Regional effects of satellite haemodialysis units on renal replacement therapy in non-urban Ontario, Canada

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Abstract

Background. To provide better dialysis care to rural communities, the Ministry of Health chose to build satellite haemodialysis (HD) units, which are affiliated with, but are distant to, a main renal centre. We considered whether constructing such units in rural regions of Ontario, Canada, alleviated under-service of rates of renal replacement therapy (RRT) locally, decreased patient travel distance and decreased local peritoneal dialysis (PD) utilization.

Methods. We compared two groups of rural regions at two time points (years 1995 and 2002) in a before and after cross-sectional study. These regions were either already serviced by a satellite unit in 1995 (control group, 10 communities), or had new satellite units built between the years 1995 and 2002 (exposure group, 24 communities).

Results. The exposure group had a slightly greater increase in prevalent rate of RRT over time, but this did not reach statistical significance (control group increased 401 per million, exposure group 436 per million, \( P = 0.8 \)). The mean weekly travel distance was reduced by 210.6 km after the construction of new satellite units (\( P < 0.001 \)). There was no significant difference between the groups in reduction of PD proportion (\( P = 0.4 \)). There was a significant increase in the number of elderly receiving RRT once local access was provided.

Conclusions. In conclusion, constructing satellite units increased access to renal care for elderly patients and reduced travel time for HD patients living in rural communities.

Keywords: ESRD; haemodialysis; peritoneal dialysis; regional variation; RRT rate

Introduction

There are many potential barriers to accessing renal care including older age, female sex and African, Hispanic and Asian races [1–3]. The reasons for the association are complex and are influenced by patient and provider preferences [4]. Travelling large distances to the closest major renal centre for renal care is a barrier to many patients, especially if they are elderly and have difficulty with mobility. A physician survey determined that the number of referrals to nephrologists was inversely proportional to the distance of older patients to the closest dialysis unit [5]. Elderly patients were more likely to be referred to a nephrologist, if they lived in a centre with a local dialysis unit [6]. Areas that were closer to a dialysis unit (satellite or non-satellite unit) had higher renal replacement therapy (RRT) rates than regions further away from a renal unit in a regional study from Wales [7].

In the 1980s, in Canada, haemodialysis (HD) was mostly available in larger metropolitan areas so patients living outside these regions needed to travel large distances to receive HD. Countries with publicly funded health care, like Canada and the UK have reported possible rationing of RRT especially in the elderly [6,8]. To provide better renal care to patients living at a distance from major renal centres, the government of Ontario in the 1990s supported the construction of satellite HD units in regions outside of large metropolitan areas [9]. There are now over 55 units in the province. Many of the units were implemented in areas distant to major dialysis centres, but are affiliated with and often managed by the closest major regional renal centre [10]. In Ontario, specialist care by a nephrologist is provided centrally in regional centres (as opposed to satellite units) and physicians are reimbursed equally for HD and peritoneal dialysis (PD).

Canada is similar to other countries with publicly funded health care systems with respect to overall...
Defining rural regions serviced by satellite units

Satellite units are those HD units that do not have an on-site nephrologist and treat patients who are not hospitalized (able to dialyse in a chair vs a stretcher and can transport to and from dialysis). Such units are affiliated with a regional renal centre, and nephrologists from the regional centre are responsible for the care of patients treated in the satellite unit.

In order to measure RRT rates, definition of geographical regions that were affected by satellite units was necessary. The area division was done in 2002, since this is the time at which all of the units were present. There were 507 CSDs in Ontario in 2002, which were combined to form dialysis service areas (DSAs). This concept was derived from earlier geographical studies using hospital service areas [12–15]. We included DSAs of 34 satellite units in this study. For each of these DSAs we knew the number of patients receiving dialysis, the demographics and characteristics of these patients and the demographics for all persons in the general population living in each area. To assign patients to either the control or exposure group, we used the rule of plurality as reported elsewhere [12–15]. In brief, this process is highlighted in Figure 1 and described subsequently.

