Cardiac arrest care and emergency medical services in Canada

Christian Vaillancourt MD MSc FRCPC[1,2], Ian G Stiell MD MSc FRCPC[1,2],
for the Canadian Cardiovascular Outcomes Research Team

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BACKGROUND: Heart disease is the primary cause of mortality in Canada and survival to hospital discharge from out-of-hospital cardiac arrest is low.
OBJECTIVE: To provide an overview of the outcomes for out-of-hospital cardiac arrest in Canada.
METHODS: A national, descriptive, Utstein-style analysis of cardiac arrest care and emergency medical services was conducted. Data were compiled from five sources: the City of Edmonton Emergency Response Department, the British Columbia Ambulance Service, the Nova Scotia Emergency Health Services, the Urgences-santé corporation of the Montreal Metropolitan region and the Ontario Prehospital Advanced Life Support (OPALS) Study database.
RESULTS: There were 5288 cardiac arrests from a range of small communities to large provincial cardiac arrest registries in 2002. They were men (62.6% to 70.1%) in their sixties and seventies, witnessed (35.2% to 55.0%), rarely receiving bystander cardiopulmonary resuscitation (CPR) (14.7% to 46.0%), often in asystole (35.7% to 51.3%), arresting at home (56.1%) and rarely surviving to hospital discharge (4.3% to 9.0%). Bystander CPR and early first responder defibrillation were significantly associated with increased survival. Cardiac arrest incidence rates per 100,000 varied between 53 and 59 among provinces and followed a downward trend.
CONCLUSIONS: The results of this study could be an important first step toward a national cardiac arrest registry comparing the impact of regional differences in patient and system characteristics. Many communities do not have accurate data on their performance with regards to the chain of survival, or need to significantly improve their capacity for providing citizen bystander CPR and rapid first responder defibrillation.

Key Words: *Canada; Cardiac arrest; Cardiopulmonary resuscitation; Emergency medical services; Sudden cardiac death*

Les soins et les services médicaux d'urgence en cas d'arrêt cardiaque au Canada

HISTORIQUE : La maladie cardiaque est la principale cause de mortalité au Canada, et la survie au congé hospitalier après un arrêt cardiaque hors du milieu hospitalier est faible.
OBJECTIF : Donner un aperçu des issues des arrêts cardiaques à l'extérieur du milieu hospitalier au Canada.
MÉTHODOLOGIE : On a procédé à une analyse nationale et descriptive de style d'Utstein des soins et des services médicaux d'urgence en cas d'arrêt cardiaque. Les données ont été compilées à partir de cinq sources : la division des interventions d'urgence de la ville d'Edmonton, les services ambulanciers de la Colombie-Britannique, les services d'urgence de la Nouvelle-Écosse, la Corporation d'urgences-santé de la région de Montréal métropolitain et la base de données de l'étude ontarienne sur les soins préhospitaliers avancés de maintien des fonctions vitales.
RÉSULTATS : On a recensé 5 288 arrêts cardiaques dans les registres des arrêts cardiaques des petites collectivités jusqu'aux grands centres provinciaux en 2002. Il s'agissait d'hommes (62,6 % à 70,1 %) sexagénaires et septuagénaires, observés (35,2 % à 55,0 %), recevant rarement une réanimation cardiorespiratoire (RCR) (14,7 % à 46,0 %), souvent en asystole (35,7 % à 51,3 %), subissant l'arrêt cardiaque à domicile (56,1 %) et survivant rarement au congé hospitalier (4,3 % à 9,0 %). Une RCR aux victimes et une défibrillation précoce de premier répondant s'associaient de manière significative à une augmentation de la survie. Les taux d'incidence d'arrêt cardiaque pour 100 000 habitants variaient entre 53 et 59 selon les provinces et affichaient une tendance à la baisse.
CONCLUSIONS : Les résultats de cette étude pourraient constituer une première étape importante vers un registre des arrêts cardiaques permettant de comparer les répercussions des différences régionales chez les patients et les caractéristiques des divers systèmes. De nombreuses collectivités ne possèdent pas de données exactes sur leur rendement en matière de chaîne de survie ou ont besoin d'améliorer de manière significative leur capacité d'effectuer une RCR aux victimes et une défibrillation rapide de premier répondant.

Cardiac arrest is defined as "…the cessation of cardiac mechanical activity, confirmed by the absence of a detectable pulse, unresponsiveness and apnea (or agonal, gasping respiration)" (1). The victim collapses when the cardiac mechanical activity becomes too limited to provide adequate blood flow and oxygen to the brain and muscles. The victim is perceived to be lifeless if no vital signs (responsiveness, pulse or respiration) are detectable. Electrical cardiac activity (ventricular fibrillation, ventricular tachycardia or pulseless electrical activity) seen on a cardiac monitor may be the only sign of vital activity. In the absence of cardiopulmonary resuscitation (CPR) and/or electrical defibrillation, such electrical cardiac activity disappears (asystole), followed by death in a matter of minutes.

Heart disease is the primary cause of mortality in Canada (2). The estimated initial cost for the care of a single cardiac arrest patient, expressed in 1996 American dollars, in a standard Emergency Medical Services (EMS) system is $5,900

