscale, MI, Myocardial Infarction, MSU, Montana State University, NYHA, New York Heart Association, NHAR, Nottingham heart attack register, PCI, Percutaneous Coronary Intervention, UA, Unstable Angina.

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* study measured both rurality and distance/time.

Table 2

Articles Examining Distance/Travel Time as Geographic Indicators of Cardiac Rehabilitation Utilization, N = 10

Study, Country	Design	Sample	Geographic Indicator	CR Utilization	Covariate Adjustment	Results
Ades et al., 1992, United States	Prospective cohort. Assessments at 2 time-points: prior to hospital discharge and 2–4 weeks post-discharge, single-site.	N=226 patients hospitalized for an MI or CABG surgery. Age range = 62–92 years. Mean age 70±6, 57% male.	Self-reported travel time from home to the CR program in Vermont in minutes.	No definition of CR use was provided. 47 (21%) self-reported participated.	Age; Sex; Education; Occupation; Marital Status; Primary care physician recommendation for participation; patient “denial” of severity of illness; history of depression; psychosocial characteristics; cardiac diagnosis; comorbidities; own and drive a car.	CR attendees had a significantly shorter mean travel time of 17±11 minutes, compared to 25±15 minutes among non-attendees (p=.003).
Melville et al., 1999, United Kingdom	2 Retrospective cohorts: 1992 and 1996, multi-centre.	1992: N=617, AMI patients from 2 large teaching hospitals, mean age 65±11, 65% male. 1996: N=261, AMI patients, mean age 66±12, 67% male.	GIS-calculated distance from home to hospital in km using “MapInfo” software.	Attending at least 1 CR session. 323 (52.4%) participated in the 1992 cohort. 131 (50.2%) participated in the 1996 cohort.	Age; Sex; Outpatient Admitted to one of the 2 hospitals in Nottingham) with appointment to Thrombolysis; Length of stay; Cardiac history; Complicated MI; Killip class; NHAR classification; Diuretic on discharge; Townsend (deprivation) score.	In the 1992 cohort, the mean distance from home was 6.2±3.6 km ranging from 0–24 km. Among the 1996 cohort, the mean distance from home was 6.4±4.1 ranging from 0–20.9 km. Distance was not a significant predictor in CR attendance in both cohorts.
Missik et al., 2001, United States	Cross-sectional comparative design between April 1, 1995 and September 30, 1995, single-site.	N=370 females treated and discharged with MI, PCI, angina, and/or CABG. Mean age 66±10, 88% with access to transportation.	Self-reported distance from home to nearest CR facility in miles. Distance as binary variable (< or ≥20 miles [or 32 km]).	Attending at least 1 CR session. 91 (24.6%) self-reported participated.	Education; history of CHD; cardiac diagnosis; physician referral; & insurance coverage.	Of those referred, 75 (21%) participants lived further than 20 miles or 32 km from the nearest CR site. 17 (19%) attendees lived farther than 20 miles or 32 km away, compared to 58 (22%) of non-attendees (p=n.s.).
Yates et al., 2003, United States	Cross-sectional, comparative design, single-site.	N=222 CAD in-patients. Mean age 67, age range = 41–92 years; 73% male, 97% Caucasian. All rural sample as defined as population <50,000 in one city or <100,000 in one metropolitan statistical area.	Self-reported distance from home to the nearest CR site in miles.	No definition of attendance available. 154 (69%) self-reported participated.	Education; physician explanation of CR; & being informed about CR during hospitalization.	The mean distance from CR for attendees was 10.7±14.1 miles or 17.1 km, compared to non-attendees who had a mean distance of 27.3±26.6 miles or 43.7 km (p<0.05). For every 10 miles that a patient lived closer to a CR site, they were 1.05 times more likely to attend (OR=1.05; 95%CI [1.02–1.07]).
Suaya et al., 2007, United States	Retrospective design using Medicare claims files from 1997, multi-centre.	N=267,427 MI and CABG outpatient Medicare beneficiaries aged ≥ 65 years at time of qualifying hospital	Distance from patient’s residence operationalized as zip code centroid to the nearest available CR facility within the state (located by its exact latitude and longitude). Five	Attending at least 1 CR session. 18.7% (n=49,877) attended at least 1 session of outpatient CR, and	Patient sociodemographics; comorbid conditions; characteristics of the index hospitalization and inpatient facility; socioeconomic and disability characteristics	Patients living in the farthest quintile were 71% less likely to participate in CR than those living in the quintile closest to a CR

