

Title:
Estimation of Potential Deceased Organ Donors in Canada.

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Objective: To estimate the number of potential deceased organ donors in Canada and to determine the potential to achieve self-sufficiency in organ transplantation by comparing the number of estimated potential donors with the number of patients wait-listed for organ transplantation in Canada.

Design: Retrospective analysis of information captured from hospital separations.

Setting: Canadian provinces with the exception of Quebec between 2005-9.

Participants: Persons ≤ 70 years of age who died in hospital.

Main outcome measure: Potential donors (identified by the presence of diagnostic codes compatible with donation, the absence of contraindications to donation defined by Canadian Standards, and the use of mechanical ventilation).

Results: Among 335,793 hospital deaths, 8,274 potential donors were identified. The study method was 81% sensitive and 93% specific for identification of potential donors, and overestimated potential donors by a factor of 1.6 -2.1 fold when compared to information from chart audits. After accounting for this overestimation, there are conservatively 400 unrecognized potential deceased donors in Canada annually.

Conclusions: With 4000 patients wait-listed for transplantation and 400 unrecognized potential deceased donors annually, there is potential to achieve self-sufficiency in organ transplantation in Canada.

Introduction:

In 2010, the World Health Organization (WHO) Global Consultation on Organ Donation and Transplantation(1) called for governments to move towards national self-sufficiency in transplantation, using their own resources to increase organ availability and reduce the need for transplantation by reducing chronic disease burden. Although the need to improve organ donation in Canada is well recognized, the number of deceased organ donors has remained relatively unchanged over the last decade. (2, 3) To what extent this stagnation is related to few potential deceased donors among patients who die in Canadian hospitals, or failure to identify and obtain consent for donation from potential deceased donors remains uncertain, and better information to understand this issue is urgently needed.

The most commonly reported metric of deceased donation, the donor rate per million persons living in a region,(3) does not account for regional and secular differences in mortality, or for the cause of death among hospitalized patients,(4, 5) and therefore may lead to regions being misclassified as underperforming.(6) Despite these well-known limitations, donor rate per million continues to be the primary metric of the efficiency of organ donation services in Canada. The recommended gold standard method to determine the efficiency of deceased donation services utilized by countries with high donation rates, involves prospective audit of all in hospital deaths to determine the number of

potential donors followed by determination of the rate of conversion of potential donors to actual donors.(1, 7, 8) Implementation of this method is particularly challenging in Canada's provincially administered health care system. Although chart audits are performed intermittently by regional organ procurement organizations, the criteria to define a potential donor are not standardized between regions. With more than 120,000 deaths annually in Canadian hospitals,(9) and the absence of a national directive to collect this information it is unlikely that prospective national chart audits to identify potential donors will be implemented in Canada in the foreseeable future.

The requirement for more informative metrics of the efficiency of deceased organ donation services prompted the current study with the following objectives: 1) to develop a practical and timely method to estimate the number of potential deceased donors using information already collected for patients who die in Canadian hospitals; 2) to determine the accuracy of this study method to identify potential deceased donors; 3) to compare the number of potential deceased donors identified by the study method with the number of actual deceased donors; and 4) to compare the number of unrecognized potential donors with information about the number of patients wait-listed for transplantation.

Methods

This is a retrospective analysis of in-hospital deaths captured in the Discharge Abstract Database (DAD) from 2005-9. The DAD contains demographic, administrative and clinical data for all acute care hospital separations, excluding emergency room admissions, and still births for all provinces and territories in Canada, excluding the

province of Quebec.(10) Diagnostic and procedural information in the DAD is recorded in a standardized format using International Statistical Classification of Diseases, 10th Revision, Canadian enhanced version (ICD-10-CA) and Canadian Classification of Health Intervention (CCI) codes.(10)

Identification of potential donors (Figure 1).