[1]*Ottawa Health Research Institute, Ottawa;* [2]*Department of Emergency Medicine, University of Ottawa, Ottawa, Ontario*
Correspondence: Dr Christian Vaillancourt, The Ottawa Hospital, Civic Campus, Clinical Epidemiology Unit, Room F658, 1053 Carling Avenue, Ottawa, Ontario K1Y 4E9. Telephone 613-798-5555 ext 17012, fax 613-761-5351, e-mail cvaillancourt@ohri.ca
Reprints: Susan Brien, Canadian Cardiovascular Outcomes Research Team, Institute for Clinical Evaluative Sciences, G246 2075 Bayview Avenue, Toronto, Ontario M4N 3M5. Telephone 416-480-4055 ext 3874, fax 416-480-6048, e-mail susan.brien@ices.on.ca
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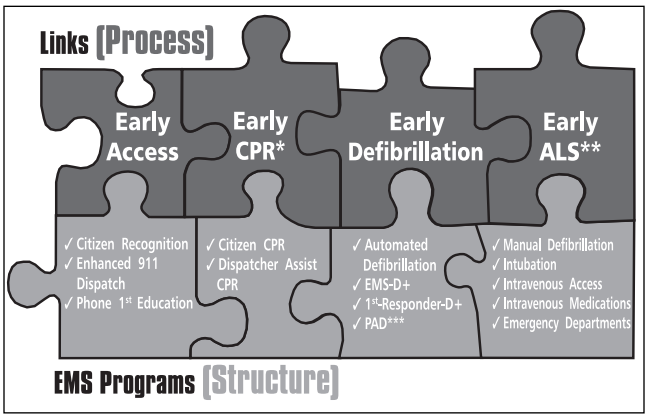

Figure 1) *Chain of survival. Separate emergency medical service (EMS) program components (structure) are required to produce strong links (process) in the chain. *Cardiopulmonary resuscitation (CPR); **Advanced life support system (ALS); ***Public access defibrillation (PAD). D+ Defibrillation capacity. Reproduced with permission from reference 34*

(interquartile range $3,200 to $10,900) (3). Over 70% of cardiac arrests occur outside the hospital (4), and 40% of all deaths from heart disease occur suddenly and may constitute the first manifestation of heart disease (5). Seventy-five per cent of cardiac arrests are caused by mechanical or electrical cardiac dysfunction, with coronary artery disease being the most frequent condition leading to such cardiac dysfunction (6). In 25% of cases, cardiac arrest is the result of another condition, such as airway obstruction, sepsis, hemorrhage or drowning (7).

Unfortunately, survival to hospital discharge from out-of-hospital cardiac arrest is low, with survival rates in several Canadian communities reported to be between 2.5% and 12% (8-10). This is in contrast with the often spectacular dramatization of resuscitation efforts depicted in certain television series; the success in bringing patients back to life in this medium has been observed to be as high as 75%, a very unrealistic number (11). The 'chain of survival' illustrates important concepts in the treatment of out-of-hospital cardiac arrest (Figure 1). The chain metaphor implies that cardiac arrest care is only as strong as its weakest link among 'early access', 'early CPR', 'early defibrillation' and 'early advanced life support (ALS)'. Ultimately, survival from cardiac arrest is dependent on the 'strength' of individual links, with each link representing a specific community response to the emergency situation of cardiac arrest.

The purpose of the present study was to provide an overview of the outcomes for out-of-hospital cardiac arrest in Canada, presenting patient and system characteristics at a regional and provincial level. Each link of the 'chain of survival' was considered and future directions for the care of out-of-hospital cardiac arrest were explored.

METHODS

Data sources

The information presented in the present study was collected and presented using the Utstein style, a widely accepted standard method to study and report on out-of-hospital cardiac arrest (1). Cases included in the analysis were limited to cardiac arrest cases of cardiac origin for which resuscitation was attempted. The cause of a cardiac arrest was determined using all available information, including autopsy findings when available. EMS providers were entitled to not initiate or pursue resuscitative efforts in accordance with a predetermined list of conditions, such as rigor mortis, decapitation or early decomposition.

A convenient sample of EMS directors and researchers across Canada in the field of cardiac arrest were approached. Data were compiled from five sources: the City of Edmonton Emergency Response Department, the British Columbia Ambulance Service, the Nova Scotia Emergency Health Services, the Urgences-santé corporation of the Montreal Metropolitan region and the Ontario Prehospital Advanced Life Support (OPALS) Study database. Data collection was mandated by regional health care organizations and/or approved by the institutional review board of participating base hospitals (OPALS Study). Representatives from Calgary, Alberta; Hamilton, Ontario; Quebec City, Quebec; and Toronto, Ontario, were also approached, but they were unable to participate at the time of data collection.

City of Edmonton Emergency Response Department: The city of Edmonton is equipped with a multiple-tier system comprising firefighters and basic care paramedics equipped with defibrillators, as well as advanced care paramedics. Information on cardiac arrest is abstracted from relevant ambulance call report forms and entered into a registry. In-hospital survival outcomes were collected until the implementation of the Alberta Health Information Act five years ago; the act now prohibits access to patient hospital records without their consent. Edmonton contributed data from 1997 to 2002, with the latest survival to hospital discharge data reported in 1999.

British Columbia Ambulance Service: British Columbia is equipped with a multiple-tier system comprising firefighters and basic care paramedics equipped with defibrillators, as well as advanced care paramedics in urban centres. Information on cardiac arrest is abstracted from relevant sources and entered into a proprietary database developed by Medtronic Physio-Control, a central provincial registry located in Victoria. Information on in-hospital survival outcomes was not available. British Columbia contributed data for the year 2002.

Nova Scotia Emergency Health Services: Nova Scotia is equipped with a multiple-tier system comprising firefighters and basic care paramedics equipped with defibrillators, as well as advanced care paramedics. Information on cardiac arrest was abstracted from a prehospital patient care record form and entered manually into a central provincial registry. Information on in-hospital survival outcomes was also extracted. Nova Scotia contributed data from 1998 to 2002.

Urgences-santé corporation of the Montreal Metropolitan region: The Urgences-santé corporation of the Montreal Metropolitan region is responsible for the care of over 2.14 million citizens distributed in 46 large and small municipalities. During the period of collection of data submitted for the present report, the Urgences-santé corporation was equipped with a two-tier system primarily comprising basic care paramedics equipped with defibrillators and a number of mobile emergency physicians, who also offered on-line supervision from the dispatch centre. Since then, the Urgences-santé corporation has been in the process of replacing physicians by advanced care paramedics, as well as expanding their volunteer

and firefighter first responder program. Information on cardiac arrest was abstracted from a prehospital patient care record form and entered into a central registry. Information on in-hospital survival outcomes was extracted with the authorization of the director of professional services at receiving hospitals. Montreal contributed data from 1995 to 2001.

