Model for Equitable Care and Outcomes for Remote Full Care Hemodialysis Units

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Background and objectives: Remotely located patients not living close to a nephrologist present major challenges for providing care. Various models of remotely delivered care have been developed, with a gap in knowledge regarding the outcomes of these heterogeneous models. This report describes a satellite care model for remote full-care hemodialysis units managed homogenously in the province of Manitoba, Canada, without onsite nephrologists. Survival in remotely located full-care units is compared with a large, urban full-care center with onsite nephrologists.

Design, setting, participants, & measurements: Data from a Canadian provincial dialysis registry were extracted on 2663 patients between 1990 and 2005. All-cause mortality after initiation of chronic hemodialysis was assessed with Cox proportional hazards regression. Both short-term (1 year) and long-term (2 to 5 years) survival were analyzed.

Results: Survival for patients receiving remotely delivered care was shown to be better than for those receiving care in the urban care center with this particular Canadian model of care. Furthermore, there was no difference when assessing short- and long-term survival. This was independent of distance from the urban center.

Conclusions: Chronic hemodialysis patients receiving remotely delivered care in a specialized facility attain comparable, if not better survival outcomes than their urban counterparts with direct onsite nephrology care. This model can potentially be adapted to other underserviced areas, including increasingly larger urban centers.

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The epidemic of ESRD requiring chronic dialysis continues internationally, resulting in an ever increasing pressure on full-care hemodialysis units. Although home-based dialysis modalities are actively encouraged in most jurisdictions, the majority of patients receive full-care hemodialysis (1,2). In 2006, approximately 34,000 Canadians were living with ESRD, with a prevalence of 1037 per 1 million, an increase from 636 per 1 million since 1996. Of the 61% (20,000) receiving chronic dialysis, almost 79% received institutionalized chronic hemodialysis (1). Because of the concentration of nephrologists in urban centers, many dialysis units are responsible for the care of patients residing in remote locations (2–7), in contrast to traditional care provided by onsite nephrologists in either hospital or community-based units. One Canadian study noted that approximately 24% of chronic dialysis patients live more than 150 km (93 miles) from the nearest available nephrologist (6). Distance from available nephrologists has been associated with poorer health outcomes (7–9). The goal of any chronic dialysis program is to provide optimal equitable care to all of its patients regardless of location and physician resources. This was a particular challenge for Manitoba, a Canadian province with a geographic dispersion spanning 1300 km (807 miles) from north to south, and a high burden of renal disease among the Aboriginal populations in northern and rural areas. This study reports the development of a unique satellite program, called the Manitoba's Local Centre Program, in an attempt to provide an equivalent level of care compared with a large, urban full-care center despite the lack of onsite nephrologists.

Because gaps in the literature regarding outcomes of care received from remote sites exist, this study also sought to evaluate this model of care through a population-based comparison of mortality between patients receiving their care from the urban care site and satellite sites.

Materials and Methods

In Manitoba, a chronic hemodialysis model for remotely delivered care was created that paralleled the care provided by onsite nephrologists in an urban full-care center. This allowed patients to remain in their own communities. "Remote" in this context is independent of distance but developed on the basis of the model in which the urban-based nephrologist directs dialysis care and is actively involved in nondialysis care in partnership with family physicians based in the patient's home community. Each offsite unit is referred to as a "local center" (LC). This model has been in place since the late 1980s and is an extension of the Manitoba Renal Program (MRP), the sole dialysis provider in Manitoba. LCs were

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created with an explicit and direct linkage to Winnipeg's (Manitoba's capital city) Health Sciences Centre (HSC), the province of Manitoba's major urban and tertiary care hospital. The HSC has two nephrologist-attended full-care units, one physically removed from the hospital, analogous to a community-based unit, and one within the hospital, providing more tertiary care, each having a comparable chronic capacity.

