ORIGINAL RESEARCH ARTICLE

Pharmacoeconomics 2001; 19 (8): 845-854
1170-7690/01/0008-0845/$22.00/0

Incremental Cost Analysis of Ambulatory Clinic and Home-Based Intravenous Therapy for Patients with Multiple Myeloma

Peter C. Coyte,[1-5] *Mark J. Dobrow*[1] and *Larry Broadfield*[6]

1 Department of Health Policy, Management and Evaluation, University of Toronto, Toronto, Ontario, Canada
2 Home and Community Care Evaluation and Research Centre, University of Toronto, Toronto, Ontario, Canada
3 Institute for Clinical Evaluative Sciences, University of Toronto, Toronto, Ontario, Canada
4 Institute of Policy Analysis, University of Toronto, Toronto, Ontario, Canada
5 Hospital Management Research Unit, University of Toronto, Toronto, Ontario, Canada
6 Hamilton Regional Cancer Centre, Hamilton, Ontario, Canada

Abstract

Background: Patients with multiple myeloma and other forms of cancer receiving pamidronate via intravenous (IV) infusion at the Hamilton Regional Cancer Centre in Hamilton, Ontario, Canada face 2 treatment options: they can have their entire treatment completed at the clinic using traditional IV therapy (e.g. IV bag and pole) or they can have the treatment initiated at the clinic and then return home to complete the treatment utilising a portable and disposable IV therapy device.

Objective: To perform a cost analysis of these 2 treatment options.

Perspective: Societal.

Methods and patients: Data on all patients with multiple myeloma who attended the Hamilton Regional Cancer Centre for pamidronate therapy from November 1, 1997 to October 31, 1998 were collected from clinic records. As almost all of these patients with multiple myeloma completed their IV therapy at home, comparison to clinic-based therapy was based on derived cost estimates. Cost data, where possible, were acquired from the Hamilton Regional Cancer Centre's records. A sensitivity analysis was also conducted.

Results: In the base-case scenario for the study period, the incremental cost of the infusion device and training in Canadian dollars ($Can; 1998 values) for the 48 patients (299 cycles) who had their infusion initiated at the clinic but completed at home was $Can15.50/cycle ($Can4636 for the 299 cycles). If these 48 patients had had their entire infusion at the clinic, the incremental costs of overtime treatment, parking, clinic overheads and lost work or leisure time would have been $Can68.49/cycle ($Can20 477 for the 299 cycles). Therefore, shifting treatment from the clinic to the home resulted in net cost savings to society of $Can52.98/cycle ($Can15 841 for the 299 cycles).

Sensitivity analysis of best- and worst-cost scenarios did not alter the substantive findings although the relative difference between treatment options varied. In the best-case scenario, home treatment was $Can95.97/cycle ($Can28 696 for the 299 cycles) less costly than clinic treatment, while in the worst-case scenario, home treatment was $Can17.19/cycle ($Can5141 for the 299 cycles) less costly than clinic treatment. The results also demonstrated that clinic overheads, the cost of a portable and disposable infusion device and the cost of lost work and leisure time had the greatest impact on incremental costs for each treatment option.

Conclusion: Subject to study limitations, a significant cost advantage was demonstrated through the home-based treatment option for patients with multiple myeloma. Key issues that must be addressed in future evaluations include the precise determination of clinic overheads, the valuation of lost work and/or leisure time and the direct cost of portable and disposable infusion devices.

Treatment of patients with multiple myeloma often includes the administration of a bisphosphonate to reduce skeletal complications commonly associated with multiple myeloma. Monthly infusions of the bisphosphonate pamidronate have been shown to be an effective and well-tolerated adjunctive treatment for patients with multiple myeloma.[1,2] However, a variety of intravenous (IV) therapy devices exist that can further impact on a patients' comfort and well-being. Conventional methods normally use a gravity source for infusion. More recently, elastomeric and other disposable and portable infusion devices have been developed. These devices allow IV therapy to be administered while the patient undertakes activities of daily living (e.g. at home or work), thereby altering the clinical and economic environment in which IV therapy is delivered.