Consistent with the U.S. definition of a death eligible for donation,(11) we limited the analysis to persons who died in hospital that were ≤ 70 years of age. Among these persons, individuals with causes of death compatible with donation were identified using a limited number of International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes (see Appendix A) as described by Holt and colleagues (the Canadian Institute for Health Information supplied a mapping of ICD-9-CM codes to ICD-10-CA codes that are recorded in the DAD). The use of these ICD-9-CM codes is 100% sensitive for identification of potential donors. (12) We further excluded individuals with absolute and relative contraindications to donation, as per the Canadian Standards Association (Appendix B).(13) With the understanding that donation is highly unlikely unless patients have access to critical care services, we further restricted our identification of potential donors to individuals for whom there was a procedural code for mechanical ventilation (Figure 1). The number of potential donors was calculated overall, by age group, and by province.

Accuracy and validity of the study method

The accuracy of our potential donor estimates was determined by comparison with potential donors identified in chart audits of in-hospital deaths (the putative gold

standard) performed by regional organ procurement organizations in British Columbia and Manitoba. In British Columbia, chart audit information was available from two major trauma hospitals in greater Vancouver between 2007-9; while in Manitoba, information from six Winnipeg area tertiary hospitals was available between 2005-9. Details of the chart audits are described in Appendix C. The British Columbia data contained patient identifiers and was linked to data in the DAD by the Canadian Institute of Health Information to permit determination of sensitivity and specificity of the study method to identify potential donors. This was not possible with the Manitoba data, as this information could only be provided in aggregate due to privacy restrictions.

Conversion of potential donors to actual donors

The donor conversion ratio represents the number of potential donors who were converted to actual donors (actual donors \div potential donors). We compared our estimates of the number of potential organ donors identified in the DAD with the number of actual organ donors recorded in the Canadian Organ Replacement Register (CORR) during the study period, to calculate the donor conversion ratio. CORR receives information annually for all deceased organ donors in Canada, directly from provincial or regional organ procurement organizations(14) and defines a deceased donor as an individual from whom ≥ 1 organ is transplanted. Donor conversion ratios were calculated by age group and by province. Provincial donor conversion ratios were standardized for age distribution using direct standardization,(15) using the age distribution of all DAD deaths as the standard population.

This study received local hospital research ethics board approval and this manuscript is compliant with privacy regulations of the Canadian Institute for Health Information,

British Columbia Transplant and Manitoba Transplant. All analyses were performed using SAS 9.4 (Carey, NC).

Results

There were 335,793 patients who died in-hospital reported in the DAD during the study period, including 106,993 patients ≤ 70 years. After the exclusion of patients with causes of death not compatible with donation (N=80,820), patients with absolute or relative contraindications to organ donation (N= 11,353), and patients without a procedural code for mechanical ventilation (N=6,546), 8,274 potential donors (7.7% of all in-hospital deaths aged ≤ 70 years) were identified. The number of patients who died in-hospital and the steps in the study algorithm used to identify potential donors are shown by age group in Table 1. The proportion of potential donors among patients who died in hospital ranged from 5.8 % in patients 61-70 years to 19.5%, among patients aged 18-40 years.

Accuracy and validity of the study method

The British Columbia chart audit included 1,989 patients and identified 165 potential donors, among whom 35 were actual donors; while the Manitoba chart audit included 3,247 patients and identified 126 potential donors, among whom 52 were actual organ donors (Table 2). Application of the study method in British Columbia identified 266 potential donors among the 1,989 audited in-patient deaths (13%); while application of the study method in Manitoba identified 266 potential donors among 3,247 audited in-hospital deaths (8%). The accuracy of the study method was higher in British Columbia (ratio of potential donors identified by the study method compared to potential donors

identified by chart audit was 1.6) than in Manitoba (ratio = 2.1), and was highest in younger age groups (Table 2).

The study method was 81% sensitive and 93% specific for the identification of potential donors. All actual donors were identified as potential donors using the study method. The reasons why N =31 potential donors in the chart audits were not identified by the study method included exclusion of n =14 (44%) because of the presence of an ICD code for anemia as per the Canadian Standards Association list of contraindications to organ donation, exclusion of N =14 (44%) because of the absence of a code for mechanical ventilation in the DAD, and exclusion of N =4 (12%) because of the presence of a code for sepsis in the DAD.