Criteria for the development of each LC included a minimum of four appropriate patients and a prohibitive distance from commuting, defined as any distance requiring more than an hour's automobile drive. This distance also precluded the nephrologist from providing onsite care on a regular basis. All chronic hemodialysis patients either presenting *de novo* and deemed end-stage or commencing electively have their dialysis care initiated in the urban center. Once considered to be ineligible for a home-based modality, they are assessed by the LCs' HSC multidisciplinary team. All potential patients originating from LC areas are considered, including those from hospitals other than the HSC. The assessment includes the suitability of dialyzing in an area remote from direct access to speciality care. Once transferred to the relevant LC, the patients' medical and dialysis care is jointly shared by the HSC multidisciplinary team, which includes a nephrologist (scheduled on a rotating basis), senior dialysis nurse, social worker, dietician, and pharmacist, and the LC team, which includes a trained dialysis nurse and a dedicated primary physician, both located in the LC. On a weekly basis, telephone rounds occur between the HSC multidisciplinary team and the LC hemodialysis nurse. During these weekly rounds, the nephrologist provides care that would simulate onsite weekly rounds, reviewing dialysis-specific issues maintained by trended flow sheets, including dialysis treatment summaries, medication, and lab test flow sheets, faxed weekly to the HSC. The LC maintains a legal dialysis record identical to the HSC record, whereas the HSC maintains a shadow chart containing the faxed flow sheets, copies of verbal orders, and documentation of the weekly phone rounds. The LC physicians are responsible for primary and emergency care, with an HSC nephrologist available continuously for backup. Each patient is reviewed annually in person. If intercurrent problems arise that require more comprehensive care than available at LCs (such as vascular access, tertiary care surgery, or critical care), patients are transferred to HSC, with their spot in the LC held for them.

Study Design and Data Sources

Currently, there are 12 LCs providing full care to approximately 22% of the Manitoba hemodialysis population. They range from 42 km (25 miles) to 759 km (464 miles), with seven LCs more than 300 km (183 miles) from Winnipeg (Table 1). This study employed a retrospective cohort research design. The data analyzed are collected as part of the MRP clinical registry. This registry contains clinical and demographic information from all patients undergoing chronic hemodialysis in Manitoba. The Manitoba dialysis registry was established with the development of the LC program in the late 1980s and is used by the clinical program to track all dialysis patients. It is closely monitored by the medical director to ensure all patients' entry and departures are captured as an administrative database. It is more complete than the Canadian Organ Replacement Registry, upon which previous published Canadian studies have been based. As an administrative and quality control database it includes all patients receiving care in Manitoba because consent or compliance with form completion is not required. Once a patient was formally transferred to an LC, that patient was deemed an LC patient until death or transplantation, even if temporarily dialyzed in the urban center.

Table 1. LC distance from Winnipeg

LC-Far (>300 km)	Kilometers (Miles)	LC-Near (<300 km)	Kilometers (Miles)
Flin Flon	743 (460)	Ashern	167 (105)
Thompson	759 (464)	Pine Falls	111 (70)
The Pas	608 (380)	Morden	102 (64)
Swan River	476 (298)	Portage	85 (51)
Garden Hill[a]	475 (298)	Selkirk	42 (25)
Norway House[a]	458 (287)		
Dauphin	304 (190)		

[a]First Nation Communities.

Study Cohort

Inclusion criteria for the study cohort included all patients receiving chronic hemodialysis from MRP between January 1, 1990, and October 31, 2005. The urban center analyzed in this study is the combined HSC units. Patients with acute renal failure were excluded from this study, as were patients if they died within 30 days of hemodialysis initiation. Study subjects were followed to the end of October 2008 (*i.e.*, a minimum of 3 years) to allow sufficient time for the development of outcomes. This study was approved by the University of Manitoba Health Research Ethics Board.