Studies assessing the effectiveness of these portable and disposable infusion devices have considered a range of issues including flow rate accuracy, flow continuity, operating and storage conditions, drug stability, range and frequency of doses, reservoir volume and methods of venous access. Although some disposable and portable devices have trouble maintaining flow rate accuracy because of variations in the viscosity of drugs, and while medication performance may be susceptible to changes in operating conditions (such as temperature), for the most part the effectiveness of portable and disposable infusion devices has been established.[3-7]

Economic evaluations of these portable and disposable devices have been less conclusive. Although some studies have demonstrated that shifting IV therapy (e.g. antibiotic IV therapy and pain management) from the hospital to the home may be cost effective,[8] many of these studies were based on hypothetical data[9-12] or limited their evaluation to the perspective of the provider of services rather than a broader societal perspective.[10,11,13]

Robson et al.[13] highlighted attention to a 3-way comparison of treatment provision: inpatient treatment; outpatient treatment at an ambulatory clinic; or outpatient treatment at home. Robson et al.[13] used a cost analysis of methylprednisolone treatment for patients with multiple sclerosis to demonstrate that both outpatient clinic and home treatment were less costly than inpatient treatment, but the cost differences between outpatient clinic and home treatment were not large. The more practical economic evaluation may therefore be between treatments provided in outpatient ambulatory clinics and those provided at home. In the case of patients with multiple myeloma at the Hamilton Regional Cancer Centre in Hamilton, Ontario, Canada they may currently receive IV therapy at an ambulatory clinic or at home; therefore an economic evaluation comparing these treatment options is both feasible and sensible.

The current emphasis on evidence-based medicine advocates treatment selection on the basis of significant improvements in health outcomes for

minimum cost.[14] A number of factors affect the choice between treatment alternatives including political, technological, clinical and patient/family preference factors, but among these factors, sound economic information is ultimately necessary to assist decision making. The purpose of this study was to conduct an incremental cost analysis, from a societal perspective, to determine if cost differences existed between ambulatory clinic and home IV therapy for patients with multiple myeloma.

Methods

Study Design

A retrospective, nonrandomised cost analysis of IV therapy was conducted comparing infusions initiated and completed at an ambulatory clinic with infusions initiated at an ambulatory clinic but completed at home. A societal perspective was taken to fully reflect the resource implications of providing treatments within these 2 environments.

Patient Selection

All patients with multiple myeloma who received pamidronate infusions at the Hamilton Regional Cancer Centre in Ontario, Canada, hereafter referred to as the study site, between November 1, 1997 and October 31, 1998 were selected. Table I summarises the patient characteristics of the 48 study participants who received 299 cycles of treatment. The mean age of participants was 65 years and 40% were female.

Current practice at the study site was for all patients with multiple myeloma receiving pamidronate infusions to attend the study site every 4 weeks for a routine assessment. Patients would see an oncologist and then have the pamidronate infusion started. Pamidronate was infused through a traditional infusion procedure (e.g. the drug was mixed into a large volume parenteral bag of diluent and slowly infused) if the patient chose to remain at the clinic for the entire infusion. The time for infusion in the clinic after initial set up was approximately 4 hours. If the patient chose to return home to complete the infusion, the 'Intermate' ambulatory infusion device (Baxter Corporation) was employed. The time for infusion after initial set up at the clinic was approximately 5 hours because of characteristics of this portable and disposable infusion device (e.g. fixed infusion rate at 50ml/hour, 250ml minimum diluent volume). These patients self-discontinued their infusions and removed their own peripheral catheters, usually with the help of a family member at home. Patients with multiple myeloma who remained at the clinic for the entire infusion are hereafter referred to as the 'clinic group' and patients who completed the infusion at home are hereafter referred to as the 'home group'.

Data Collection

Data were derived from the study site data systems and clinic records. The cost analysis was conducted from a societal perspective, focusing on the incremental costs of the alternative treatment options. Costs that were common to both treatment options were not included as they would not influence the relative cost estimates (e.g. the direct drug costs, direct costs associated with the oncologist visit, direct costs of nursing time associated with initiating the IV therapy and costs associated with transportation to and from the clinic). Direct costs that did differ between the treatment options included the cost of the infusion device used, training costs in the use of the 'Intermate' ambulatory infusion system, costs to the patient/family/friends

