SUBSTUDY 3

COST IMPLICATIONS OF INFORMAL SUPPORTS

A Report Prepared for
the Health Transition Fund, Health Canada

April 2001

To obtain additional copies of this report, please contact either the National Evaluation of the Cost-Effectiveness of Home Care or the principal author:

National Evaluation of the Cost-Effectiveness of Home Care
308 – 895 Fort Street
Victoria, BC
V8W 1H7
Canada

Tel: (250) 389-0123
Fax: (250) 389-0105
info@homecarestudy.com
www.homecarestudy.com

Konrad Fassbender, PhD
Senior Research Associate
Alberta Cancer Board Palliative Care Research Initiative
Division of Palliative Care Medicine
Department of Oncology, University of Alberta
Room 4014, Grey Nuns Community Hospital and Health Centre
1100 Youville Drive West
Edmonton, Alberta
T6L 5X8
Canada

Tel: (780) 450-7525
Fax: (780) 450-7700
konrad.fassbender@ualberta.ca

SUBSTUDY 3

COST IMPLICATIONS OF INFORMAL SUPPORTS

A Report Prepared for
the Health Transition Fund, Health Canada

by Konrad Fassbender, PhD

April 2001

PREFACE

The National Evaluation of the Cost-Effectiveness of Home Care is an integrated program of research with 15 studies being conducted across Canada. There is an overall strategy for the program of research to make it as useful to administrators and decision makers as possible. The program of research is designed to determine whether or not home care is a cost-effective alternative to institutional care, that is, care in long term care facilities and acute care hospitals. However, the program of research is also designed to provide an educational function to inform decision makers and the public about home care and to provide advice about issues related to implementing new and cost-effective home care initiatives. Thus, the overall strategy has the following components:

- Conduct studies to determine whether or not home care is a cost-effective alternative to institutional care, and if so, under what conditions it is cost-effective.

- Conduct studies to inform decision makers about the nature and scope of home care services across Canada. These studies provide a baseline of information about home care clients, costs, and utilization. This baseline is important because there is currently no national database on home care in Canada.

- Conduct studies to explore opportunities for potential savings in the hospital sector by substituting home care services. At present there are relatively few areas noted in the literature where home care has been shown to be a cost-effective alternative to hospital care.

- Conduct studies to provide decision makers with information about some of the issues they may face if they try to implement new initiatives to enhance the cost-effectiveness of the health care system.

This study, Substudy 3, *Cost implications of informal supports*, examines the relationship between the amount of formal home care services clients receive and the amount of informal (family) support that is available to them using an Edmonton database.

Neena Chappell, PhD
Co-Director
National Evaluation of the
Cost-Effectiveness of Home Care

Marcus Hollander, PhD
Co-Director
National Evaluation of the
Cost-Effectiveness of Home Care

ACKNOWLEDGEMENTS

Funding for this study was provided by Health Canada through the Health Transition Fund, as part of the National Evaluation of the Cost-Effectiveness of Home Care. The views expressed herein do not necessarily represent the official policy of Health Canada.

The author gratefully acknowledges helpful comments and insight from Neena L. Chappell and Evelyn Shapiro. As well, the paper has benefited substantially from numerous discussions with Marcus Hollander. Finally, as this study makes use of a model developed by the author in his PhD dissertation, thanks are given to Philip Jacobs, Richard Plain, Duncan Saunders and L.J. Wei. Any errors or omissions remain the responsibility of the author.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Continuing care expenditures are the third largest in the Canadian health care sector behind acute-care hospitals and physician services (23). Within this sector, formal home care expenditures have more than doubled within the last decade and now constitute 4% of total public health care spending ($2,096m in 1997/98) (21). Despite the emphasis which provincial governments place on the curtailment of public expenditures, there is little evidence supporting the prima facia acceptance that community-based provision of health-related services are cost-effective or efficient (6, 25).

The acceptance of increased formal home care is driven by public support for community-based services. On the other hand, the public is concerned as a shift toward community based care may result may result in an increased reliance on informal care. In particular, caregivers do 'not react well to being conscripted into care giving' and are 'fearful of being overwhelmed in the process' (39). At first glance, these statements appear contradictory but in reality reflect the public's uncertainty of the implications arising from their government's embracing this new paradigm shift. In other words, we do not know very much about the relationship between the formal and informal health care sectors.

Understanding the relationship between the formal and informal care sectors may be confounded by the role of demographics and social values. Increased labor mobility, increasing female participation in the workforce and increasing one-parent families exemplify possible constraints on future availability of informal care. As well, the importance of family and neighbors has declined (5, 10). Given the fact that the vast majority of care in the home is provided by the informal sector, the potential for increased burden on informal caregivers reinforces concern regarding the amount of formal care services that are available.