OPALS Study database: The OPALS Study database is the largest prospective database on cardiac arrest known worldwide, and is unique in its degree of standardization and quality control (12). It was developed in the context of a before-and-after multicentre trial evaluating the incremental benefit of rapid defibrillation followed by advanced cardiac care on survival from out-of-hospital cardiac arrest. The database also includes victims of trauma, acute respiratory distress and chest pain. OPALS Study data were collected in 21 communities by 11 participating base hospital programs staffed with firefighters and basic care paramedics equipped with defibrillators, as well as advanced care paramedics. Data were abstracted from the ambulance call records, rhythm records, dispatch reports and in-hospital records before being sent to the co-ordinating centre in Ottawa. Although data collection began in July 1991, data from 1995 to 2002 were included in the present report.

Statistical analysis

A national descriptive analysis of cardiac arrest care and EMS was conducted. The incidence rate of cardiac arrest cases of cardiac origin for which resuscitation was attempted in the year 2002 per 100,000 population was calculated using 1991 Canadian census data. Similarly, trends in the cardiac arrest incidence rate for Edmonton (1997 to 2002), Ontario communities (1995 to 2002), Montreal Metropolitan region (1995 to 2001) and Nova Scotia (1998 to 2002) were explored.

Patient characteristics for the year 2002 included the percentage of men, median age, percentage of collapse witnessed by a citizen bystander, initial cardiac rhythm seen on the monitor and cardiac arrest location (British Columbia, Ontario communities or Nova Scotia). The cardiac arrest location in Ontario communities was reported over a five-year period (1995 to 2000) and was obtained via electronic linkage between the OPALS database, the Provincial Ambulance Response Information System (ARIS) database and the Municipal Property Assessment Corporation database. Base hospital personnel manually extracted the information from the ambulance call reports in cases where OPALS Study records could not be found in the ARIS database, no specific address could be found in the Municipal Property Assessment Corporation database (eg, cardiac arrest occurred on the street) or the MPAC database could not provide a location description for the address submitted.

System characteristics for the year 2002 included the percentage of CPR being performed by a citizen bystander, firefighters or policemen, or EMS paramedics. In the case of British Columbia, no distinction could be made between CPR performed by a citizen bystander or a firefighter first responder. Similarly, trends in citizen bystander CPR for Ontario communities (1995 to 2002), the Montreal Metropolitan region (1995 to 2001) and Nova Scotia (1998 to 2002) were explored. The median time intervals between the receipt of a call by a dispatch centre and arrival at the scene of the first responding unit equipped with a defibrillator was described, as was the percentage of times for which that unit comprised firefighter first responders.

Overall survival rates to discharge from hospital and 95% CIs were reported for all victims of cardiac arrest of cardiac origin for which resuscitation was attempted. Similarly, trends in overall survival for the city of Edmonton (1997 to 1999), Ontario communities (1995 to 2002), the Montreal Metropolitan region (1995 to 2001) and Nova Scotia (1998 to 2002) were explored. Also, survival by initial cardiac rhythm was stratified. Finally, the Utstein methodology suggests that system performance should be compared using survival rates among bystander-witnessed victims for which the initial cardiac rhythm was ventricular fibrillation or tachycardia, and for whom bystander CPR was administered. Such estimates were obtained for the Ontario communities, Montreal and Nova Scotia.

The results of locally performed descriptive analysis as provided by British Columbia, Edmonton, the Montreal Metropolitan region and Nova Scotia were used. OPALS data were analyzed using SAS version 8.01 (SAS Institute, USA).

Interpretative cautions

Apart from the OPALS Study, there was no direct access to raw data provided by the other four large regions, and simple data cleaning verifications could not be performed. However, descriptive statistics prepared by well-renowned researchers and organizations in the field of cardiac arrest were available.

Caution needs to be used when comparing regions with one another. Although the Utstein methodology was usually followed, there were some differences among sites. Edmonton, the OPALS Study communities and Nova Scotia limit their reports to a population aged 16 years and older. Montreal and British Columbia include all ages in their reports. Montreal defines "return of spontaneous circulation" as maintaining a pulse until arrival to receiving hospital, whereas Utstein defines it as "any" return of circulation, regardless of duration. The British Columbia database cannot make the distinction between citizen bystander-initiated and volunteer firefighter-initiated CPR.

RESULTS

Incidence rates, demographic characteristics and clinical characteristics for cardiac arrests occurring in 2002 are presented in Table 1. Information for 5288 cardiac arrests from a range of small communities (Lindsay, Ontario; population 16,696) to large provincial cardiac arrest registries (British Columbia; population 3,282,061) was obtained. Cardiac arrest incidence rates per 100,000 varied between 53 and 59 among provinces. Most victims were men in their late sixties or early seventies. Their collapse was witnessed 35.2% to 55.0% of the time. Asystole was the initial cardiac rhythm most frequently seen on the cardiac monitor, with ventricular fibrillation or tachycardia present 26.5% to 30.2% of the time.

Trends in cardiac arrest incidence rates are presented in Figure 2. A downward trend was noticeable for most regions, in spite of the fact that calculations were based on 1991 census data and may not adequately represent population growth. Information on cardiac arrest location is presented in Figure 3. The large majority of cardiac arrests occurred in residential locations, with only 14.6% to 22.0% occurring in public places. A more detailed description of cardiac arrest locations over a five-year period for 20 communities in Ontario is presented in Figure 4.