Table I. Patient characteristics

	Males	Females	Total
N (%)	29 (60%)	19 (40%)	48 (100%)
Age (years)			
Mean	63.4	66.8	64.7
Minimum	33.3	45.6	33.3
Maximum	82.2	85.3	85.3
<55 [n (%)]	5 (17%)	1 (5%)	6 (13%)
55-65 [n (%)]	11 (38%)	7 (37%)	18 (38%)
>65 [n (%)]	13 (45%)	11 (58%)	24 (50%)
Cycles (per patient over period of study)			
Mean	6.3	6.1	6.2
Minimum	1	1	1
Maximum	13	12	13

and/or study site associated with incomplete treatment, parking costs to the patient/family/friends and allocated clinic overhead costs. Indirect costs that differed between treatment options were the costs caused by lost work and/or leisure time. All costs are in 1998 Canadian dollars ($Can; $Can1 ≈ $US0.67).

Infusion Device and Pharmacy Preparation Costs

The incremental cost of using the 'Intermate' ambulatory infusion device rather than the traditional IV therapy equipment was $Can14.40 per cycle. For this study, we included the costs of the IV bag and tubing as part of the direct costs of the gravity source infusion device but excluded the cost of other associated equipment, as these were included in the clinic overheads. Pharmacy preparation costs were similar for both devices and therefore were not included in the analysis.

Training Costs for 'Intermate' Ambulatory Infusion Device

Current practice dictated that the nursing time required to train patients in the use of the 'Intermate' device was 15 minutes for the first treatment and zero thereafter. The average nursing rate at the study site, including all benefits and other nursing remuneration costs, was $Can27.50 per hour. Data were not available on which patients actually received training during the study period but given that all patients required training before using the portable and disposable infusion device, training costs for all home group patients were included. Thus, the home group incurred incremental costs of $Can6.88 (0.25hr × $Can27.50 per hour) per patient trained.

Overtime Treatment Costs

The hours of clinic operation were from 9am to 5pm. Full completion of the pamidronate infusion at the clinic normally required a minimum of 6 hours (2 hours for the oncologist visit, IV therapy set-up and initiation and 4 hours for the infusion). Treatment for clinic group patients initiated after 1pm would therefore not be completed within the normal operating hours of the clinic. Two alternatives existed to address this situation. First, a nurse could remain with the patient until the infusion was completed, with the clinic incurring overtime costs for the nurse. Or second, the patient's treatment appointment could be rescheduled to another day with the patient incurring extra transportation costs, parking costs and lost work/leisure time.

Using the study site's scheduling practices and experience, it was estimated that approximately 10 percent of clinic group patients would not have completed their treatment within the clinic's normal operating hours. Although both options for incomplete treatment were practised at the clinic, for this cost analysis it was assumed that these patients would have remained at the clinic until the treatment was completed rather than having the treatment rescheduled. This eliminated the need to determine transportation costs and additional parking and lost work/leisure time costs. Average overtime associated with the continuation of treatment was estimated to be 1 hour. Since overtime rates were 50% higher than regular rates, the incremental overtime costs for patients in the clinic group were $Can4.13 per cycle (1.5 × $Can27.50 × 0.1).

Parking Costs

The cost of parking at the study site was $Can1.50 per half-hour with a maximum rate per day of $Can8. As patients in both the clinic and home groups were required to attend the clinic for an oncologist visit in addition to having the pamidronate infusion initiated, the minimum time at the clinic for a patient in either group was approximately 2 hours ($Can6 for parking). The additional time spent at the clinic for the clinic group of patients would result in parking costs of $Can8 per day. The incremental parking costs for this group of patients would therefore be $Can2 ($Can8 – $Can6) per cycle.

Allocated Overhead Costs

As patients in both the clinic and home groups were required to attend the clinic to see the oncologist and have the infusion initiated, some overhead costs did not need to be considered. Administrative costs associated with initial attendance at the clinic and waiting room overhead costs would be incurred regardless of treatment option, how-

ever, other overhead costs that would differ between the groups were considered, including power, maintenance and some general administration costs.