Statistical Analysis

Kaplan-Meier methods were used to compare the survival rates between local centers and the urban site. Cox proportional hazards regression was used to model the independent predictors of time to mortality. Hazard ratios (HRs) with 95% confidence intervals (95% CIs) are reported in our tables. Patients were right-censored if they received a transplant, moved from the province, or were lost to follow-up during the study period. The proportional hazards assumption was assessed through log-negative log graphs, as well as the *stphtest* command in Stata, which is developed on the basis of the work of Grambsch and Therneau with scaled Schoenfeld residuals (10). Stata 9.2 (11) was used for all analyses. Sensitivity analyses were performed to assess the effects of varying the minimum follow-up and survival times.

Measures

The outcome examined was all-cause mortality after initiation of hemodialysis. Five-year mortality was examined, with the unit of time being measured in days. Location of care was categorized as urban, LC-near (local centers up to 300 km away from Winnipeg), and LC-far (local centers located more than 300 km from Winnipeg). Two of the LC Far units are exclusively First Nation Communities with only nursing stations adjacent to the dialysis unit. Aside from location of care, Aboriginal ethnicity has been associated with higher rates of ESRD (12–14) and both poorer access to and increased mortality after kidney transplantation (15,16) and initiation of hemodialysis (8).

Results

In total, 2663 patients met the study criteria. Of these, 46 were missing data on ethnicity. All 2663 patients were included in descriptive analyses, whereas only those with complete data were included in multivariable analyses. Table 2 displays the characteristics of the study sample, stratified by location of care. There were slightly more men (56%), with the average age 59.1 years. Patients were predominantly Caucasian (65%) and

Table 2. Comparison of study characteristics between LCs and urban patients, MRP

	Urban (n = 2196; 82.5%)	LC-Near (n = 285; 10.7%)	LC-Far (n = 182; 6.8%)	P
Sex				
female	970 (44.2)	123 (43.2)	93 (51.1)	0.17
male	1226 (55.8)	162 (56.8)	89 (48.9)	
Age, yrs				
17 to 39	302 (13.8)	23 (9.7)	27 (14.8)	
40 to 54	494 (22.5)	75 (21.9)	58 (31.9)	
55 to 69	750 (34.2)	131 (39.4)	75 (41.2)	
70+	650 (29.6)	56 (29.0)	22 (12.1)	
Mean (SD)	58.9 (15.6)	58.4 (13.5)	54.2 (14.1)	<0.001
Race[a]				
Caucasian	1457 (68.6)	145 (51.4)	42 (23.1)	<0.001
Aboriginal	492 (23.2)	136 (48.2)	140 (76.9)	
Other	174 (8.2)	1 (0.4)	0 (0.0)	
Primary diagnosis				
TID	295 (13.4)	28 (9.8)	11 (6.0)	<0.001
DN	1023 (46.6)	183 (64.2)	126 (69.2)	
GN	561 (25.6)	49 (17.2)	40 (22.0)	
HTN	317 (14.4)	25 (8.8)	5 (2.8)	
Decade				
1990 to 1994	472 (21.5)	43 (15.1)	34 (18.7)	0.13
1995 to 1999	725 (33.0)	99 (34.7)	65 (35.7)	
2000 to 2005	999 (45.5)	143 (50.2)	83 (45.6)	

Values are given as number of patients, with percentage in parentheses. Age based on ANOVA; all others based on χ^2 test of association. TID, tubulointerstitial disease; DN, diabetic nephropathy; GN, nondiabetic glomerular disease; HTN, primary hypertension.

[a]Missing, n = 46.

Aboriginal (28%), with less than 1.0% being African-Canadian. Almost 18% of the study sample received care from an LC, with 11% in an LC-near location and 7% located in an LC-far. Approximately 56% of the sample died within 5 years of MRP enrolment, with a median survival time of 615 days. Significant differences were observed for age at admission ($P < 0.001$) and by primary diagnosis ($P < 0.001$). LC patients tended to be younger, more likely to be Aboriginal, and have diabetes as their renal diagnosis.