In Figure 1, panel a, the province of Ontario is theoretically represented by the large box. The smaller squares numbered 1–9 represent individual CSDs. The hatched rectangle in the top left hand corner represents a dialysis unit built before 1995 (control unit) and the solid rectangle in the bottom right hand corner represents a satellite HD unit built between 1995 and 2002 (exposure unit). The hatched circles in Figure 1, panel b, represent people living in different CSDs, who receive their HD treatment at the unit built before 1995 and in Figure 1, panel c, the solid circles are added to represent individuals receiving HD at the unit built after 1995. A CSD, and therefore, patients living in that area, were assigned to DSAs based on where the highest number of HD patients in that area travelled to receive treatment (referred to as a plurality rule). In Figure 1, panel d, the CSDs numbered 1 and 2 are assigned to the control unit as all HD patients who lived in those CSDs in the year 2002, received treatment at that unit. CSDs numbered 6 and 8 are assigned to the exposure unit built after applying similar reasoning. In Figure 1, panel e, patients living in CSDs 4 and 5 have a mix of patients receiving care at control and exposure units, and are assigned to the control unit built based on the plurality rule even if the highest percentage of patients going to the assigned unit was not a majority. Similarly, CSD number 9 was assigned to the DSAs of the exposure unit. CSDs in the following situations were excluded: those with no patients receiving HD (CSD number 7) and those with equal numbers of patients going to different units were also excluded as one would not be able to assign the CSD to a particular DSA definitively (CSD number 3). CSDs with both a satellite and a hospital unit were excluded because it was not possible to distinguish which patients were treated at which facility within the same CSD. RRT rates were measured in the same DSA boundaries in both 1995 and 2002. Although total rates of RRT were measured, the area division was based on where HD patients were treated, since they are the ones who travel for service.

Areas with teaching hospitals and tertiary care centres and large metropolitan cities and patients living within them were excluded from the analysis since the focus of this study

Subjects and methods

Study design

Ontario administrative data were utilized to assess the effects of constructing satellite HD units on rates of RRT and dialysis modality selection. The unit of analysis for this study was the geographic region, not the patient. We compared two groups of rural regions at two time periods in a before and after cross-sectional study. The years 1995 and 2002 were used as the before and after time periods because the number of satellite units markedly increased in Ontario during this time. These regions outside large metropolitan centres either already had a local satellite unit in 1995 (control group), or acquired a new local satellite unit by the year 2002 (exposure group). Prior to construction of the new satellite units, HD patients in the exposure group had to travel large distances to the closest HD centre.

Data sources

The main sources of information were data sets from 1995 and 2002 from the Canadian Organ Replacement Register (CORR), a clinical registry held at the Canadian Institutes for Health Information (CIHI). This registry records patients’ modality of treatment for kidney failure, patient residence location, demographics and baseline comorbid conditions. Patient residence location and treatment facility location were recorded by census subdivision (CSD) in the CORR database. CSD is a geographical unit used by Statistics Canada to define sections of provinces and is similar to a postal code. The geographical region of Ontario is divided into 507 distinct CSDs.

Age and gender distribution of the population of Ontario by CSD was obtained from the Registered Persons database (RPDB) for both 1995 and 2002. The RPDB provides demographic information about individuals who were eligible for publicly funded health care from 1991 onwards. The regional diabetes rates were obtained from the Ontario Diabetes Database (ODD), which has records of all incident and prevalent diabetes patients starting from 1994 and 1991, respectively. The RPDB and ODD are held at the Institute for Clinical Evaluative Sciences (ICES), Toronto, Canada. The locations of the satellite dialysis units in 2002 were obtained from the Ontario Diabetes Atlas [10].

prevalent rates of RRT [11]. However, subsequent to the satellite unit expansion in Ontario, there have been no studies examining the local impact on RRT rates or dialysis modality distribution in regions more remote from a major renal centre. The purpose of this study was 3-fold: (i) to determine whether new provision of local HD access disproportionately increased RRT rates relative to communities with prior access, or merely decreased travel distance (ii) to determine if there was a larger decline in PD utilization in areas where HD was initially absent and (iii) to determine whether elderly and sicker patients were being disadvantaged in areas that initially were without local access.
was to examine regions and individuals with distance barriers to accessing renal care. Patients living in the excluded areas would not have the same geographic barriers to accessing care as those in more remote regions. After these exclusions, the DSAs of control and exposure group units were mapped. The map of DSAs for Southern Ontario is shown in Figure 2.

A localization index was calculated as a validity check of the geographical area division [13–14]. This was done by calculating the percentage of patients in each dialysis catchment area that receive their treatment locally as opposed to travelling to other DSAs for treatment.