The study site's Systemic Treatment Program, which provided chemotherapy to patients with cancer had treatment space that included 11 chemotherapy chairs, 12 stretchers and 3 private rooms (with chair or stretcher, as needed). Almost all patients with multiple myeloma who received pamidronate at the study site were treated in a chemotherapy chair, which was occupied for the duration of the treatment visit. Patients in the clinic group required a chair for 4.5 hours while home group patients required a chair for 0.5 hours (based on current experience, an additional 1.5 hours was spent by patients in both groups in either the waiting room or in consultation with the oncologist). The Systemic Treatment Program had a capacity of 22 880 chair-hours of services over the study period (where chair-hours were determined as 11 chairs × 8 hours/day × 5 days/week × 52 weeks/year), with allocated overhead costs associated with power, maintenance and general administration estimated at $Can200 000 for this component of the total operation at the study site. Using the number of chair-hours as the method to allocate these overhead costs, the incremental overhead cost per hour was estimated to be $Can8.74 per chair-hour ($Can200 000/22 880 chair-hours) and the resulting incremental overhead costs for patients in the clinic group were $Can34.96 ($Can8.74 × 4) per cycle.

Lost Work/Leisure Time Costs

Treatment provided at the clinic resulted in lost work and/or leisure time costs, affecting both the patient and his/her family or friends. Since patients in the clinic group spent 4 hours more at the clinic than patients in the home group, this represented potentially significant costs to the patient and his/her family or friends. A number of methods have been debated regarding how best to value lost time including opportunity cost methods and replacement cost methods, but no clear consensus exists.[15-17] In this study, specific information on the employment status of the patients was unavailable, but given the nature of the illness and the fact that 50% of these patients were aged >65 years and 88% were >55 years, it was unlikely that a large proportion of these patients would have been at risk to lose employment wages during their treatment. On the other hand, patients in the clinic group lost leisure time relative to home group patients. It was also likely that patients in the clinic group were accompanied to the clinic by a family member or friend, who may have lost work and/or leisure time. Therefore, to recognise some of the lost work and leisure time to the patient and his/her family or friends, the minimum wage rate for Ontario ($Can6.85 per hour) was used, thereby yielding incremental time costs to patients in the clinic group of $Can27.40 ($Can6.85 × 4) per cycle.

Sensitivity Analysis Using Best-/Worst-Case Scenarios

Sensitivity analyses were performed using best- and worst-case scenario estimates which included potential cost efficiencies/inefficiencies and rate decreases/increases. The best-/worst-case scenarios were derived from the perspective of the home group. For example, the best-case scenario included assumptions that decreased incremental costs for the home group and increased incremental costs for the clinic group. Therefore, from the perspective of the clinic group, the scenarios are reversed (e.g. the best-case scenario = the worst-case scenario). The rationale for the best-/worst-case scenario estimates is detailed in table II.

Results

The cost analysis considered only incremental costs that would be incurred when shifting treatment from the ambulatory clinic to the home. The incremental cost of treating all 48 patients with multiple myeloma (299 cycles) at the study site over the period November 1, 1997 to October 31, 1998 is presented in table III.

The incremental cost of treating clinic group patients was $Can68.49/cycle ($Can20 477 for the 299 cycles). This incremental cost was due to over-

Table II. Sensitivity analysis assumptions for incremental costs of ambulatory clinic and home-based intravenous (IV) therapy for patients with multiple myeloma: best-, base- and worst-case scenarios[a]

Costs	Best-case scenario	Worst-case scenario
IV device costs ($Can)[b]	base –30%	base +15%
Training costs (hours)[c]	base –33%	base +33%
Overtime treatment costs (cycles)[d]	base +100%	base –50%
Parking costs [$Can (best); cycles (worst)][e]	base –50%	base –15%
Allocated overhead costs ($Can)[f]	base +50%	base –10%
Lost work/leisure time costs ($Can)[g]	base +50%	0

a The best-/worst-case scenarios have been made from the perspective of the home group. The best-case scenario includes assumptions that decrease incremental costs for the home group and increase incremental costs for the clinic group. The worst-case scenario includes assumptions that increase incremental costs for the home group and decrease incremental costs for the clinic group. Therefore, from the perspective of the clinic group, the scenarios are reversed (i.e. the best-case scenario = the worst-case scenario, and *vice versa*).

b In the best-case scenario, the assumption made was that the incremental cost of the disposable/portable IV device might decrease because of potentially greater employment of the device which could lower the average cost/device. In the worst-case scenario, the assumption made was that the incremental cost of the disposable/portable IV device might increase because of small decreases in the cost of the standard gravity source IV device (i.e. IV bag and/or IV line).