Multivariable Analyses

After data were fitted to the Cox proportional hazards regression model, assessment of the model suggested some violation of the proportional hazards assumption. Model checking revealed that hazards were changing over time with the diagnosis and the decade variables. Thus, the diagnosis × time and decade × time interactions were tested through likelihood ratio tests, and both were significant at the $P < 0.001$ level. To facilitate global understanding of mortality in the study period, and as a strategy to address the changing hazards suggested by the decade × time interaction, models were fitted that examined 1-year (*i.e.*, short-term) and 2 to 5 years (*i.e.*, longer-term) survival separately, but not stratified by primary diagnosis. Five years was chosen as the upper limit because this allowed sufficient time for mortality to be observed (*i.e.*, more than half

Table 3. Adjusted HRs and 95% CIs from multivariable Cox regression, 1-year and 2- to 5-year survival, by location of care

	1 yr		2 to 5 yrs	
Location of Care	HR	95% CI	HR	95% CI
Urban	Reference	–	Reference	–
LC-near	0.27[a]	0.17, 0.45	0.67[a]	0.54, 0.82
LC-far	0.27[a]	0.14, 0.53	0.72[b]	0.55, 0.92

Minimum of at least 30 days of survival and 3 years of observation. All models adjusted for sex, age, primary diagnosis, race, and treatment period.

[a]$P < 0.001$.

[b]$P < 0.05$.

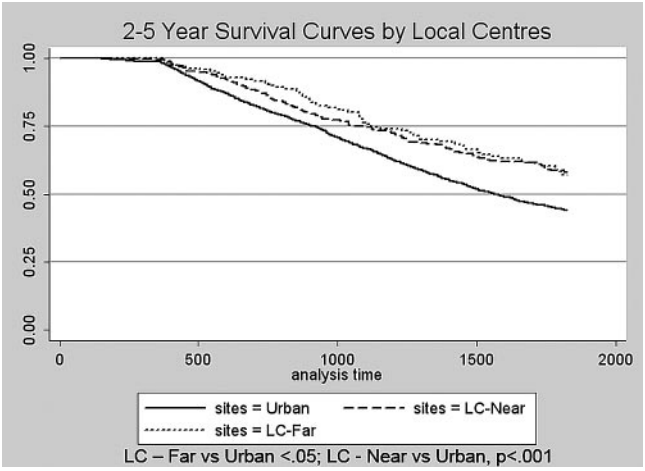

Figure 1. Long-term survival: local centers *versus* urban center.

of patients died within 5 years of entry into the MRP database), whereas further inspection of survival probabilities suggested further violation of the proportional hazards assumption past 5 years of survival. Patients surviving longer than 5 years were censored out of the analysis after 5 years from their entry into the MRP database. Finally (and motivated by the significant diagnosis × time interaction), as a subanalysis, models were then fitted that were stratified by primary diagnosis.

There were significant differences in mortality between LCs and the urban care center in multivariable analysis for short- and longer-term survival in unstratified analyses (Table 3, Figure 1). For short-term survival, receiving care from LC-near (HR: 0.27; 95% CI: 0.17, 0.45) and LC-far (HR: 0.27; 95% CI: 0.14, 0.53) were both significantly associated with increased survival, adjusted for sex, age, race, primary diagnosis, and treatment decade. Similarly, receiving care from LC-near (HR: 0.67; 95% CI: 0.54, 0.82) and LC-far (HR: 0.72; 95% CI: 0.55, 0.92) LCs was significantly associated with increased longer-term survival, adjusted for all other variables.