Conversion of potential donors to actual donors

There were 1,209 actual deceased organ donors aged ≤ 70 identified in CORR during the study period for an estimated overall donor conversion ratio of 15% (1,209 actual \div 8,274 potential donors) (Table 3). The donor conversion ratio varied by age, ranging from 5% in patients aged 61-70 years to 43% among patients < 18 years of age (Table 3). Figure 2 shows that the provincial age-standardized donor conversion ratios varied two-fold across regions, from a low of 11% in British Columbia, to a high of 21% in Saskatchewan.

After accounting for the overestimation of the study method, donor conversion ratios remained low. For example, in British Columbia the overall conversion ratio was 17.6% after accounting for the 1.6 fold difference in potential donors in the study method compared to the chart audit (11% conversion ratio X 1.6 correction for the overestimation of the number of potential donors using the study method). Even after allowing for a

conservative 2.5 fold difference in potential donors identified by the study method compared to the chart audit in the entire data set, N =2,100 potential donors or 525 donors per year were not converted to actual donors during the study period.

Discussion

Principal Findings

Using routinely collected administrative data, we estimated that 7.7% of patients who died in-hospital aged ≤ 70 years are potential deceased donors. By comparison with information from chart audits, we found that the use of administrative data overestimated the number of potential donors by a factor of 1.6 - 2.1 fold. Assuming a conservative 2.5 fold difference in the number of potential donors identified by use of administrative data and chart audit, the findings suggest that there are more than 800 potential donors (3.1 potential donors per 100 in-hospital deaths among patients aged ≤ 70 years) in Canadian provinces per year (excluding Quebec). In the last year of study, there were 312 deceased organ donors aged ≤ 70 years in the Canadian provinces studied (there were 446 donors aged ≤ 70 years in all of Canada including Quebec),(16) indicating there are at least 400 unrecognized potential donors in Canada annually. These findings suggest a significant opportunity to increase deceased organ donation in Canada.

Strengths and weakness

Countries with higher donation rates than Canada including the United States, the United Kingdom and Spain perform regular chart audits of patients dying in hospital to identify potential donors and their conversion to actual donors. Our study method to estimate potential donors using administrative data falls short of this standard and importantly

does not provide information about why potential donors are not converted to actual donors. In the absence of a national mandate and funding to complete these recommended chart audits, the study method provides a practical alternative to assess the efficiency of the deceased organ donor system in Canada and has recently been adopted by the Canadian Institute of Health Information as a supplement to the deceased donor rate per million population in their national report on organ donation and transplantation in Canada. (17) Importantly continued efforts to improve the study method are needed, including ongoing comparison with information from hospital chart audits and efforts to improve the assignment of diagnostic codes to hospitalized deaths in critical care areas. Our analysis was purposefully restricted to in-hospital deaths between 2005-9 because of the limited availability of regional chart audit data. However the number of deceased donors in Canada has remained relatively unchanged since 2009,(16) and a 2014 report from the Canadian Institute for Health Information confirmed a similar estimate of the number of potential donors in Canada using the DAD and the study algorithm, indicating that our findings likely remain applicable.(17)

Comparison to other studies

Previous studies of deceased organ donation in Canada were limited to regional analyses. A study from Ontario reported that 1 in 4 potential donors actually donated but the definition of a potential donor was restricted to individuals less than 59 years of age who survived in hospital for less than 1 week.(18) A recent study from Calgary suggested few critically ill patients with severe brain injuries qualify as potential donors. (19) However, the study relied on electronic charting of a neurological diagnosis of brain death to identify potential donors, and it was unclear how often patients were in fact evaluated for

neurologic brain death, or how complete the capture of brain death diagnoses were in the electronic charts used in the study.(19)