c In the best-case scenario, the assumption made was that the time required for training might be reduced. In the worst-case scenario, the assumption made was that the time required for training might be increased. Nursing remuneration rates were not adjusted.

d In the best-case scenario, the assumption made was that more patients might not complete treatment during the clinic's operating hours. In the worst-case scenario, the assumption made was that fewer patients might not complete treatment during the clinic's operating hours. Overtime, nursing remuneration rates and additional parking costs were not adjusted.

e In the best-case scenario, the assumption made was that the average length of stay (for the oncologist visit and initiating IV therapy) might be reduced thereby increasing incremental parking costs. In the worst-case scenario, the assumption made was that fewer patients might travel by personal car or use the pay parking lot. Parking rates were not adjusted.

f In the base scenario, the assumption made was that the estimate for allocated overhead was modest. Therefore, in the best-case scenario, the assumption made was that the potential for an increase in the estimate of allocated overhead was high. In the worst-case scenario, the assumption made was that the potential for a decrease in the estimate of allocated overhead was low.

g In the base scenario, the assumption made was that a proxy measure (the Ontario minimum wage rate) could modestly represent some lost work/leisure time costs. Therefore, in the best-case scenario, the assumption made was that the potential for an increase in the estimate of lost work/leisure time costs was high. In the worst-case scenario, lost work/leisure time costs were eliminated from the analysis.

$Can = 1998 Canadian dollars

time treatment costs, parking, overheads and lost work/leisure time. For the home, group the incremental cost was $Can15.50/cycle ($Can4636 for the 299 cycles), due to incremental costs of the infusion device and training. This would result in net cost savings to society of $Can52.98/cycle ($Can15 841 for the 299 cycles) by shifting treatments from the clinic to the home. The clinic group incremental costs were composed of 60% direct costs and 40% indirect costs, with overhead (51%) and lost work/leisure time costs (40%) being the largest components of the incremental costs. This is in contrast to the incremental costs of the home group that were composed of 100% direct costs, with almost all (93%) of these incremental costs attributable to the cost of the infusion device.

Sensitivity Analyses

The results from the sensitivity analysis using best- and worst-case scenarios are reported in Table IV. For the best-case scenario, the incremental cost of treating clinic group patients would have been $Can106.79/cycle ($Can31 930 for the 299 cycles), while for the home group the incremental cost was $Can10.82/cycle ($Can3234 for the 299 cycles). This would have resulted in net cost savings to society of $Can95.97/cycle ($Can28 696 for the 299 cycles) from shifting treatments from the clinic to the home. The clinic group incremental costs were composed of 62% direct costs and 38% indirect costs, with overhead (49%) and lost work time costs (38%) being the largest components of

the incremental costs. The composition of the home group costs did not change from the base scenario with 93% of these incremental costs due to the cost of the infusion device.

For the worst-case scenario, the incremental cost of treating clinic group patients would have been $Can35.23/cycle ($Can10 532 for the 299 cycles), while for the home group the incremental cost was $Can18.03/cycle ($Can5391 for the 299 cycles). This would have resulted in net cost savings to society of $Can17.19/cycle ($Can5141 for the 299 cycles) from shifting treatments from the clinic to the home. The clinic group costs were composed of 100% direct costs, with overheads (89%) being the single largest component of the incremental costs. The home group incremental costs were still primarily composed of the direct infusion device costs (92%) with the remainder due to training costs (8%).

Therefore, in each of the scenarios analysed societal cost savings would be gained by shifting treatment from the clinic to the home although these savings ranged from $Can17.19/cycle in the worst-case scenario to $Can95.97/cycle in the best-case scenario.

Discussion

This study has demonstrated significant societal cost savings associated with home-based infusional IV therapy for patients with multiple myeloma relative to treatment provided in an ambulatory clinic setting. Incremental costs associated with home-based IV therapy were <23% of those for ambulatory clinic IV therapy. Even with a fairly robust sensitivity analysis, a cost advantage for home-based IV therapy was maintained under all scenarios analysed. Over the study period, the net cost savings to society of home-based IV therapy ranged from $Can17.19/cycle ($Can5141 for the 299 cycles) in the worst-case scenario to $Can95.97/cycle ($Can28 696 for the 299 cycles) in the best-case scenario.

