Should geographic analyses guide the creation of regionalized care models for ST-segment elevation myocardial infarction?

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Read the related article by Alka B Patel and colleagues on pages 13-21.

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In the past half-century, we have witnessed substantial advances in the management of ST-segment elevated myocardial infarction (STEMI) that have led to large reductions in case-fatality. In the 1960s, the advent of defibrillation and coronary care units reduced in-hospital case-fatality rates by half, from 30% to 15%.[1] The "thrombolytic era" saw even greater reductions in mortality with the rapid administration of thrombolytic therapy.[2] Evidence from a number of recent randomized controlled trials has shown that primary percutaneous coronary intervention (PCI) is superior to thrombolysis provided it is delivered within 90 minutes.[3] Despite these improvements, STEMI continues to be a serious and costly condition that imposes enormous burdens on individuals, caregivers and Canadian society. In 2004, myocardial infarctions accounted for 8%, or 18 102,[4] of the 226 584 deaths nationwide.

In Canada, 40 hospitals are currently equipped to provide PCI. These PCI facilities are located in larger urban centres in nine provinces. Given the geographic size of Canada and he relatively few PCI facilities, timely access to primary PCI for STEMI is currently available only to people living in or close to those urban centres. For Canada's 16.6 million people aged 40 years and over, there is one PCI facility for every 416 000 people; this is a fraction of what is available in the United States, where 140 million people aged 40 and over have access to 2100 PCI facilities.[5]

Geographic information systems (GIS) are a novel way of studying the effects of regionalization that can help guide strategies for resource allocation in Canada and other countries with a large land mass whose populations are concentrated in relatively few cities. In this issue of *Open Medicine*, Patel and colleagues report the estimated travel times by ground transportation to PCI facilities across Canada.[6] They used the geographic centre of individual census dissemination areas (the smallest geographic unit at which the census is publicly distributed) as the originating point of travel. These distances were used to estimate the proportion of the Canadian population aged 40 and older with timely access to PCI facilities (within 60, 90 and 120 minutes). The authors found that 63.9% of Canadians 40 years of age and older had access to a PCI facility within 60 minutes, 72.4% within 90 minutes and 78.8% within 120 minutes.

Patel and colleagues also examined the effect on these estimates of the hypothetical addition of a new PCI facility in medium-sized cities in the four most populated provinces: Kelowna (British Columbia), Lethbridge (Alberta), St. Catharines (Ontario) and Trois Rivières (Quebec). They estimated that the proportion of the population with access to a PCI facility within 60 minutes would increase by 3.2% and 4.3% depending on the province. They also estimated that about 17 deaths within four to six weeks of an acute myocardial infarction (AMI) and 34 recurrent nonfatal myocardial infarctions or strokes could be avoided through the addition of these four hypothetical facilities.

GIS analyses have an important and growing role in health services and population health research. They provide useful tools to document inequity in access to services across communities and neighbourhoods. They can also be used to assess populations at risk for environmental exposures, to optimize allocation of human resources, to identify effective and convenient means of transportation to facilities and services for users, and to characterize the health needs of specific populations. Investigators are now moving beyond the technical implementation by using GIS to develop practical

knowledge about person, place and time. For example, an earlier study by some of the same authors analyzed geographic areas and populations with timely access to PCI facilities by different modes of transportation in the province of Alberta.[7] They found that, compared with air ambulance, ground transportation by ambulance covered a greater proportion of the population and, in some areas, greater distances within the critical 90-minute window. They concluded that, in Alberta, air ambulances were not an effective means of transporting patients to a PCI facility.

In the current study, Patel and colleagues show an interesting and straightforward application of GIS analysis. The road network analysis using GIS is beneficial in incorporating a temporal component of geographic access. As expected, the authors found that "The hypothetical addition of a new PCI facility in each of the 4 most populated provinces would increase the proportion of the population with timely access." Based on their analyses, they seem to be advocating for new PCI facilities. Although the straightforward study design may seem compelling, we think that Patel and colleagues have oversimplified the issue and that numerous other factors are required to develop models for regionalized STEMI care.

First, serious concerns have been raised about the assertion that PCI is superior to thrombolysis, including potential biases and confounding that threaten the internal validity of the randomized trials.[8,9] For example, although randomized clinical trials have confirmed the superiority of PCI over fibrinolysis,[10] patients enrolled in the larger trials were selected mostly from high-volume centres. Studies from the late 1980s and 1990s showed reduced mortality and better outcomes in PCI facilities with larger volumes, which led to the 2001 consensus recommendation of a minimum institutional requirement of 400 procedures per year.[11] Since then, improvements in PCI, including stenting and better technology, have made the procedure considerably safer, such that the relation between volume and in-hospital mortality has weakened.[12] Nevertheless, there remains a relation between patient volume and major adverse cardiovascular events,[13] and technological improvements have yet to completely offset the effect of volume on PCI outcomes.[14] That finding is of direct relevance to regionalized STEMI care models in Canada. The lower procedural volumes that would be likely in the four hypothetical PCI facilities described by Patel and colleagues may be prone to suboptimal patient outcomes. The external validity of the randomized trials must also be considered carefully: one trial enrolled only 17% of the screened population,[15] which begs the question of the applicability of the results; in another trial, from the United States, only 4% of patients were treated within the critical 90-minute window.[16]

Second, the authors estimated that, each year, "about 17 deaths that would have occurred within 4–6 weeks of an AMI and 34 recurrent nonfatal myocardial infarctions or strokes could be avoided through the addition of these 4 hypothetical facilities." Again, we believe that their analysis is oversimplified. The development of credible estimates of this nature would require more robust and better described methodology that included estimates of dispersion and of the degree of confidence in the results. In the worst case, those numbers could be quoted inappropriately.