Implication of Study Findings

In the United States approximately 5% of the 210,000 patients ≤ 70 years who die in hospital are potential donors, and over 70% of these potential donors actually donate organs. (6, 20, 21) There are important differences between the organization of organ donation services in Canada and the United States that may contribute to these differences in donation. In the U.S, the federal government reimburses costs associated with deceased organ donation on a cost recovery basis, and transparent reporting of organ donation metrics is required. In contrast, in Canada there is considerable variation in the amount hospitals are reimbursed for supporting organ donation services in different provinces, and there is no federal mandate for reporting.(3) Although the rate of deceased organ donation in Canada lags behind that in the United States, evaluation of each country's ability to meet its citizen's need for organ transplantation requires a broader examination of both the incidence of end organ failure and allograft survival. Using end stage renal disease (ESRD) as an example, the ESRD incidence in the United States (350 per million) is over twice that in Canada (160 per million), while 5 year survival of first deceased kidney transplants recipients in the United States is 72% compared to 83% in Canada.(16, 22) Accordingly 32% of all prevalent ESRD patients in the United States < 75 years are treated with transplantation (35% < 65 years) compared to 50% in Canada (55% < 65 years).(16, 23) Although some of these discrepancies are related to differences in population characteristics and perhaps access to renal replacement therapy between the countries, the differences nonetheless illustrate the relevance of the self-sufficiency

concept as advanced by the WHO. An important implication of these differences is that there may be sufficient potential donors to meet the need for organ transplantation in Canada (approximately 4000 wait-listed patients and 400 unrecognized potential donors annually).(24) In contrast efforts to increase the conversion of potential donors to actual in the United States (over 120 000 wait-listed patients and only 2000 to 3000 unrecognized potential donors per annum)(21, 22, 25-29) may be insufficient to achieve self-sufficiency without a significant effort to decrease the incidence of ESRD.

The potential for improvement in donor conversion is not unique to Canada. Similar observations were made in the United Kingdom via its Potential Donor Audit by the Government's Organ Donation Taskforce in 2008.(30) The Taskforce concluded that it was essential for clinical staff to be offered a clear ethical framework and clinical guidelines through which to ensure consistency of practice across the UK.(31, 32) These initiatives, alongside other improvements to donation and transplantation infra-structure led to a 50% increase in the number of deceased donors during 2008-2013.(33)

Future research

The transparent reporting of potential donors using the study method is an important first step in improving deceased organ donation in Canada. Future research will focus on understanding why potential donors are not converted to actual donors, and demonstrating improvements in organ donation by sharing of best practices between high and low performing regions identified by the study method.

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Competing interests: All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare:

Ethical Approval: This study was approved by the research ethics board at the University of British Columbia under protocol H09-02915.

Data Sharing: Requests for access to data, and statistical code may be made to the corresponding author at jgill@providencehealth.bc.ca.

Transparency: The lead author (CR) affirms that the manuscript is an honest, accurate and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