**Patient selection**

Patients living in the geographic regions composing either the exposure or control group who received RRT were eligible for inclusion in the study. Patients were identified using the CORR database and needed to be on RRT for at least two consecutive months in either 1995 or 2002 to be included in the study. Patients of age \( \leq 19 \) were excluded, as RRT modality distribution is different in children.

**Statistical analyses**

Prevalent rates of RRT were defined as all people who were on RRT in a given year, regardless of their year of starting RRT. Thus prevalent rates of RRT in 1995 and 2002 were calculated by dividing the total number of people receiving RRT in a DSA in a given year by the population for the corresponding DSA in the same year. This was a regional population-based analysis and our numerators and denominators came from different non-linkable data sources, therefore, it was not possible to fit a multivariate model for risk adjustment since we did not know which patients received RRT in the population. For this reason, the region was used as the unit of analysis for both years since the patients in 1995 were not all the same as in 2002. Indirect standardization was utilized to adjust for age, gender and diabetes rates by DSA, as older age and diabetes are associated with increased risk of end-stage renal disease. The change in adjusted RRT rates between 1995 and 2002 was then calculated for each DSA. The means of the changes in RRT rate for the communities comprising the control and exposure groups were compared using an independent two sample \( t \)-tests. A power calculation was performed to estimate the ability to detect a specified difference in changes in RRT rate between control and exposure groups. The sample sizes were fixed at 10 and 24 satellite HD units, respectively. The SD of 126 per million people was derived from taking the difference in RRT rate over time by county and calculating a mean and SD on the differences in rate by county. (Counties are larger than DSAs). We estimated that the control groups would have an increase in RRT of 20%, or 100 patients per million population over 7 years and that over a similar time period, the exposure group would experience an increase of 50% or 250 patients per million population. The mean values for changes in RRT rate entered in to the power and sample size calculator (PASS NCSS, Kaysville, Utah, 2005) for the control and exposure groups were as follows: 100 and 250 per million people, SD was 126 per million people and the alpha value was 0.05. It was estimated that we had 85% power to detect the difference of changes in rates over time between groups of 150 patients per million people.
The following supplementary analyses were done to determine the robustness of the primary outcome: an analysis that weighted changes in RRT by precision, an analysis which excluded transplantation from renal replacement rates, an analysis which only considered Southern Ontario, the most populated area of the province; an analysis which categorized dialysis service units using a 70% majority instead of a plurality rule. Another supplementary analysis to determine if there were marked differences in access to care specifically in the elderly patients (age > 65 years) was performed.

PD proportions were calculated for each group in 1995 and 2002 by dividing the number of PD patients by the total number of RRT patients. The between-group values were compared with a Chi-squared test. The change in PD proportion between 1995 and 2002 was calculated for each group in the same fashion as was done for the rates of RRT, and the groups were compared using an independent samples t-test. The second analysis describes changes over time in proportion of PD per average DSA while the former PD analysis gives an overall picture of PD in all DSAs in the study combined in a given year.

All analyses were conducted using SAS version 9.1.3, SAS Institute Inc., Cary, NC, USA, 2002–03. Maps of the DSAs were created using MapInfo Professional version 7.0 from MapInfo Corporation, Troy New York, USA. This software was also used to calculate the straight-line distance between patient residence and dialysis unit location. Ethics review boards at the University of Toronto and the Sunnybrook Health Sciences Centre approved the study protocol.

**Results**

**Geographical division of Ontario**

There were 82 dialysis units in Ontario in 2002 of which 25 were excluded because they were in cities with teaching hospitals. An additional 22 HD centres were excluded because they contained a non-satellite unit and one was excluded because it is run by the province of Manitoba and not by Ontario. There were 10 HD units in the control group and 24 in the exposure group for a total of 34 HD units in the study.

After application of the exclusion criteria, there were 337 CSDs in the 2002 CORR data set. Of these, 26 were excluded secondary to being unassignable (Figure 1), leaving 311 CSDs in the area for assignment analysis. Excluding these 26 CSDs resulted in 1.9% and 1.1% of the RRT populations in 1995 and 2002, respectively, being excluded. The mean of the localization indices for the control and exposure groups were 0.78 and 0.67, respectively. The map of Southern Ontario demonstrating DSAs is shown in Figure 2.