Stratified Subanalysis

Table 4 displays adjusted HRs from the subanalysis where short-term and longer-term survival were examined, stratified by primary diagnosis at entry into MRP. For short-term survival, location of care was associated with increased survival for those diagnosed with tubulointerstitial disease, diabetic nephropathy, and nondiabetic glomerular disease but not those with diagnosis of hypertension. For diabetic nephropathy, receiving care from both LC-near (HR: 0.27; 95% CI: 0.14, 0.52) and LC-far (HR: 0.28; 95% CI: 0.13, 0.60) was associated with longer survival times. Because of small cell sizes, LC-near and LC-far were collapsed for the short-term analyses. For those diagnosed with tubulointerstitial disease and nondiabetic glomerular disease, HRs were 0.11 (95% CI: 0.02, 0.81) and 0.18 (95% CI: 0.04, 0.76), respectively. For longer-term survival, location of care was associated with improved survival for tubulointerstitial and diabetic nephropathy only. Diabetic nephropathy was the one diagnosis consistently associated with improved short- and long-term survival in the LCs regardless of distance.

Discussion

In many jurisdictions, chronic hemodialysis patients living in remote areas that are not serviced by onsite nephrologists are required to travel to urban centers to access care. Negative consequences of travel for dialysis by remotely located patients include inadequate social support, financial burden, and psychosocial disruptions (17–20). In Canada, Aboriginal popula-

Table 4. Adjusted HRs and 95% CIs from multivariable Cox regression, 1-year and 2- to 5-year survival, by location of care, stratified by primary diagnosis

	TID[a]		DN		GN		HTN[a]	
	HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI
1-year survival								
n (%)	328 (12.7)		1298 (50.2)		625 (24.2)		336 (13.0)	
urban	Reference	–	Reference	–	Reference	–	Reference	–
LC-near	0.11[b]	0.02, 0.81	0.27[c]	0.14, 0.52	0.18[b]	0.04, 0.76	0.37	0.11, 1.17
LC-far	–		0.28[d]	0.13, 0.60	0.40	0.09, 1.67	–	
2- to 5-year survival								
n (%)	266 (12.3)		1100 (50.8)		547 (25.3)		253 (11.7)	
urban	Reference	–	Reference	–	Reference	–	Reference	–
LC-near	0.40[b]	0.16, 0.98	0.63[c]	0.49, 0.81	0.94	0.54, 1.65	0.93	0.50, 1.75
LC-far	1.34	0.53, 3.36	0.63[d]	0.47, 0.85	1.01	0.53, 1.92	0.65	0.20, 2.08

Minimum of at least 30 days of survival and 3 years of observation. All models adjusted for sex, age, primary diagnosis, race, and treatment period. TID, tubulointerstitial disease; DN, diabetic nephropathy; GN, nondiabetic glomerular disease; HTN, primary hypertension.

[a]LC-near and LC-far cases collapsed because of small cell sizes for TID and HTN in 1-year survival models

[b]$P < 0.05$.

[c]$P < 0.001$.

[d]$P < 01$.

Table 5. Comparison of government-funded LC and an urban care center

	LC	Regional Center Linked to LC	Urban Full-Care Center
Proportion of funding	45% (nonspecific supplies and staff)	55% (dialysis-specific supplies)	100%
Patient type	Stabilized chronic only		Any
Treatment type	Only scheduled chronic treatment; no acute or urgent	For urgent treatments, on the basis of phone consultation, managed conservatively, or transferred to Winnipeg	Chronic and acute or urgent
Staff	MRP-trained nurses	Senior dialysis nurse Pharmacy/social work/dietary support linked to the LC	MRP-trained nurses Pharmacy/social work/dietary support
Medical	Onsite general physician	Nephrologist	Nephrologist only
Model of care	Primary and emergency care	Weekly phone rounds to review faxed treatment, lab, drug flow sheets, and intercurrent problems	Weekly walk rounds and onsite coverage
Medical record	MRP dialysis record with flow sheets identical to urban full care	Shadow chart with faxed flow sheets and informal documentation of weekly phone rounds	MRP dialysis record
Vascular access (and other tertiary care support including allied health)	Organized with regional site and typically provided by urban tertiary care unit	Organizes various support activities	Available onsite