References

1. The Madrid resolution on organ donation and transplantation: national responsibility in meeting the needs of patients, guided by the WHO principles. *Transplantation*. 2011;91 Suppl 11:S29-31.
2. Information CIOH. **Canadian Organ Replacement Register Annual Report: Treatment of End-Stage Organ Failure in Canada, 2002-2011**. Ottawa, ON: Canadian Institute of Health Information, 2012.
3. Gill JS, Klarenbach S, Cole E, Shemie SD. Deceased organ donation in Canada: an opportunity to heal a fractured system. *Am J Transplant*. 2008;8(8):1580-7.
4. Cuende N, Cuende JI, Fajardo J, Huet J, Alonso M. Effect of population aging on the international organ donation rates and the effectiveness of the donation process. *Am J Transplant*. 2007;7(6):1526-35. Epub 2007 Apr 8.
5. Ojo AO, Wolfe RA, Leichtman AB, Dickinson DM, Port FK, Young EW. A practical approach to evaluate the potential donor pool and trends in cadaveric kidney donation. *Transplantation*. 1999;67(4):548-56.
6. Sheehy E, Conrad SL, Brigham LE, Luskin R, Weber P, Eakin M, et al. Estimating the number of potential organ donors in the United States. *N Engl J Med*. 2003;349(7):667-74.
7. Delmonico FL, Domínguez-Gil B, Matesanz R, Noel L. A call for government accountability to achieve national self-sufficiency in organ donation and transplantation. *Lancet*. 2011;378(9800):1414-8.
8. Domínguez-Gil B, Delmonico FL, Shaheen FA, Matesanz R, O'Connor K, Minina M, et al. The critical pathway for deceased donation: reportable uniformity in the approach to deceased donation. *Transpl Int*. 2011;24(4):373-8.
9. Statistics Canada. Table 102-0509- Deaths in hospital and elsewhere, Canada, provinces and territories [Internet]. CANSIM (Database).
10. Canadian Institute of Health Information. Data Quality Documentation for External Users: Discharge Abstract Database, 2010-2011. 2011.
11. Network OPaT. http://optn.transplant.hrsa.gov/ContentDocuments/OPTN_Policies.pdf-nameddest=Policy_08 2014 [June 2, 2014].
12. Holt AW, Hodgeman GK, Vedig AE, Heard PE. Organ donor index: a benchmark for comparing hospital organ donor rates. *Med J Aust*. 1999;170(10):479-81.
13. Canadian, Standards, Association. Safety of Human Cells, Tissues and Organs for Transplantation Regulations S.O.R./2007-118 to 152 and SI/2007-63 to 69. Part II: Canada Gazette; 2007.
14. The Canadian Organ Replacement Register [Internet]. 2013. Available from: <http://www.cihi.ca/corr>.
15. Naing NN. Easy way to learn standardization : direct and indirect methods. *Malays J Med Sci*. 2000;7(1):10-5.
16. Canadian Organ Replacement Register CIOHI. 2014 CORR Annual Report: Treatment of End-Stage Organ Failure in Canada 2003-2012. Toronto: 2014.
17. Canadian Institute of Health Information. Deceased Organ Donation Potential in Canada. Ottawa, ON: 2014.

18. Redelmeier DA, Markel F, Scales DC. Organ donation after death in Ontario: a population-based cohort study. *CMAJ*. 2013;185(8):E337-44.
19. Kramer AH, Zygun DA, Doig CJ, Zuege DJ. Incidence of neurologic death among patients with brain injury: a cohort study in a Canadian health region. *CMAJ*. 2013;185(18):E838-45.
20. Hall MJ LS, DeFrances CJ. Trends in Inpatients Hospital Deaths: National Hospital Discharge Survey, 2000-2010. NCHS data brief, no 188. Hyattsville, MD: National Center for Health Statistics, 2013.
21. Israni AK, Zaun1 DA, Rosendale JD, Snyder JJ, Kasiske BL. OPTN/SRTR 2013 Annual Data Report: Deceased Organ Donation. *Am J Transplant*. 2015;15(S2):1-13.
22. Matas AJ, Smith JM, Skeans MA, Thompson B, Gustafson SK, Stewart DE, et al. OPTN/SRTR 2013 Annual Data Report: Kidney. *Am J Transplant*. 2015;15 Suppl 2:1-34.
23. USRDS. Annual Data Report: Atlas of End Stage Renal Disease in the United States. National Institute of Health, National Institute of Diabetes and Digestive and Kidney Disease, 2012.
24. Kim SJ FS, Kappel J, Moist LM, Klarenbach SW, Samuel SM, Singer LG, Kim DH, Young K, Webster G, Wu J, Ivis F, de Sa E, Gill JS. Organ Donation and Transplantation in Canada: Insights from the Canadian Organ Replacement Regsiter. *Canadian Journal of Kidney Health and Disease*. 2014;1(31).
25. Colvin-Adams M, Smith JM, Heubner BM, Skeans MA, Edwards LB, Waller CD, et al. OPTN/SRTR 2013 Annual Data Report: Heart. *Am J Transplant*. 2015;15 Suppl 2:1-28.
26. Kandaswamy R, Skeans MA, Gustafson SK, Carrico RJ, Tyler KH, Israni AK, et al. OPTN/SRTR 2013 Annual Data Report: Pancreas. *Am J Transplant*. 2015;15 Suppl 2:1-20.
27. Kim WR, Lake JR, Smith JM, Skeans MA, Schladt DP, Edwards EB, et al. OPTN/SRTR 2013 Annual Data Report: Liver. *Am J Transplant*. 2015;15 Suppl 2:1-28.
28. Smith JM, Skeans MA, Horslen SP, Edwards EB, Harper AM, Snyder JJ, et al. OPTN/SRTR 2013 Annual Data Report: Intestine. *Am J Transplant*. 2015;15 Suppl 2:1-16.
29. Valapour M, Skeans MA, Heubner BM, Smith JM, Hertz MI, Edwards LB, et al. OPTN/SRTR 2013 Annual Data Report: Lung. *Am J Transplant*. 2015;15 Suppl 2:1-28.
30. Department of Health. Organs for transplants: a report from the Organ Donation Taskforce. London, England: 2008.
31. UK Donation Ethics Committee. An Ethical Framework for Controlled Donation after Circulatory Death. London, England: 2011.
32. National Institute for Health and Clinical Excellence. Organ donation for transplantation: Improving donor identification and consent rates for deceased organ donation. 2011.
33. NHS Blood & Transplant. Taking organ transplantation to 2020 - a UK strategy. 2014.