**Patients**

The demographics of renal patients in the control and exposure groups in 1995 and 2002 are described in Table 1. Interestingly, there was a significant increase in the number of elderly patients receiving RRT in the exposure group and significantly more patients with comorbidities being treated for RRT in 2002 vs 1995 in both groups. There were 6532 patients in the 1995 data set. Patients who met at least one of the following criteria were excluded: lived outside of Ontario, were under the age of 20, had residence location missing, or lived in cities with teaching hospitals. A total of 3494 patients were excluded which resulted in a data set with 2858 patients to be included in the analysis. A further 83 patients were excluded because of changes in CSD boundaries over time. Therefore, there were 2775 patients in the 1995 data set. Similarly, there were 11 293 people in the 2002 data set from which 5408 met exclusion criteria and
were excluded. After accounting for boundary changes in CSDs, there were 5747 patients in the 2002 data set.

Renal replacement therapy rates and peritoneal dialysis proportions

The adjusted changes in RRT rates for the control and exposure groups, respectively, between 1995 and 2002 were 401 and 436 per million people. These are shown in Table 2. The unadjusted results were similar (data not shown). The adjusted RRT rates for the control and exposure groups in 1995 were 683 and 506 pmp, respectively. This represents an RRT rate that is 26% higher at baseline in the control areas, suggesting under-utilization of RRT in the exposure areas ($P = 0.14$). In 2002, RRT rates for the control and exposure groups were 1084 and 943 pmp, respectively. The RRT rate was only 13% different between groups in 2002 vs a 26% difference in 1995. Results in the supplementary analyses were similar and are shown in Table 3. Of note, in the elderly group, there was a 30.6% relative difference in the RRT rates between groups in 1995, which decreased to 4.6% by 2002. None of these differences achieved statistical significance.

The proportions of RRT patients on PD in the control and exposure groups in 1995 were 0.28 and 0.24, respectively, and the difference was not significant ($P = 0.2$). The corresponding PD proportions for 2002 were 0.15 and 0.11, respectively, with the rate of PD utilization in the exposure group now being significantly greater ($P = 0.03$). The decrement in PD proportions between 1995 and 2002 was more in the exposure vs the control group, but this did not reach statistical significance. These results are shown in Table 4.

Distances and mapping

The mean straight-line distances to the nearest HD facility for all HD patients in the study were 37.0 km and 10.6 km in 1995 and 2002, respectively ($P < 0.0001$). In the control group, the distances to the closest HD unit were 14.7 km in 1995 and 10.4 km in 2002 ($P = 0.27$). In the exposure group, however, there was a significant reduction in mean distance to the closest unit as the average distances in 1995 and 2002 were 45.8 km and 10.7 km, respectively ($P < 0.0001$) (Table 5).

Discussion

Constructing a satellite unit reduced travel time for patients living outside large metropolitan centres and receiving haemodialysis. Regions initially without local access to RRT may have experienced under-service.
There was a significant increase in the number of elderly patients being treated with RRT after local access was available. Satellite units did not significantly decrease the proportion of patients being treated with PD. Overall results were similar in adjusted, unadjusted and supplementary analyses. Implementation of satellite HD units did not appear to create a supply-induced demand for RRT in regions where they were built.

The finding of no difference in RRT rates between groups might be secondary to adequate care being provided to people in the exposure areas prior to local access. However, the issue of confounding by change in access in the control units cannot be ignored. The databases used in this study were not able to account for the fact that when the exposure group units opened, some patients moved from the control to exposure units, which created space and service availability in both regions, as opposed to only the exposure group. Therefore, the control communities also experienced increased local access resulting in a smaller difference between groups. We had 85% power to detect a between-group difference of changes in RRT rates of 150 per million people, hence, smaller but clinically important differences may have gone undetected. Administrative data were used, so only limited clinical information was available. Unlike prevalent rates, incident rates may give a better picture of trends in RRT during a given year. However, in this study there was insufficient sample size of incident RRT patients for this analysis.