TABLE 1
Demographic and clinical characteristics of cardiac arrest patients in selected communities, 2002

	Incidence rate			Patient characteristics			Initial rhythm at arrest		
Communities	Population*	Cardiac arrests per year†	Incidence rates per 100,000 population	Men (%)	Median age (years)	Citizen witnessed (%)	VF or VT (%)	PEA (%)	Asystole (%)
Ontario									
Lindsay	16,696	13	78	69.2	77.0	30.8	38.5	15.4	46.2
Grimsby	18,520	7	38	71.4	79.0	42.9	42.9	28.6	28.6
Port Colborne	18,766	10	53	80.0	73.0	40.0	20.0	30.0	50.0
Port Hope/Cobourg	26,584	18	68	77.8	77.0	44.4	56.3	31.3	12.5
Welland	47,914	36	75	58.3	68.0	41.7	27.8	25.0	47.2
Peterborough	68,379	32	47	50.0	76.0	18.8	24.1	20.7	55.2
Sarnia	74,167	57	77	78.9	73.0	47.4	35.1	21.1	43.9
Niagara Falls	75,399	54	72	74.1	70.0	40.7	31.5	29.6	38.9
Cambridge	92,772	60	65	63.3	70.0	35.0	27.3	38.2	34.5
Sudbury	92,884	58	62	63.8	72.5	37.9	31.0	29.3	39.7
Oakville	114,670	45	39	68.9	71.0	37.8	22.0	19.5	58.5
Kingston	56,597	67	118	62.7	72.0	41.8	31.3	26.9	41.8
Thunder Bay	113,946	78	68	60.3	68.0	34.6	30.8	16.7	52.6
St Catharines	129,300	85	66	60.0	73.0	42.4	37.6	28.2	34.1
Burlington	129,575	80	62	55.0	74.0	35.0	27.3	35.1	37.7
Windsor/Tecumseh	201,930	99	49	64.6	70.0	41.4	30.5	26.3	43.2
Kitchener/Waterloo	239,463	113	47	69.0	70.0	40.7	30.9	34.5	34.5
London	311,620	215	69	68.8	71.0	40.5	29.9	28.0	42.1
Ottawa‡	523,291	261	50	62.8	72.0	37.5	25.8	25.0	49.2
Provincial average	2,352,473	1395	59	65.0	72.0	38.9	29.9	27.2	42.9
Nova Scotia									
Provincial average	899,942	476	53	62.6	70–79§	54.6	28.4	20.2	51.3
British Columbia									
Provincial average	3,282,061	1951	59	70.1	64.0	35.2	26.5	21.5	35.7
Quebec (2001)									
Montreal Metro	2,140,000	1125	53	63.2	73.0	45.7	27.0	34.9	38.0
Alberta									
Edmonton	616,741	341	55	N/A	N/A	55.0	30.2	24.9	44.9

**Population data are from the 1991 Canada census; †Cardiac arrests of cardiac origin for which resuscitation was attempted in 2002 (2001 for Quebec); ‡The Ontario Prehospital Advanced Life Support (OPALS) Study started before amalgamation; the Ottawa region includes Gloucester and Nepean; §In Nova Scotia, the majority of cardiac arrests (22.1%) occurred in the 70- to 79-year-old age group. N/A Data not available; PEA Pulseless electrical activity; VF Ventricular fibrillation; VT Ventricular tachycardia. Data from the OPALS Study database, Nova Scotia Department of Health, Emergency Health Services database, British Columbia Cardiac Arrest Registry, La Corporation d'urgences-santé de la région de Montréal Métropolitain (2001) and Edmonton Cardiac Arrest Registry*

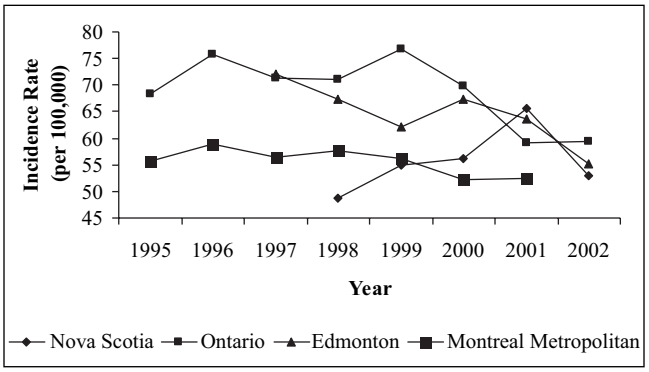

Figure 2) *Trends in cardiac arrest incidence rates per 100,000 population. Population data are from the 1991 Canada census; Montreal Metropolitan is estimated at 2,140,000. Data from the Ontario Prehospital Advanced Life Support (OPALS) Study database, Nova Scotia Department of Health, Emergency Health Services database, Edmonton Cardiac Arrest Registry and La Corporation d'urgences-santé de la région de Montréal Métropolitain*

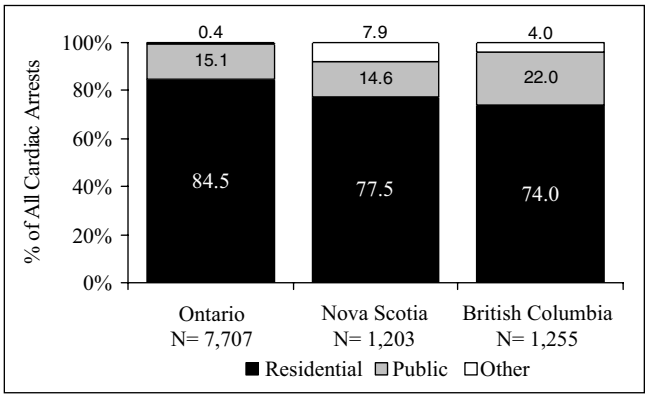

Figure 3) *Cardiac arrest location in Canada, 2002. Data collected over a five-year period in Ontario, 1995 to 2000. Data from the Ontario Prehospital Advanced Life Support (OPALS) Study database, Nova Scotia Department of Health, Emergency Health Services database and British Columbia Cardiac Arrest Registry. The composition of residential and public location by province can be found in Appendix 1*