Figure 1- A flow chart describing the study method used to refine the estimate of the number of potential deceased organ donors

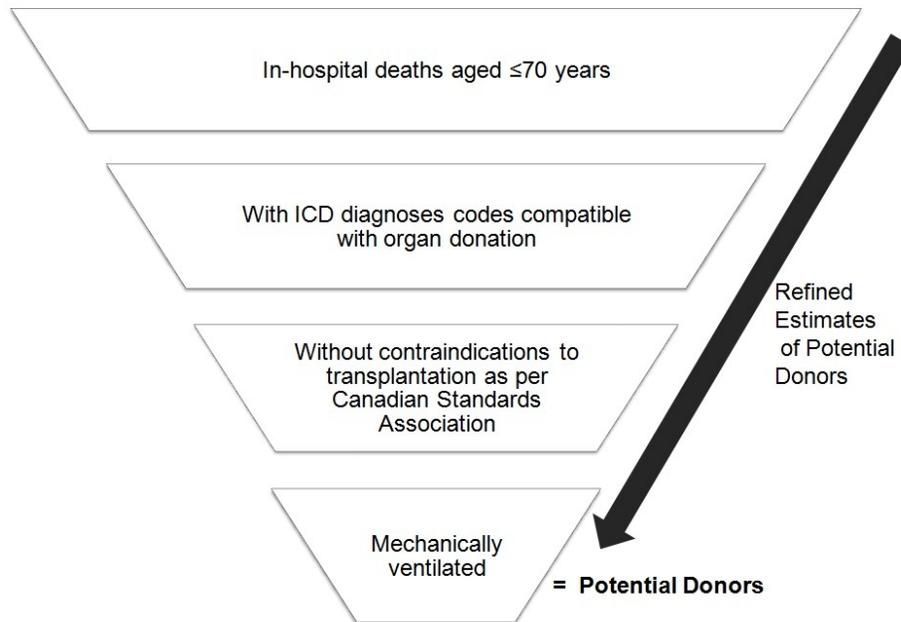


Figure 2- The number of potential donors, actual donors and the age-standardized donor conversion ratio by province. (BC=British Columbia; AB=Alberta; SK=Saskatchewan; MB=Manitoba; ON=Ontario; NS=Nova Scotia, New Brunswick, Prince Edward Island and Newfoundland)