A simultaneous increase in the formal service sector and potentially declining availability of informal services presents a challenge to policy and decision-makers. If the sectors complement one another, then an increased provision of formal home care services will result in increased caregiver burden. In this scenario, accompanying caregiver costs offset client benefits arising from increased formal care. On the other hand, if formal and informal sectors are substitutes for one another, then increased provision of formal home care services are required to offset future decreases in the availability of informal care.

The evidence suggests that formal care complements rather than substitutes for informal care (29, 38, 49, 50). Others argue that despite various modeling efforts, the exact nature for this interrelationship is not known (38, 20, 45). One problem arises from the fact that informal care data is scarce. Secondly, many of these studies do not use appropriate statistical techniques for the analysis of non-experimental datasets. Finally, evidence that is largely gathered in the US may not be applicable in the Canadian context.

To address these important issues, this study attempts to examine and quantify the relationship between formal and informal services. This will be accomplished by analysis of a unique Canadian home care database. To begin with, we conceptualize and operationalize the relationship between formal and informal care. Next, we review the application of statistical

techniques appropriate to non-experimental, home care datasets. A brief description of the data used in the analysis is provided. Methods, results, discussion and policy implications complete the report.

A CONCEPTUAL MODEL OF FORMAL AND INFORMAL HOME CARE COSTS

A conceptual model is introduced to help understand the interrelationship between formal and informal home care services or costs. In this model we consider the wellbeing or welfare of three 'actors': client, caregiver and ministry of health. In economics, these could be represented by objective functions. Objective functions are mathematical relationships between the welfare of a group or individual and variables of interest including those that summarize the behavior of other actors. For example, a client's wellbeing increases with an increase in either informal or formal home care services (provided by caregivers or the Ministry of Health, respectively). In this study, we are particularly interested in how the Ministry of Health (formal) and caregivers (informal) react to one another.

The variables of interest summarize an actor's incentives and opportunity costs. In the case of caregivers, informal care of clients results in caregiver time-related costs. Determinants of informal caregiving include cognitive impairment, activity of daily living, client age, caregiver age, and marital status (20, 35). Evidence also suggests that caregiver benefits are often ignored even though there is considerable literature on caregiver's attitudes (45). It seems plausible that the provision of informal services by caregivers results in both costs and benefits. An ambiguous net effect is therefore hypothesized for caregiver's welfare. Similar ambiguous net effects can be derived for the formal (Ministry of Health) service sector.

The answer to the fundamental question cannot be determined on the basis of theoretical conjecture alone. That is to say that theory does not provide us with an insight into whether formal and informal care are substitutes or complements to one another. As a consequence, a statistical model must be specified that allows for either a substitutable or complementary nature of the interrelationship. The answer to the study question is then derived empirically subject to the choice of an appropriate statistical technique and limitations associated with the data. In the next two sections, we consider statistical techniques and describe a unique Canadian home care dataset.

STATISTICAL ANALYSIS OF NON-EXPERIMENTAL HOME CARE DATA

The choice of statistical technique is constrained by the nature of the dependent variable, interrelationship between multiple dependent variables and whether data are observed or experimentally generated. To begin with, we measure client welfare by independence (institutional free days). Time-to-event variables require survival analysis (parametric or semi-parametric hazard models).

In addition to the client we also consider caregivers and the Ministry of Health. Since we simultaneously consider the welfare of these three actors, a system of equations or causal modelling is required. One major limitation imposed by these requirements is that there is no published model that can deal with "time-to-event" and causal modelling simultaneously. Another consideration is that home care data are non-experimental (or observational) and subject to selection bias, which requires special statistical techniques.

In the case of experimental data for example, univariate analysis is sufficient as the randomization process ensures an equal distribution of covariate values between the treatment and control groups. Non-experimental or observational studies however require statistical methodology to adjust for confounding variables. When patients are not randomized to treatment and control groups, the choice of treatment is typically correlated with client or provider characteristics. The purpose of statistical modelling therefore is to remove or adjust for presence of selection bias.

A review of the literature reveals 24 articles (14 studies) in which statistical techniques were applied to non-experimental home care databases. These are briefly summarized in Table 1. Three articles report univariate statistical methods (21, 56, 57) ignore selection bias, are incorrectly specified and are dated (1980, 1978, 1978 respectively). Three additional papers employ techniques that are not useful to this study (35, 40, 41). Markov models used in the B.C. study (40, 41) have merit but are not relevant to the relationship between formal and informal service provision. Multivariate techniques (especially the single equation variety) are useful and have been considered in three papers (18, 19, 61). In particular two (18, 19) have attempted to correct for selection bias but include too few variables in comparison with other, more theoretically justified techniques.