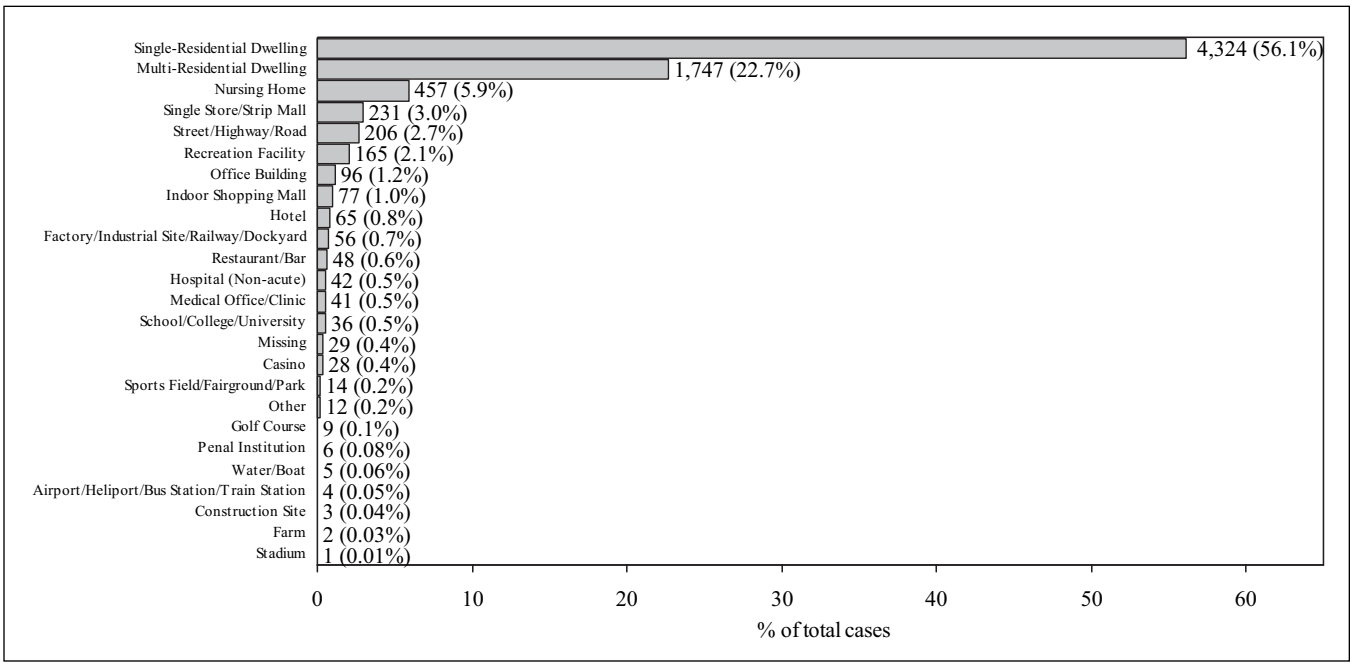

Figure 4) *Specific cardiac arrest locations in Ontario, 1995 to 2000 (N=7707). Data from the Ontario Prehospital Advanced Life Support (OPALS) Study database*

Information on CPR and defibrillation time intervals is presented in Table 2. Citizen bystander rates varied between 14.7% in Ontario to an impressive 46.0% in Edmonton. The provinces with the highest citizen bystander CPR rates provided dispatch-assisted CPR instructions to 911 callers (ie, all except Ontario). CPR was initiated by first responding firefighters 33.8% of the time in Ontario, but these data were not available for the other regions. The median time interval between a call received by dispatch and arrival at the scene of the first responding unit equipped with a defibrillator varied between 5.1 min and 9.3 min, and this interval was less than 8 min more than 90% of the time in most regions. In regions with established first responder firefighter programs, these units arrived first at the scene approximately one-half of the time. Trends in citizen bystander CPR for three large regions are illustrated in Figure 5. Although variations existed among regions, the rates remained stagnant over time.

Overall cardiac arrest survival statistics for 2002 are presented in Table 3. In-hospital survival information could not be obtained from the British Columbia registry. Edmonton only provided data until 1999. Survival ranged from 4.3% in the Montreal Metropolitan region to 9.0% in Edmonton. In the OPALS Study database, the largest cardiac arrest registry, overall survival for out-of-hospital cardiac arrest was 5.0% (95% CI 3.9% to 6.2%). Trends in overall cardiac arrest survival rates are presented in Figure 6. The rate of cardiac arrest survival was significantly higher in Edmonton than in other regions. Stratifying survival by initial cardiac rhythm showed that ventricular fibrillation and tachycardia were associated with the best survival rates (Table 3). Indeed, survival was almost invariably less than 1% in cases where the initial cardiac rhythm was asystole.

A few regions have attempted to report their cardiac arrest survival data in the style suggested by the Utstein method. While the Montreal Metropolitan region stratified their cardiac arrest cases in strict accordance with this reporting methodology, data from Nova Scotia were stratified in a slightly different manner. Uniform survival rates were calculated for those witnessed cases with ventricular fibrillation or tachycardia who received citizen bystander CPR. This Utstein reporting strategy is meant to facilitate performance comparisons among different EMS systems by comparing survival rates in the best patient conditions. In the present group, survival rates of 13.9%, 15.0% and 16.7% were found for the Ontario communities, Nova Scotia and the Montreal Metropolitan region, respectively.