Other potential reasons for the absence of a difference were explored in supplementary analyses. Small sample sizes can yield potentially unstable rate estimates. Transplant patients generally have longer survival than dialysis patients, which may have masked differences in prevalent dialysis rates. Access to medical care in Northern Ontario is generally more difficult and limited when compared with Southern Ontario. The geographical boundary definition influenced rates of RRT in this study. To account for the aforementioned factors, four supplementary analyses were performed as follows: weighted by precision, with transplant patients excluded, with the units and patients in Northern Ontario excluded and the last one used only CSDs with ≥70% of patients receiving RRT in the assigned DSA. None of these analyses significantly changed the overall results of this study. We hypothesized that if the exposure areas were underserved in 1995, that access would be reduced for elderly patients with comorbidities. For the elderly in 1995, RRT rates in the exposure communities were 30.6% lower than in the control communities. This rate in 2002 was only 4.6% lower in the exposure vs the control group. The increase in proportion of elderly patients receiving care in 2002 suggests that they were benefited by local access. This study, however, was not powered for the supplementary analyses so this can be viewed only as an association that warrants further examination. Although this study may have been under-powered, this methodology could be used in other jurisdictions with larger numbers of units and the ability to account for movement between units to assess local impacts of satellite units on RRT.

Although not statistically significant, the results of this study give approximate expected increases of RRT rates in regions with pre-existing units and those acquiring new satellite HD units. This has importance in terms of regional health care planning for end-stage renal disease. In a single-payer system such as Canada, especially if travel is covered by the provincial Ministry of Health (Ontario covers nursing home residents’ travel to HD units), building local units may make economical sense since it reduces travel costs. The average base cost for a wheelchair transport starts at CDN $47.50 and is $1.70/km after the first 10 km. In systems where costs are fragmented (city pays for transport while the province/state pays for dialysis treatment), there may not be as much benefit economically, but it would improve quality of life for patients.

Both increased age and higher comorbidity have been shown to favour the choice of HD over PD in studies examining dialysis modality selection [16–18]. PD proportions were declining in urban and rural areas in Canada and the US between 1995 and 2002, so the decline seen in the exposure group in this study, may or may not have been secondary to provision of HD locally [19]. There was possibly a trend towards under-service in areas without local access initially, given the 26% difference in rates between groups in 1995. The significant increase in the elderly patients receiving RRT after local access was provided may indicate that the elderly in these regions were being disadvantaged when there was no local HD. This could either be because they were not suited to PD as much as HD or their preference was HD compared with PD.

Policy-makers considering local expansion of health services in a single-payer system are often concerned that an increase in local availability will induce greater demand for the service [12]. This effect may prompt inappropriate utilization and lead to inefficient investment. The current study suggests that improved local access to HD does not create this sort of supply-induced demand.

In conclusion, building satellite units was an effective approach to HD delivery in Ontario, Canada, since they improved access to RRT for elderly

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### Table 5. Distances to nearest HD facility in 1995 and 2002

<table>
<thead>
<tr>
<th>Group</th>
<th>Year</th>
<th>1995</th>
<th>2002</th>
<th>(P)-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All HD Patients</td>
<td>37</td>
<td>10.6</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Control</td>
<td>14.7</td>
<td>10.4</td>
<td></td>
<td>0.27</td>
</tr>
<tr>
<td>Exposure</td>
<td>45.8</td>
<td>10.7</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Distances are in kilometres and listed from the centre of the patient’s CSD to the nearest HD facility (one direction only).
patients, decreased travel time for patients on HD and did not create a supply-induced demand for RRT.

Acknowledgements. The authors thank Drs L. Moist, R. Suri, J. Bargman, R. Goluch, N. Delbrouck, T. Toffelmire, T. Liu, W. McCready, C. Williams and A. House for their suggestions and help with data collection; R. Croxford and J. Guan for help with SAS programming; T. Gomes for map creation and the Canadian Institutes for Health Information (CIHI) for data provision.

Conflict of interest statement. Dr Prakash received salary support research fellowship from Canadian Institutes for Health Research (CIHR), AXG was supported by a clinician scientist award from CIHR, PCA was supported by a new investigator award from CIHR and JEH receives salary support from the Institutes for Clinical Evaluative Sciences. The opinions, results and conclusions are those of the authors and no endorsement by the Ontario Ministry of Health and Long-Term Care or by the Institute for Clinical Evaluative Sciences is intended or should be inferred.

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Received for publication: 16.12.06
Accepted in revised form: 6.3.07