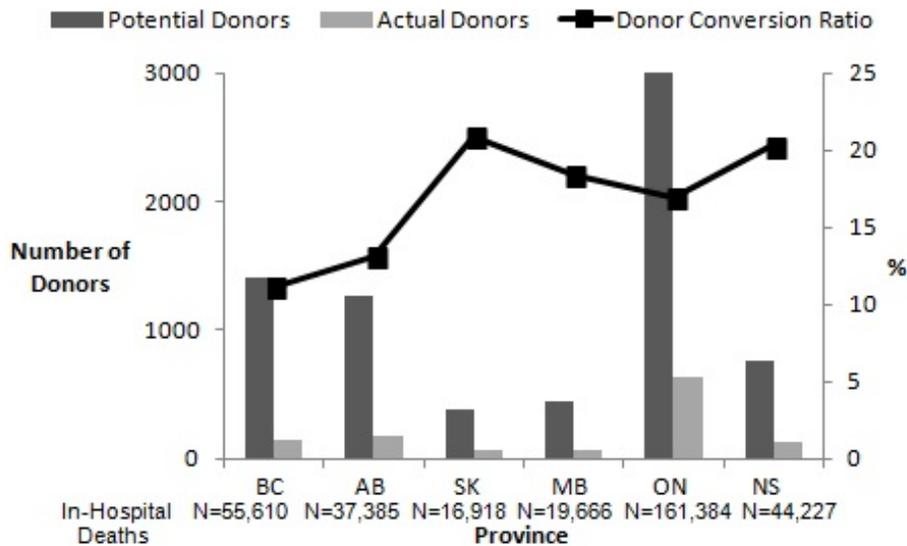


Table 1- Identification of potential donors using the study method						
	Age Group (years)					
	All patients ≤ 70	<18	18-40	41-50	51-60	61-70
In-hospital deaths (N)	106 993	6 267	6 381	12 942	29 814	51 589
ICD diagnoses codes compatible with organ donation	26 173	1 140	2 822	3 739	7 078	11 394
Without contraindication to transplantation as per Canadian Standards Association	14 820	570	1 742	2 088	3 876	6 544
Potential organ donors (mechanically ventilated)	8 274 (7.7%)	419 (6.7%)*	1 245 (19.5%)	1 381 (10.7 %)	2 232 (7.5%)	2 997 (5.8%)
* Percentage of in-hospital patient deaths identified as potential donors						

Table 2- Number of Potential Donors Identified by Chart Audit and the Study Method

British Columbia Chart Audit			
Age***	Potential Donors in Chart Audit	Potential Donors in DAD by Study Method	Ratio of Potential Donors Identified with Study Method Compared to Chart Audit
Total	165*	266	1.6
<18 years	2	2	1.0
18-40 years	53	66	1.2
41-50 years	33	50	1.5
51-60 years	42	70	1.7
61-70 years	34	78	2.3
Manitoba Chart Audit			
Total	126*	266	2.1
<18 years**	11	14	1.3
18-40 years	39	44	1.1
41-50 years	26	53	2.0
51-60 years	29	67	2.3
61-70 years	18	88	4.9
*1 individual missing age data in British Columbia chart audit; 3 individuals missing age data in Manitoba chart audit			
** Conversion ratios by age could not be determined for the Manitoba chart audit as only aggregate information regarding the total number of donors was obtained.			
*** Validation data was not available for in-hospital deaths aged > 70 years.			

	Age Group (years)					
	All patients ≤70	<18	18-40	41-50	51-60	61-70
N						
Potential donors	8 274	419	1 245	1 381	2 232	2 997
Actual Donors	1 209	181	322	281	285	140
Donor Conversion Ratio	15%	43%	26%	20%	13%	5%

Appendix A. Diagnostic inclusion codes for eligible causes of death.

Diagnosis Description	ICD-10-CA Diagnostic Codes
Head Injury	
Intracranial injury	S06.2, S06.3, S06.4, S06.5, S06.6, S06.8, S06.9, S02.001, S02.101, S02.701, S02.891
Cerebrovascular Accident (CVA)	
Subarachnoid haemorrhage	I60
Intracerebral haemorrhage	I61
Other intracranial haemorrhage	I62
Occlusion or stenosis of precerebral/ cerebral arteries	I63, I65, I66
Stroke, not specified as haemorrhage or infarction	I64
Other	
Central nervous system tumours	C70, C71, C72
Anoxic brain damage	G93.1
Compression of brain	G93.5
Cerebral oedema	G93.6, S06.1
Ventricular tachycardia	I47.2
Ventricular fibrillation and flutter	I49.00, I49.01
Cardiac arrest	I46.0, I46.1, I46.9
Status asthmaticus	J45.01, J45.11, J45.81, J45.91
Asphyxia	R09.0
Respiratory arrest	R09.2
Asphyxiation and strangulation	T71