DISCUSSION

The present study presents a descriptive analysis of cardiac arrest care and EMS in Canada. The study was only made possible through the contribution of information from a select number of institutions and individuals. Collecting cardiac arrest data highlights the need for a national cardiac arrest registry, for better communication among cardiac arrest care partners across the country, and to evaluate the feasibility of such a national endeavour. Currently, there is no national cardiac arrest registry in Canada, and only two provincial registries (Nova Scotia and British Columbia) exist. The two main challenges facing the creation of a national cardiac arrest registry are access to information and standardization of data. With the introduction of new laws limiting access to personal patient information, linkage of prehospital care data to in-hospital outcome information is becoming increasingly difficult. Moreover, despite the publication of guidelines for uniform reporting of data from out-of-hospital cardiac arrest (1), it

TABLE 2
Prehospital cardiopulmonary resuscitation and defibrillation response in selected Canadian communities, 2002

	Cardiopulmonary resuscitation rates			Arrival at scene with defibrillator*		
Communities	Citizen (%)	Fire/ police (%)	Ambulance (%)	Median interval (min)	8 min or less (%)	Firefighters first (%)
Ontario						
Lindsay	0.0	0.0	100.0	5.8	92.3	7.7
Grimsby	42.9	14.3	42.9	5.5	83.3	33.3
Port Colborne	0.0	50.5	40.0	6.4	100.0	44.4
Port Hope/Cobourg	38.9	33.3	27.8	5.6	88.9	33.3
Welland	13.9	16.7	66.7	5.4	97.1	34.3
Peterborough	6.3	46.9	40.6	4.8	96.6	69.0
Sarnia	15.8	43.9	36.8	4.4	96.0	64.0
Niagara Falls	20.4	27.8	48.1	5.1	93.9	34.7
Cambridge	6.7	56.7	35.0	5.1	98.0	78.0
Sudbury	19.0	20.7	58.6	4.9	96.4	20.0
Oakville	8.9	44.4	46.7	5.4	100.0	57.1
Kingston	16.4	28.4	52.2	4.8	85.5	30.6
Thunder Bay	6.4	35.9	55.1	4.5	94.4	52.8
St Catharines	14.1	28.2	50.6	5.5	90.0	52.5
Burlington	20.0	40.0	38.8	5.0	97.1	70.0
Windsor/Tecumseh	22.2	23.2	48.5	4.8	90.3	45.2
Kitchener/Waterloo	16.8	32.7	45.1	5.1	95.0	65.3
London	15.3	29.8	53.0	5.3	86.0	37.1
Ottawa†	11.1	39.5	44.8	5.1	94.2	61.8
Provincial average	14.7	33.8	48.0	5.1	92.6	50.8
Nova Scotia						
Provincial average	31.9	N/A	N/A	7.0	90.0‡	N/A
British Columbia						
Provincial average	38.6		N/A	9.3	38.5	N/A
Quebec (2001)						
Montreal Metro	25.4	N/A	N/A	7.6	55.2	N/A
Alberta						
Edmonton	46.0	N/A	N/A	5.4	89.0	45.0

**Time interval of call received by dispatch to arrival at scene by first responding unit with defibrillator; †The Ontario Prehospital Advanced Life Support (OPALS) Study started before amalgamation; the Ottawa region includes Gloucester and Nepean; ‡Arrival at scene with defibrillator in 9 min or less for Nova Scotia. N/A Data not available. Data from the OPALS Study database, Nova Scotia Department of Health, Emergency Health Services database, British Columbia Cardiac Arrest Registry, La Corporation d'urgences-santé de la région de Montréal Métropolitain (2001) and Edmonton Cardiac Arrest Registry*

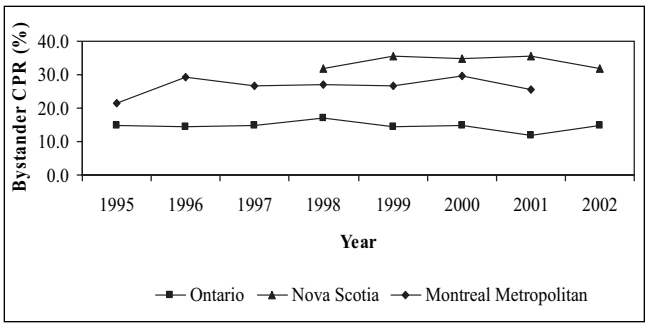

Figure 5) *Provincial trends in bystander cardiopulmonary resuscitation (CPR). Data from the Ontario Prehospital Advanced Life Support (OPALS) Study database, La Corporation d'urgences-santé de la région de Montréal Métropolitain and Nova Scotia Department of Health, Emergency Health Services database*

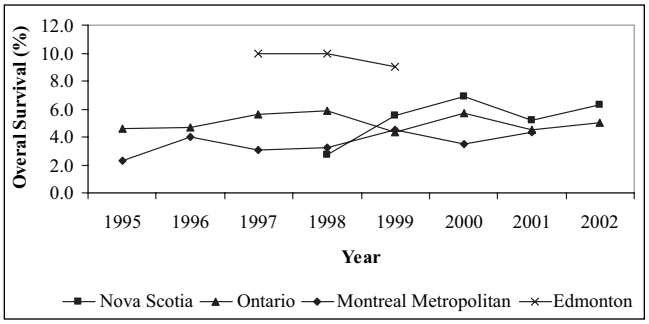

Figure 6) *Provincial trends for cardiac arrest survival rates. Data from the Ontario Prehospital Advanced Life Support (OPALS) Study database, La Corporation d'urgences-santé de la région de Montréal Métropolitain, Nova Scotia Department of Health, Emergency Health Services database, and Edmonton Cardiac Arrest Registry*

became apparent during the preparation of the present manuscript that some definitions are being interpreted in various ways.