If the perspective was narrowed from a societal perspective to a health system perspective (e.g. excluding non-medical costs of parking and lost work/leisure time) the results would still demonstrate a relative cost advantage for home-based IV

Table III. Incremental cost analysis of ambulatory clinic and home-based intravenous therapy for patients with multiple myeloma: base scenario (incremental cost and incremental cost/cycle[a,b])

Cost component	Clinic group		Home group		Total incremental cost of clinic over home group	
	incremental cost per cycle ($Can)	incremental cost for 299 cycles ($Can)	incremental cost per cycle ($Can)	incremental cost for 299 cycles ($Can)	total incremental cost per cycle ($Can)	total incremental cost for 299 cycles ($Can)
Direct costs						
Infusion device			14.40	4306	–14.40	–4306
Training			1.10	330	–1.10	–330
Overtime treatment	4.13	1233			4.13	1233
Parking	2.00	598			2.00	598
Overhead costs	34.96	10 453			34.96	10 453
Incremental direct costs	41.09	12 284	15.50	4636	25.58	7648
Indirect costs						
Lost work/leisure time	27.40	8193			27.40	8193
Incremental indirect costs	27.40	8193			27.40	8193
Incremental direct and indirect costs	68.49	20 477	15.50	4636	52.98	15 841

a As a result of rounding, column and row sums may not be exact.

b The blanks in the table indicate that no incremental costs are incurred by the particular group for the particular cost.

$Can = 1998 Canadian dollars ($Can1 ≈ $US0.67).

Table IV. Direct and indirect incremental costs of ambulatory clinic and home-based intravenous therapy for patients with multiple myeloma: base-, best- and worst-case scenarios[a] (incremental cost and incremental cost per cycle[b])

	Clinic group		Home group		Total incremental cost of clinic over home group	
	incremental cost per cycle ($Can)	incremental cost for 299 cycles ($Can)	incremental cost per cycle ($Can)	incremental cost for 299 cycles ($Can)	total incremental cost per cycle ($Can)	total incremental cost for 299 cycles ($Can)
Best-case scenario						
Direct costs	65.69	19 641	10.82	3234	54.87	16 407
Indirect costs	41.10	12 289			41.10	12 289
Direct and indirect costs	106.79	31 930	10.82	3234	95.97	28 696
Base-case scenario						
Direct costs	41.09	12 284	15.50	4636	25.58	7648
Indirect costs	27.40	8193			27.40	8193
Direct and indirect costs	68.49	20 477	15.50	4636	52.98	15 841
Worst-case scenario						
Direct costs	35.23	10 532	18.03	5391	17.19	5141
Indirect costs	0	0			0	0
Direct and indirect costs	35.23	10 532	18.03	5391	17.19	5141

a The best-/worst-case scenarios have been made from the perspective of the home group. The best-case scenario includes assumptions that decrease incremental costs for the home group and increase incremental costs for the clinic group. The worst-case scenario includes assumptions that increase incremental costs for the home group and decrease incremental costs for the clinic group. Therefore, from the perspective of the clinic group, the scenarios are reversed (i.e. the best-case scenario = the worst-case scenario, and *vice versa*).

b As a result of rounding, column and row sums may not be exact.

$Can = 1998 Canadian dollars ($Can1 ≈ $US0.67).

therapy. For example, health system total incremental cost savings with home-based IV therapy in the base scenario would be $Can23.58/cycle ($Can7051 for the 299 cycles) over the study period (ranging from $Can15.49/cycle in the worse-case scenario to $Can49.87/cycle in the best-case scenario).

Overall, the difference in incremental costs was primarily attributable to the incremental direct cost of the infusion device, allocated overheads and the estimated cost of lost time. The results from the sensitivity analysis showed that the combination of clinic overheads and the cost of lost time accounted for 88% to 91% of the incremental costs of the clinic group while the cost of the infusion device accounted for 92% to 93% of the incremental costs for the home group. Other costs had a minimal impact on the incremental cost differences. Training costs, parking costs and overtime treatment costs ranged from 3 to 8% of incremental costs for either group in each scenario analysed.