Four articles (2, 4, 14, 28) employ hierarchical regression analysis that calculates the incremental explanation of variation through the stepwise addition of blocks of variables. One limitation of this method is the increased complexity of estimating direct versus indirect effects (more easily accomplished in causal modelling). More importantly, the dependent variable is constrained (eg. skewed, dichotomous, or censored dependent variables are inappropriate for this statistical model). The estimation of simultaneous relationships is better accomplished with causal modelling. Only four articles (17, 37, 38, 48) employ this technique. Sample sizes for three of the studies (17, 38, 48) vary from 124 to 400 and is judged to be insufficient for this type of model. One study (37) has a sufficient sample size of 4,335.

Seven studies employ survival analysis (3, 9, 20, 32, 33, 51, 54). One model employs stepwise selection of variables (54). Three others are (3, 9, 32) utilize the basic semi-parametric form. Three studies employ competing hazard analysis (20, 33, 51), one of which is the parametric form (33). Competing hazard analysis is important since death and institutionalization "compete with each other." In other words they are mutually exclusive outcomes for a single patient.

Table 1: Review of Statistical Analyses in Non-Experimental Home Care Studies

Study	No	Statistical Method	Dependent Variable
Arizona	3	Cox Proportional Hazards	LOS (home care)
	17	Causal Modelling (2 simultaneous equations)	Formal Support (levels), Informal Support (levels)
Boston	53	Multivariate Regression (stepwise)	Formal Services (nursing visit time)
British Columbia	30	Markov Chain Model	Transition Probability (insitutionalization)
	31	Markov Chain Model, Moving Average Growth, and Log-Linear Regression	Transition Probability (insitutionalization)
	46	Univariate (no formal tests)	
	47	Univariate (no formal tests)	
Bundoora	32	Cox Proportional Hazards	LOS (home care)
Lucas County	48	Path Model, Hierarchical Regression Analysis	Home Care Utilization (form not specified)
Maryland	54	Cox Proportional Hazards (stepwise)	LOS (home care)
Massachusetts	4	Hierarchical Regression Analysis	Home Care Utilization
	14	Hierarchical Regression Analysis (stepwise)	Home Care Utilization (dichotomous, used in past 15 months)
Minnesota PAS/ACG Program	9	Cox Proportional Hazards	LOS (Home Care)
	38	Causal Modelling (2 simultaneous equations), 2SLS	Formal Care, Informal Care
Monroe County	51	Discrete Time Hazard Function (competing hazards)	LOS (Home Care)
Netherlands	27	Mokken Scale Analysis	Home Care Utilization (yes/no)
	28	Hierarchical Regression Analysis	Home Care Casemix (logarithm)
New York: Nursing Homes Without Walls	16	Univariate	
NHIS Longitudinal Study on Aging	37	Structural Equation Model (path analysis), Logistic Regression	Functional Status, Nursing Home Admission
NLTC Survey	12	Univariate, Probit	Waiting List Status (probit model)
	13	Probit	Home Care Utilization (days/week)
	20	Cox Proportional Hazards (competing hazards)	LOS (home care)
	33	Weibull Hazard Function (single equation, competing hazards)	LOS (home care)
Ohio	2	Hierarchical Regression Analysis	Home Care Utilization (dichotomous)

Of four articles (2, 4, 14, 28) that employed hierarchical regression analysis, one did not specify the exact specification of home care utilization (4), two were dichotomous (2, 14) and one was a logarithmic transformation of home care casemix (14). Linear regression techniques are not appropriate for dichotomous dependent variables and the technique does not deal with selection bias.

The estimation of simultaneous relationships is accomplished with causal modelling in four articles (17, 37, 38, 48). In two of the cases (38, 48) the specification of home care utilization is not provided. Levels of formal and informal care characterize another study (17). In one case functional status and nursing home admissions are the dependent variables (37). Seven studies employ the survival technique (3, 9, 20, 32, 33, 51, 54), all of which use length of stay in home care as a dependent variable.

In conclusion, there is no evidence that takes the nature of the dependent variable, interrelationship between multiple dependent variables and non-experimental data into account at the same time. As a result, we describe a novel statistical approach that deals with all three aspects of the problem and data following a brief description of a unique Canadian home care database.

A Unique Canadian Home Care Database

Ideally the analysis of the relationship between formal and informal care is determined experimentally. When this is not practical, a non-experimental database can be used but must contain sufficient variables to account for the selection bias. Furthermore, this database must contain sufficient description of informal resources available to clients and amount of formal services provided. In Canada, the Edmonton, Alberta dataset meets these criteria.