Although mortality rates from ischemic heart disease are decreasing worldwide (13-15), the increasing severity of disease in the aging population (13), increasing smoking rates in women and increasing overall body mass index in the general population (16) may ultimately reverse this reassuring trend. Despite public information on cardiovascular health and disease prevention, survival is low once cardiovascular disease reaches the stage of cardiac arrest. Improving cardiac arrest outcomes can only occur with a concerted and continuing effort to strengthen each link of the chain of survival presented in Figure 1, with the greatest improvement seen with strengthening of the second and third links. However, the best way to strengthen these links has yet to be determined. The impact and sustainability of future cardiac arrest interventions need to be monitored and evaluated; this could potentially be accomplished via the proposed national cardiac arrest registry.

First link: Early access

Brain damage may start after only 4 min of cardiac arrest and irreversible brain damage is certain after 10 min (17). We can understand the importance of a universal access number such as 911. It is not only quick to dial but also easy to remember. According to the National Emergency Number Association, 96% of the geographical United States is covered by a 911 service. This service is also widely distributed in Canada. When dialing 911, a caller is put in communication with personnel who will appropriately dispatch police, firefighters, EMS or all three. In case of a medical emergency, the call will rapidly be transferred to an affiliate dispatch centre. Because many enhanced 911 communication centres automatically display

the 'billing address' on their computer screen, the dispatch centre will confirm the location of the patient; take down information on the nature of the call and dispatch the appropriate EMS unit(s), often as more information is being collected; and, in some regions, provide dispatch-assisted CPR instruction.

Second link: Early CPR

The Heart and Stroke Foundation of Canada (HSFC) establishes guidelines for resuscitation based on recommendations from the International Liaison Committee on Resuscitation. The HSFC also develops and makes available training programs for partners such as the Canadian Red Cross, St John's Ambulance, the Canadian Ski Patrol, the Advanced Coronary Treatment Foundation of Canada and the Lifesaving Society. Actual CPR training of the population is usually performed by one of these organizations or other private companies. Municipalities need to have a heightened awareness of the importance of CPR in saving lives and should actively partner with training agencies to maximize the number of citizens trained in CPR.

Data from Seattle indicate that a survival rate of 30% can be achieved for witnessed cardiac arrest cases receiving bystander CPR (18). Other communities, such as Akita and Otsu, Japan, are reporting overall survival rates from cardiac arrest of 15% and 9% in association with bystander CPR rates of 49% and 29%, respectively (19). In comparison, citizen bystander CPR rates and survival rates are rather modest in most areas of Canada. Poor incentives, lack of motivation, inconvenience of having to leave the house for classes and cost of classes are all good reasons to explain why people may not seek CPR training. Fear of communicable diseases, fear of litigation, emotional reaction, shyness and diffusion of responsibility in a group are reasons why even trained CPR providers may fail to apply what they have learned. However, to date, no case of HIV or hepatitis and no successful legal actions have been reported as a consequence of providing CPR.

Overall, the odds of survival for a victim of cardiac arrest are almost four times greater if bystander CPR is administered (OR 3.7; 95% CI 2.6 to 5.1) (20). CPR can sometimes be efficacious alone (21), and it can also prolong the period of time during which the heart is in ventricular fibrillation or tachycardia, hence increasing the potential success of defibrillation (22-24).

Third link: Early defibrillation

Defibrillation occurs when myocardial cells in a chaotic or abnormal electrical rhythm are depolarized at the same time by the delivery of an electrical current. This should result in the re-establishment of a rhythmic and organized heart beat. Ideally, defibrillation should occur as soon as possible after the victim's collapse. Through inexpensive optimization of existing EMS systems in Ontario communities, it has been demonstrated that reducing the time to defibrillation can increase overall cardiac arrest survival from 3.9% to 5.2% (P=0.03) (20). This was achieved by equipping firefighters with defibrillators and/or by improving the deployment of the ambulance fleet. Nevertheless, most communities have not followed this approach to rapid defibrillation and probably have no knowledge of their response times.

TABLE 3
Cardiac arrest survival rates for selected communities, 2002*

		Overall survival rates		Survival by initial cardiac rhythm		
Communites	Number of cardiac arrests	%	95% CI	VF or VT (%)	PEA (%)	Asystole (%)
Ontario						
Lindsay	13	0.0	–	0.0	0.0	0.0
Grimsby	7	0.0	–	0.0	0.0	0.0
Port Colborne	10	0.0	–	0.0	0.0	0.0
Port Hope/Cobourg	18	5.6	0.0–17.3	11.1	0.0	0.0
Welland	36	5.6	0.0–13.4	20.0	0.0	0.0
Peterborough	32	12.5	0.4–24.6	42.9	16.7	0.0
Sarnia	57	5.3	0.0–11.2	10.0	0.0	4.0
Niagara Falls	54	3.7	0.0–8.9	0.0	6.3	4.8
Cambridge	60	6.7	0.2–13.2	13.3	0.0	0.0
Sudbury	58	10.3	2.3–18.4	16.7	11.8	4.3
Oakville	45	6.7	0.0–14.2	33.3	0.0	0.0
Kingston	67	3.0	0.0–7.2	9.5	0.0	0.0
Thunder Bay	78	2.6	0.0–6.2	8.3	0.0	0.0
St Catharines	85	11.9	4.8–19.0	22.6	12.5	0.0
Burlington	80	5.0	0.1–9.9	19.0	0.0	0.0
Windsor/Tecumseh	99	5.1	0.7–9.4	17.2	0.0	0.0
Kitchener/Waterloo	113	4.4	0.6–8.3	11.8	2.6	0.0
London	215	4.7	1.8–7.6	14.5	1.7	0.0
Ottawa†	261	2.7	0.7–4.7	7.8	1.6	0.8
Provincial average	1395	5.0	3.9–6.2	13.4	2.7	0.7
Nova Scotia						
Provincial average	476	6.3	N/A	19.3	3.1	0.4
British Columbia						
Provincial average	1951	N/A	N/A	N/A	N/A	N/A
Quebec (2001)						
Montreal Metro	1125	4.3	N/A	10.5	3.3	0.7
Alberta (1999)						
Edmonton	415	9.0	N/A	26.0	N/A	N/A