These results should impact future decision-making regarding the provision of IV therapy for patients with multiple myeloma, suggesting that from both a societal and health system perspective, home-based IV therapy provides more efficient use of resources. This study draws further attention to 3 key factors in the decision-making process – the incremental cost of the infusion device, the methods for allocating overheads and the methods for determining lost time costs. Using our estimates, these factors had considerable impact on the results and should be studied further to better assess their full effect on the cost of providing treatment in either a clinic or home-based setting. These results may also be extended to other chemotherapy drug regimens that can be provided in the home, contributing a base of evidence to assess the relative im-

portance of various cost factors on the relative efficiencies of treatment alternatives.

The generalisability of these results could be affected by several factors, including patterns of practices at other cancer centres, technological factors and clinical factors. Although Ontario has a centralised cancer agency, regional cancer centres do not necessarily provide similar treatment options or have similar operating hours or capacity. These differences might affect the determination of overheads, lost time and incomplete treatment costs leading to different results. Technological development may also affect the generalisability of our results. Currently, trials are examining the possibility of pamidronate infusion over shorter time frames and the development of an oral formulation of pamidronate.[1,2,18,19] Either of these developments could dramatically affect the results. For example, an infusion time of 1 hour would negate much of the cost differences between the 2 alternatives studied and the existence of an oral formulation of pamidronate would eliminate the need for infusion. Clinical factors could limit the generalisability of the results to other chemotherapy drug regimens in the home. While pamidronate is a relatively nontoxic drug, the highly toxic nature of many chemotherapy drugs necessitates additional clinical expertise to assist patients in the home, potentially altering both the clinical and economic environments in which these treatments can be offered.

There are several limitations that warrant consideration. In this study, patient eligibility was restricted to only 1 cancer centre in Ontario. This eliminated the need to directly consider potential factors that might vary between different cancer centres. But as almost all patients at the study site completed their IV therapy at home, this necessitated deriving cost estimates for clinic-based IV therapy based on clinic records. Sensitivity analysis was used to assess the role played by various cost estimate assumptions in the overall analysis.

Potential differences in the effectiveness of treatment options were not investigated, thereby resulting in our focus on a cost analysis. This could be a limitation if adverse reactions were prevalent or technical/mechanical problems were more likely for patients receiving therapy at home. But in addition to the literature review that suggested technical/mechanical problems with portable and disposable devices were rare,[3-7] no significant adverse reactions to pamidronate or problems with the 'Intermate' infusion device were reported. Therefore, the limitation of not incorporating a full economic evaluation was considered to be small.

As limited data were available we used basic methods for estimating lost time and overhead costs. For example, to represent lost work and leisure time costs borne by the patient and his/her family or friends, the minimum wage rate in Ontario was used. Other more sophisticated methodologies that take into account greater detail on lost productivity or benefits should be used. This could include surveying patients and their families and friends directly.

Similarly, allocation of overheads was based on general overhead data for the study site and therefore lacked the precision needed for a more comprehensive analysis.

In particular, in our analysis we assumed that treating patients at home would vacate clinic chemotherapy chairs which would be utilised by other patients. In reality, chemotherapy chairs may not be able to be utilised for all of the vacated time. Therefore, when the chair is vacant, overhead costs to the clinic are still incurred, and the cost savings of treating patients at home is reduced. Estimates of overhead costs could undoubtedly be improved in future studies, with more information on clinic capacity rates. Special consideration should be given to the susceptibility of overhead allocation to temporal biases, related to either short term or long term focuses that may either exclude or include specific overhead costs.

Although the nature of indirect costs means that estimates will be less certain, excluding these costs, as is often done, is a major weakness of many cost analyses, neglecting the impact of relevant information on the decision-making process. A societal perspective and the inclusion of indirect costs

are necessary to consider fully the potential economic impact of the treatment options.

Conclusion

The results from this cost analysis suggest that more efficient use of resources, from a societal perspective, could be made through the provision of infusional IV therapy for patients with multiple myeloma in the home. A significant cost saving to society of $Can52.98/cycle was demonstrated through the home-based treatment rather than the clinic-based treatment. This cost saving should form part of the treatment decision and should supplement information on the effectiveness of treatment options and the preferences of patients and providers. Future evaluations of home-based treatment which include more precise determination of clinic overhead costs and the valuation of lost work and/or leisure time would be beneficial.