In Alberta, home care was transferred from local health departments to regional health authorities (RHA) in April 1995. Health services provided to home care clients without charge are home nursing services, occupational therapy, physiotherapy, respiratory therapy and speech therapy. Additional services may include: dressing, medication and other related preparations, and temporary use of health aids not provided under the Alberta Aids to Daily Living and Extended Health Benefits Program. Personal care and home support services are provided without charge for the first two weeks on the program. Home support may include heavy housework service, handyman services, meals-on-wheels, wheels-to-meals, and transportation services. At this time, a $3,000/month service limit applies unless the individual is waiting admission to a long-term care facility, or the high service needs are required for less than three months. Home Care does not provide 24-hour professional services on an ongoing basis.

Clients do not pay for health or personal care services. The fee for home support however is $5 per hour to a maximum of $300/month. The monthly charge is determined by a sliding scale that takes both family income and family size into consideration. Low-income clients are exempt (Supports for Independence, Widow's Pension, the Guaranteed Income Supplement, and the Assured Income for the Severely Handicapped).

In Alberta, a uniform assessment form is used, the Alberta Assessment and Placement Instrument for long-term care (36), as required criteria for admission. In summary, a client is admitted if: a health condition is present that limits independent function, the client requires and wishes to receive care at home, the home is suitable for providing care, home care is the most suitable method of care and has adequate resources available, and the client is eligible for Alberta Health Care Insurance.

Given these criteria, a study population consisting of 4,962 clients classified as long-term care clients receiving services between May 1, 1991 and December 31, 1995 was identified. In addition to program eligibility, three additional criteria were necessary for study inclusion: each client must have: a valid episode defined by an admission date and a valid discharge date if discharged (Hornbrook et al 1985); a valid assessment where each client must have received at least one assessment during their last episode; and valid demographic data (minimally each client must have a valid date of birth, gender, and a valid diagnosis).

A list of variables associated with this database are provided in Table 2. Descriptions are provided in the same table. Detailed notes on the derivation of these variables can be found elsewhere (15).

METHODS

Descriptive Statistics

Descriptive statistics for service intensity (endogenous) and independent variables including the minimum, maximum, mean and standard deviation are calculated. Although length of time in the home care program (LOS) is the dependent variable, there exists many problems in the tabular or graphical representation of survival times of censored variables, even without consideration of the large number of observations. Hence these statistics are not calculated for LOS.