**Time periods for Quebec and Alberta are specified; †The Ontario Prehospital Advanced Life Support (OPALS) Study started before amalgamation; the Ottawa region includes Gloucester and Nepean. N/A Data not available; PEA Pulseless electrical activity; VF Ventricular fibrillation; VT Ventricular tachycardia. Data from the OPALS Study database, Nova Scotia Department of Health, Emergency Health Services database, British Columbia Cardiac Arrest Registry, La Corporation d'urgences-santé de la région de Montréal Métropolitain (2001) and Edmonton Cardiac Arrest Registry (1999)*

In a study (25) of cardiac arrest occurring in casinos, security officers were trained to apply automatic external defibrillators (AEDs) to witnessed victims. Such devices are equipped with electrodes that can very simply be applied to the victim's chest. Accurate rhythm analysis is performed automatically and defibrillation is performed when appropriate. In the group defibrillated for ventricular fibrillation within 3 min, the 'casino' study achieved an unprecedented survival rate of 74% (25). Recognizing the limited external validity of this study, the authors of the Public Access Defibrillation (PAD) trial (26) endeavoured to train 20,000 volunteers in CPR in 24 centres across Canada and the United States. One-half of those centres were randomly selected to receive additional access to, and

training in, the use of AEDs. Results from that trial were released in Orlando, Florida, on November 11, 2003, during the American Heart Association's scientific session. Among the 44 survivors (N=292), 15 were in the CPR arm and 29 were in the CPR+AED arm (P=0.042) (26).

Despite the preliminary release of promising results from the PAD trial, not everyone is convinced that PAD programs will have a significant impact on overall cardiac arrest survival because most cardiac arrests occur at home. In a retrospective cohort study (27) of 15,189 cardiac arrests, a statistical model was used to estimate the potential effect of PAD programs on overall survival from cardiac arrest in public location. The model estimated that overall survival from cardiac arrest may increase from 5% to a range of 6.3% to 6.5%, depending on the assumptions made regarding defibrillator coverage; this would likely occur at a significant cost (27). PAD programs may have an extremely limited applicability and are no substitute for optimized citizen bystander CPR and first responder defibrillation programs.

Fourth link: Early ALS

Advanced care is defined by the use of definitive airway management, such as endotracheal intubation, intravenous access and drug administration. Such drugs serve the purpose of increasing the coronary perfusion pressure by increasing peripheral vascular resistance (epinephrine and vasopressin), or promote arrhythmia termination by acting on the myocardial cell action potential and/or by facilitating defibrillation (lidocaine, procainamide and amiodarone).

Although these drugs are recommended by the American Heart Association and the HSFC, and are taught as part of advanced cardiac life support training, they have never demonstrated any significant improvement in overall cardiac arrest survival (28,29). There has been much hope that amiodarone and vasopressin would improve survival to cardiac arrest. The use of amiodarone remains highly controversial. In a recent study (30), survival to hospital admission for patients in ventricular fibrillation improved from 33% to 44% (OR 1.6; 95% CI 1.1 to 2.4; P=0.03). The study could not find any difference in survival to hospital discharge. While vasopressin was previously believed to be of no help (31), a recent publication (32) indicates the potential benefit of vasopressin in a subgroup of victims in asystole. In that group, survival to hospital discharge increased from 1.5% to 4.7% (P=0.04).

Typically, emergency medical technicians with training in ALS, otherwise called paramedics, provide advanced cardiac care. Similar to advanced cardiac care drugs, paramedics have not been clearly associated with any improvement in survival from cardiac arrest. The recently completed phase III of the OPALS Study, looking at the incremental benefit of such ALS paramedics on cardiac arrest survival, failed to show any significant clinical difference (33). Communities must emphasize CPR and rapid defibrillation rather than ALS in the prehospital setting.

CONCLUSIONS

Heart disease remains the leading cause of mortality in the Canadian population. The present study compared the impact of regional differences in patient and system characteristics; it is also the first step toward a cardiac arrest registry because it confirmed a deficit in data collection and established strong links between cardiac arrest researchers across the country. CPR is clearly associated with improved survival and it appears that improving citizen bystander CPR rates should remain a priority in most regions. While the optimization of ambulance and firefighter defibrillation programs has shown a positive impact on survival, the potential impact of public access defibrillation programs appears to be quite limited. Given the lack of impact of ALS on cardiac arrest survival, it becomes increasingly important to optimize all the other links of the chain of survival. Most communities do not have accurate data on their performance with regards to the chain of survival, and thus are unaware of the need within the community to significantly improve their capacity of providing citizen bystander CPR and rapid first responder defibrillation.

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APPENDIX 1
Composition of location categories by province

Ontario	
Residential	Single residential dwelling
	Multiresidential dwelling
	Nursing home
	Hospital (nonacute)
Public	Construction site
	Farm
	Golf course
	Medical office/clinic
	Restaurant/bar
	Single store/strip mall
	Sports field/fairground/park
	Airport/heliport/bus station/train station
	Casino
	Factory/industrial site/railway/dockyard
	Hotel
	Indoor shopping mall
	Office building
	Penal institution
	Recreation facility
	School/college/university
	Stadium
Other	Street/highway/road
	Water/boat
	Other
	Missing
British Columbia	
Residential	Home
	Residence (not own home)
Public	Public place
	Vehicle
	Workplace
Other	Other
Nova Scotia	
Residential	Home/cottage
	Group home
	Extended care facility
Public	Public building
	Ambulance/helicopter landing zone
	Recreational facility
	Industrial
	School/daycare
	Doctor's office
	Hospital
	Airport
	Casino
	Penitentiary
	Street or public walkway
Other	Other public areas
	Not documented

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