tions have been shown to have both a higher prevalence of ESRD and higher ESRD-related mortality than the general population (14). To address some of the challenges of providing chronic hemodialysis remote from available nephrologists, various models of remotely delivered care have been developed (2–4,7,17). Typically, these remote, or satellite centers are staffed by specially trained nurses and/or general nonspecific physicians. Case consultation is achieved through periodic (*e.g.*, once a month) site visits by a nephrologist via another medium (*e.g.*, teleconferencing), or sometimes not at all. Manitoba is challenged by a high prevalence of ESRD (1), vast geographic distances (comparable to the state of California), and low population density; the LC model was developed to provide equitable care to those located remotely from nephrologists, with an explicit goal of minimizing travel. This study suggests that despite the above challenges, short- and longer-term mortality may be better in the LCs compared with receiving care from a large urban center. This is in contrast to other studies where distance from nephrologists correlated with poor outcomes (6,7,16). It is important to recognize, however, that those studies used proxy measures for distance and did not specifically assess the effect of care model on mortality. A possible explanation may be related to screening practices for transfer to an LC. The result may be that the most complex patients remain in the urban full-care unit in Winnipeg. However, unless the patients have persistently unstable dialysis treatments or frequent emer-

gency room visits, they are not denied treatment in their home communities, and they rarely return to Winnipeg permanently once transferred to an LC. Alternative explanations include the opportunity for remotely located full-care hemodialysis patients to live in their own communities, addressing some of the financial and psychosocial disruptions identified in previous studies (18–20). The actual clinical model may also be a factor, with care shared by the centrally located nephrologist with a multidisciplinary team and the LC team. Further research needs to be conducted to determine which exact mechanisms are operative in obtaining the positive outcomes observed.

Although our results align with recent work suggestive of equitable care delivered in satellite sites in Ontario, Canada, it is important to note that the Manitoba model is distinct from the Ontario model of care (2). According to Lindsay *et al.* (2), the Ontario model has 25 "regional hubs" associated with 46 satellite units. Because protocols for service delivery are unique to each regional hub, in actuality the Ontario model comprises multiple, heterogeneous models of care. The single-provider model in Manitoba allows for a more homogenous approach to service delivery with respect to remotely delivered care, and process for transfer to the urban center with direct access to tertiary and specialized services (*i.e.*, vascular access, critical care).

Table 5 summarizes the differences between the LC model compared with the more traditional full-care model in Winnipeg, in terms of proportion of funding, patient type, treatment type, staff composition, and other care delivery characteristics. In addition to being a model to provide physically remote care, it can be used in other settings, such as the increasingly larger full-care units where the ability to provide onsite nephrology coverage is being exhausted.

Strengths and Limitations

The population-based perspective offered by the MRP was a major strength of this study, as well as the availability of ethnicity data. Limitations to the study include a lack of socioeconomic data on patients, which may have an unmeasured effect on patient outcomes. In addition, because comorbid conditions were not captured by the MRP registry, selection bias cannot be excluded as a contributing factor. Finally, because survival was only measured up to 5 years, it is possible that survival probabilities after this period may be different from that observed in this study. However, from a methodological viewpoint, it was important to ensure that the proportionality assumption of the statistical model was met. On a related note, it should be acknowledged that results for longer-term survival are biased toward those that survive more than 2 years after their entry into the MRP database to be included in the analysis.

Conclusion

We report that with respect to mortality, chronic disease hemodialysis patients receiving remotely delivered care in a specialized facility are at least no worse off than their urban counterparts, although our conclusions are limited by the absence of comorbidity data and a potential selection bias. This study contributes to the nascent literature on outcomes related to remotely delivered hemodialysis, suggesting that care can be delivered in an equitable manner at remote sites with no onsite nephrologist compared with urban, regional, or tertiary care centers with onsite nephrologists. The Manitoba model of care can permit individuals to live far from the source of nephrology care, allowing them to remain in their primary residence or relocate to their residence of choice without apparent detrimental affects to their survival.

Disclosures

None.

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