Appendix B. Diagnostic exclusion codes for contraindications to organ donation

Diagnosis Description	ICD-10-CA Diagnostic Codes
Death, unknown cause	R96, R98, R99
Nervousness, Malaise and fatigue	R45.0, R53
Cachexia	R64
Other specified general symptoms and signs	R68.8
Unknown and unspecified causes of morbidity	R69
Tuberculosis	A15-A19, O98.0
Sepsis	A40-A41, A03.9, A20.7, A21.7, A24.1, A26.7, A28.0, A28.2, A32.7, A42.7, B37.7, O03.0, O03.5, O04.0, O04.5, O05.0, O05.5 O07.3, O08.0, T80.2, T81.4, T88.0, T82.6, T82.7, T83.5, T83.6, T84.5-, T84.6-, T85.7, R65.0, R65.1, R65.9, A22.7, A02.1, O85
Brucellosis/ Listeriosis	A23/ A32
Other infection during labour	O75.3
Acute and chronic meningococcaemia	A39.2, A39.3
Meningococcaemia, unspecified	A39.4
Human immunodeficiency virus [HIV]	B24, Z20.6, Z21, R75, O98.7
Cytomegaloviral disease	B25
Acute poliomyelitis	A80
Jakob-Creutzfeldt disease	A81.0, F02.1
Normal-pressure hydrocephalus	A81.1
Subacute sclerosing panencephalitis	G91.2
Other rickettsioses	A79
Progressive multifocal leukoencephalopathy	A81.2
Disseminated herpesviral disease	B00.7
Viral encephalitis	G04.0, G04.8, A85, A88.8, A86, A89, B00.0-4, A83, A84, A85.2, G05.1, G05.2, G04.9

Hepatitis	B16, B17, B18, B19, O98.3, O98.4-9
Rabies	A82-A89
Malaria	B50-B54
Active Syphilis	A50-A53, O98.1
Gonococcal infections	A54, O98.2
Other and unspecified mycoses	B48, B49
Malignant neoplasms	C00-C96
Haemolytic anemias	D55-D59
Aplastic and other anemias	D61, D62, D64
Meningitis (bacterial/viral)	G00, G01, G02, G03, G05.2, B45.1, B83.2, A87
Alzheimer's disease	G30
Parkinson's disease	G20
Motor neuron disease	G12.2
Multiple sclerosis	G35
Active endocarditis	I33.0, I33.9, I01.1, I52.0
Mixed connective tissue disease	M32, M33, M34, M35
Certain conditions with origin in perinatal period	P00-P96
Radiotherapy or chemotherapy session	Z51.0, Z51.1
Hypopituitarism	E23.0
Transplanted organ and tissue status	Z94
Presence of heart valve	Z95.2, Z95.3, Z95.4
Severe acute respiratory syndrome	U04.90, U04.91
West Nile virus/ Lyme disease	A92.3/ A69.2
Resistance to antibiotics	U82, U83

Appendix C- Overview of chart audit methodology

British Columbia Transplant: Death reports are received from critical care areas and the emergency room. Each death is reviewed for determination of GIVE criteria (Glasgow Coma Score <5, Injury to the brain, Ventilation, and End of life consideration). A chart review of each patient that meets the GIVE criteria is performed to determine organ donation potential.

Manitoba Transplant: During the study period there were two methods used to identify which chart to review to identify potential donors: 1) retrospective use of ICD codes of patients who died in-hospital, and 2) real-time audit of all in-hospital deaths. Each chart was reviewed for death criteria, contraindications for donation and presence of mechanical ventilation.