Study, Country	Design	Sample	Geographic Indicator	CR Utilization	Covariate Adjustment	Results
		admission. 56% male, 92% white.	quintiles (Q) were used to classify distance from closest CR site, with Q1 being closest and Q5 being farthest.	attended an average of 24 of 36 sessions.	associated with the patient's zip code; state indicators; clustering of patients within their index hospital.	facility (OR=0.29; 95%CI [0.27–0.31]).
De Angelis et al., 2008, Australia	Prospective cohort between July and December 2005, multi-centre.	N=97 rural patients with a principal discharge diagnosis of PCI, CABG, AMI, or UA; mean age=66.5±10.8; age range 42–90; 72% male; One community-based and 5 hospital-based CR programs located within the Greater Green Triangle region in south-west Victoria were chosen as sites for this study.	Self-report distance from home to closest CR site in km	No definition of attendance available. 81 (84%) self-reported participated in the CR program.	None	Attendees lived an average of 15.4±20.6 km from the CR program whereas, non-attendees lived an average of 40.4± 37.5 km from the CR program (p=0.019).
Grace et al., 2008, Canada	Prospective cohort recruited from 97 cardiologists in Ontario, multi-centre.	N=1268 CAD patients, mean age=67.3±11.2; 71.8% male, 86.3% white.	Distance (km) and travel time (minutes) from home to closest CR were computed using GIS.	Attending at least one CR session. Overall, 469 (37%) self-reported enrolled in CR.	Physician referral intentions; physician perceptions of CR; Work status; income; Marital status; Education; Strength of provider CR endorsement; comorbidities; Age; Depressive symptoms; Exercise benefit perceptions; Illness perceptions; Functional status; Type of referring physician; CR barriers	The mean CR travel time and distance of CR attendees were 16.14 ± 23.91 km, 21.12 ± 23.03 minutes, for non-attendees were 27.91±87.34 km, 31.39 ± 79.23 minutes. Only distance was entered to the logistic regression model. Shorter distance to CR was a factor associated with enrollment (p<.001).
*Higgins et al., 2008, Australia	Prospective cohort between July 2001 and April 2004, single-site.	N=184 patients undergoing CABG, mean age=66±10; range= 42–88, 79.4% male.	Drive time (minutes) and distance (km) between the home and the CR site referred were calculated using GIS software: www.Whereis.com	Attending at least 1 CR session. 123 (72%) attended CR. Most patients (90/123, 73%) who attended one session completed the full program. Self-report data was confirmed by CR programs.	Whether patients being referred to the program at Royal Melbourne Hospital or elsewhere.	Mean travel time to CR for attendees was 11±10.1; for non-attendees was 16.4±8.2 (p=0.02). Travel time was significantly negatively related to CR utilization (OR=0.86; 95%CI (0.75–0.99)).
Dunlay et al, 2009, U.S.	Prospective cohort between June 2004 and May 2006, single-site.	N=179 patients with suspected MI, mean age=64.8 no SD or range was stated. 65.9% male.	Self-report driving distance from home to the CR site, with a cut-off <5 miles living from home to the CR site.	No definition of attendance available. 115 (64.2%) attended. The mean number of sessions attended within 90 days of MI was 13.5±8.2 of 36 sessions. Data obtained through electronic medical records.	None	Driving distance from a CR center was not significantly associated with CR utilization (p=0.11).
Brual et al., 2010, Canada	Prospective cohort recruited from 97 cardiologists in	N=1268 CAD out-patients; mean	Drive time (minutes) and distance (km) between the	Enrollment rate was reported as in Grace et al., 2008. Self-reported	None	Patients with 50–60 minutes drive time were less likely to enroll CR (OR=.51 [95%

Study, Country	Design	Sample	Geographic Indicator	CR Utilization	Covariate Adjustment	Results
	Ontario, multi-centre.	age=67.2±11.2, 71.8% male, 86.3% white.	home and the nearest CR site were calculated using GIS	degree of participation was defined by the percentage of prescribed sessions attended. Enrollees attended a mean of 84.6±25.7% of prescribed sessions. Data was verified by CR programs.		CI .26–.98]). Degree of participation among enrollees was not significantly related to drive time (p=0.63).

2MWT, Two Minute Walk Test, CABG, CAD, Coronary Artery Disease, coronary artery bypass graft, CHD, Coronary Heart Disease, COPD, Chronic Obstructive Pulmonary Disease, CR, cardiac rehabilitation, GIS, geographic information system, GPS, Global Positioning System, Km, Kilometers, CESEI, Cardiac Exercise Self-Efficacy Instrument, HADS-D, Hospital Anxiety and Depression scale-Depression subscale, MI, Myocardial Infarction, MSU, Montana State University, NYHA, New York Heart Association, NHAR, Nottingham heart attack register, PCI, Percutaneous Coronary Intervention, UA, Unstable Angina.

* study measured both rurality and distance/time.