Third, even if the authors' estimates are correct, basing the case for new PCI facilities on avoiding such a relatively small number of deaths within four to six weeks of an AMI—which amount to less than 0.01% of the 201 488 deaths in the 4 target provinces in 2008—might be used as evidence against the addition of those facilities.

Regardless of whether primary PCI or fibrinolysis is chosen, the successful reperfusion of the infarct-related artery in the shortest amount of time is a key determinant of optimal patient outcomes. Contemporary evidence suggests that the speed of reperfusion after infarct onset may be more important than whether mechanical or pharmacological intervention is used. Furthermore, the evidence suggests that the impact of delay to reperfusion on outcome depends considerably on patient age, infarct location and symptom duration.[17] For example, a patient younger than 65 years with an anterior myocardial infarction and less than 2 hours of symptoms can have a PCI-related delay of only 40 minutes. Conversely, a patient 65 years or older with an inferior myocardial infarction and at least 2 hours of symptoms can be subjected to a PCI-related delay of 179 minutes.[17]

In terms of allocating resources, would investments other than new PCI facilities reduce the burden of STEMI to a greater degree? Policies to reduce travel times to existing facilities may be more effective or less costly for achieving the same outcomes. For example, studies done in Calgary and Ottawa have shown that prehospital assessment and direct transfer (bypassing the emergency department) to the appropriate facility can speed access to PCI.[18,19] Although these strategies are not applicable to Canadians living in areas without a nearby PCI facility, organizational strategies such as those could be more effective in shortening the mean delay to PCI, be less expensive, and be more straightforward to implement than the addition of new PCI facilities.

Underlying the authors' GIS-based approach to regionalized STEMI care models is the question "how can the highest proportion of the Canadian population be provided with rapid access to PCI?" That question, which views access to PCI in isolation, is not useful for decision-makers. More relevant questions are "How much PCI should the health care system provide?" "How quickly?" and "To which patients?"[20] Current guidelines explicitly recognize that the "emphasis on PCI should not obscure the importance of fibrinloytic therapy"[21] and that a regionalized STEMI care model must include all alternative therapies, including facilitated PCI (administration of thrombolysis before a planned immediate PCI) and thrombolysis. From an economic point of view, even if, on balance, PCI is considered cost-effective relative to thrombolysis for treating STEMI, Canada's large geographic size necessitates a mix of services because thrombolysis is easier to administer and requires less specialized equipment. Even then, the incremental cost-effectiveness of PCI will vary according to many factors, among them distance to the facility, volume and organization of STEMI treatment.

More generally, tertiary care cardiology services must be viewed in the context of delivering all health services and other societal goods by explicitly considering technical efficiency (the degree to which a given set of inputs is used to produce an output) and allocative efficiency (the degree of benefit derived from a specific distribution of resources).[22] The line of reasoning that seeks the most efficient ways of delivering health care is consistent with the ethical stance arising from a single public payer constrained by a fixed health care budget. Of course, other ethical stances must be considered, including the rights of all Canadians to timely access to treatment for STEMI.[23]

Health services researchers must take the lead in developing a modern approach to health care delivery by identifying and testing new policies designed to equitably meet the health needs of the entire population. For example, the demographic composition of the population determines to a large degree which health services are required. Given the rapid increase in the rate of acute coronary syndromes after age 50 years and the increasing size of our elderly population, there may be a need for increased services to treat STEMI in Canada. That trend may be offset by lower age-standardized rates of death from AMI, which declined substantially between 1994 and 2004.[4] Although the information is dated, investigators have attributed two-thirds of this decline to healthier lifestyles and better primary prevention and one-third to reduced case-fatality rates owing mainly to treatments.[24,25] Studies designed to increase knowledge about the interplay between these trends are critical for planning services for cardiovascular health promotion, prevention and treatment. GIS analysis can play an important role in that effort by helping assess the population at highest risk for cardiovascular disease, describing the need for services and identifying effective means of transportation to PCI facilities.

A modern approach to examining the delivery of health services must go beyond studying isolated tertiary care services such as PCI. Although Patel and colleagues provide information on population coverage that would be required for establishing new PCI facilities, their regionalized STEMI care model views PCI in isolation, does not estimate the return on investment and is predicated on adding hypothetical PCI facilities based on existing models of care delivery. In the face of increasing expectations from the public and greater fiscal constraints, real improvements in efficiency, sustainability, quality and appropriateness of health care require new methods of delivering services that go beyond growth of the existing system. Without doing so, a reasoned and cohesive plan for developing a sustainable, responsive, transparent and equitable health care system will remain elusive.

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