Acknowledgements

The authors appreciate the co-operation and assistance of Hannah Farrell, National AMS Business Manager, Baxter Corporation. Dr. Coyte holds a Canadian Health Services Research Foundation/Canadian Institutes of Health Research Professorship in Healthcare Settings and Canadians. The opinions expressed are those of the authors and do not necessarily reflect the opinion of any funding agency or institution. The Home and Community Care Evaluation and Research Centre, University of Toronto, is partially supported by a contribution from Baxter Corporation.

References

1. Berenson J, Lichtenstein A, Porter L, et al. Efficacy of pamidronate in reducing skeletal events in patients with advanced multiple myeloma. Myeloma aredia study group. N Engl J Med 1996; 334 (8): 488-93
2. Hillner BE, Ingle JN, Berenson JR, et al. American Society of Clinical Oncology guideline on the role of bisphosphonates in breast cancer. American Society of Clinical Oncology Bisphosphonates Expert Panel. J Clin Oncol 2000; 18 (6): 1378-91
3. Schleis TG, Tice AD. Selecting infusion devices for use in ambulatory care. Am J Health Syst Pharmaceut 1996 Apr 15; 53: 868-77
4. Veal DF, Altman CE, McKinnon BT, et al. Evaluation of flow rates for six disposable infusion devices. Am J Health Syst Pharmaceut 1995; 52 (5): 500-4
5. Capes DF, Asiimwe D. Performance of selected flow-restricting infusion devices. Am J Health Syst Pharmaceut 1999 Feb 15; 55 (4): 351-9
6. Hamid SK, Wong PK, Carmichael F, et al. A novel device for patient-controlled sedation: laboratory and clinical evaluation of the baxter intermate LV250 infusor and patient-control module. Anaesthesia 1996 Feb; 51 (2): 145-50
7. Otsuka A, Ono S, Hata M, et al. Outpatient chemotherapy with continuous intravenous infusion for patients with recurrent renal cell carcinoma or advanced prostate carcinoma. Gan To Kagaku Ryoho 1997 Dec; 24 (4): 485-9
8. Health Services Utilization and Research Commission (HSURC). The cost-effectiveness of home care: a rigorous review of the literature. Saskatchewan: HSURC, 1996
9. Poretz D, Woolard D, Eron L, et al. Outpatient use of ceftriaxone: a cost-benefit analysis. Am J Med 1984; 77 (4C): 77-83
10. Stiver H, Trosky S, Cote D, et al. Self-administration of intravenous antibiotics: an efficient, cost-effective home care program. CMAJ 1982; 127: 207-11
11. Culbertson V, Rhodes R, Hill E, et al. Impact of home infusion therapy on the Colorado Medicaid program budget. Am J Hosp Pharm 1988; 45: 1346-9
12. Eisenberg J, Kitz, D. Savings from outpatient antibiotic therapy for osteomyelitis: economic analysis of a therapeutic strategy. J Am Med Assoc 1986; 255 (12): 1584-8
13. Robson L, Bain C, Beck S, et al. Cost analysis of methylprednisolone treatment of multiple sclerosis patients. Can J Neurol Sci 1998; 25: 222-9
14. Evidence-Based Medicine Working Group. Evidence-based medicine: a new approach to teaching the practice of medicine. JAMA 1992; 268: 2420-5
15. Drummond MF, O'Brien BJ, Stoddart GL, et al. Methods for the economic evaluation of health care programmes. 2nd ed. Toronto: Oxford University Press, 1997
16. Gold MR, Siegel JE, Russell LB, et al., editors. Cost-effectiveness in health and medicine. New York: Oxford University Press, 1996
17. Posnett J, Jan S. Indirect cost in economic evaluation: the opportunity cost of unpaid inputs. Health Econ 1996; 5 (1): 13-23
18. Coukell A, Markham A. Pamidronate: a review of its use in the management of osteolytic bone metastases, tumour-induced hypercalcaemia and Paget's disease of bone. Drugs Aging 1998; 12 (2): 149-68
19. van Holten-Verzantvoort A, Kroon H, Bijvoet O, et al. Palliative pamidronate treatment in patients with bone metastases from breast cancer. J Clin Oncol 1993; 11 (3): 491-8

Correspondence and offprints: Professor *Peter C. Coyte*, Department of Health Administration, University of Toronto, McMurrich Building, 12 Queen's Park Crescent West, Toronto, Ontario, M5S 1A8, Canada.
E-mail: peter.coyte@utoronto.ca