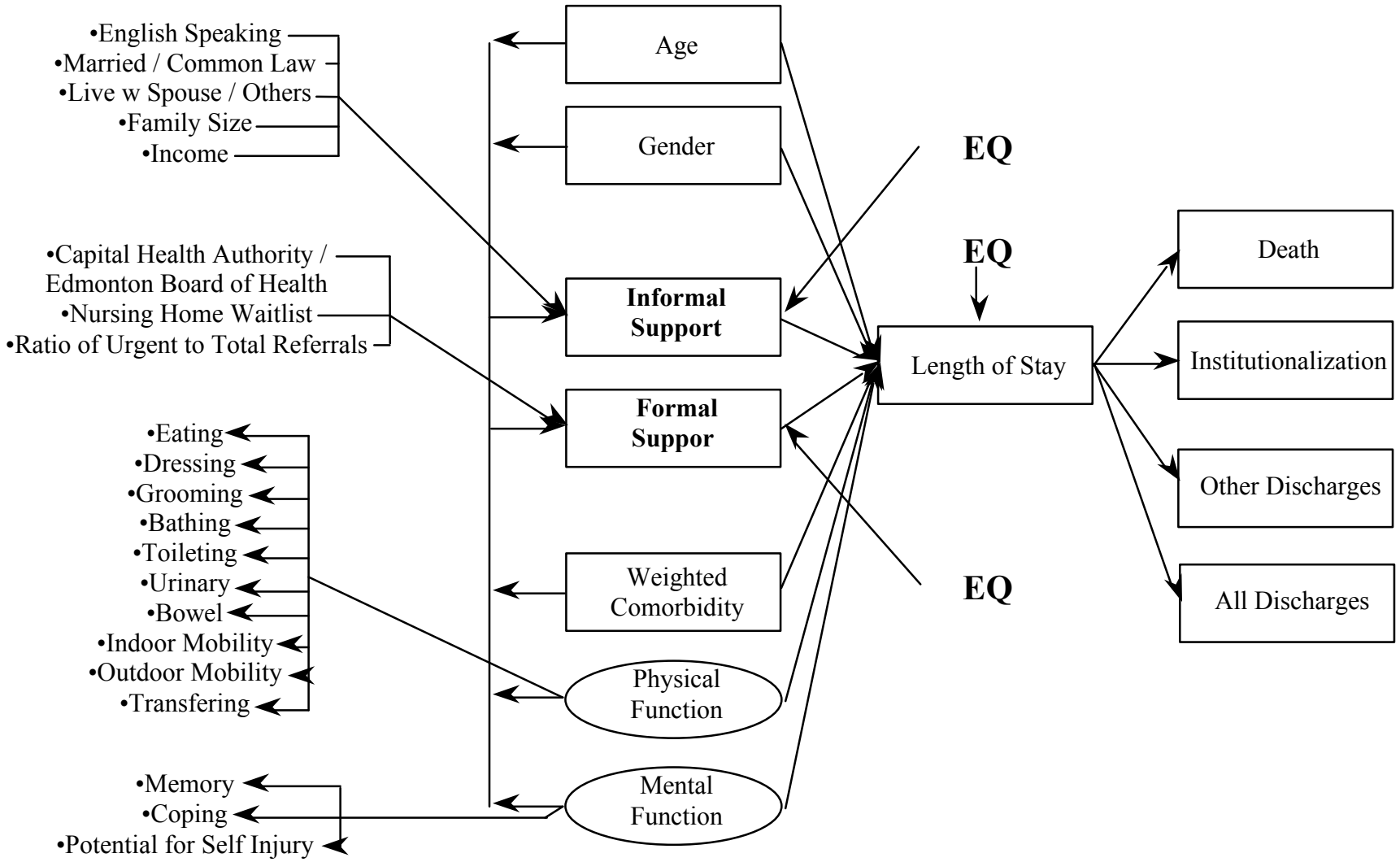
The Model

Operationalization of the conceptual model is illustrated in Figure 1. In the diagram, arrows signify all hypothesized relationships between the variables. There are three dependent or endogenous variables labelled EQ1-3. For example, length of stay in the home care program or institutional free days (EQ1) is the proxy for client outcomes. It is a function of seven variables age, gender, formal service intensity, informal service intensity, comorbidity and physical plus mental functional status. Similarly, formal and informal care service intensity is a function of various client characteristics plus other variables described in Table 2.

Table 2: Description of the Edmonton, Alberta Database Variables

Name	Variable	Definition
AGE	Age	Age at index admission, continuous variable.
RHA	Regional Health Authority	Proportion of episode after April 1995 reflecting a transition to regionalization of health care services.
ENG	English Speaking	English speaking, dummy variable (1=yes).
FAM	Family Size	Number of family members, continuous variable.
FS	Formal Service Intensity	$FS_i = \frac{\sum_{j=1}^{5}\sum_{k=1}^{6} w_{jk} \times hr_{ijk}}{LOS_i}$ • Where i = 1…n clients; j = physician services, inpatient services, outpatient services, medication, and home care services (assessment, case management, direct services, personal care, and home support); k = home care aide, licensed practical nurse, physician, nurse, occupational therapist, respiratory therapist, and social worker; w_{jk} = a weighting factor; and hr_{ijk} = the number of hours. • Formal service intensity will be expressed as $/day. Setting w_{jk} = average (standard) costs for $\forall\, j,k$ (each service service-provider combination) results in an expression of average formal service $ per day. A standard cost list will be used (Jacobs et al 1995).
SEX	Gender	Dummy variable, (1=female).
INC	Income	Self-reported income, continuous variable derived from a categorical variable.
IS	Informal Service Intensity	Average caregiver cost or hours per day, calculated variable.
LIV	Live With Spouse or Others	Living arrangements, dummy variable (1=yes).
LOS	Length of Service	Duration of home care service provision. Calculated as the number of days from admission to discharge.
MS	Married or Common Law	Marital status, dummy variable (1=yes).
MFN	Mental Function	Factor analytic construct from three functional status indicators of the home care classification system (memory, coping, and potential for self-injury), calculated variable.
WTL	Nursing Home Waitlist	Average waitlist during episode of care, continuous variable.
PFN	Physical Function	Factor analytic construct from ten functional status indicators of the home care classification system (eating, dressing, grooming, bathing, toileting, urinary, bowel, transferring, indoor mobility, and outdoor mobility), calculated variable.
RUT	Ratio of Urgent to Total Referrals	Ratio of urgent to total referrals during episode.
WCI	Weighted Comorbidity Index	Modified Charlson index (Charlson et al 1987, Romano et al 1993), calculated variable.

Figure 1: Model of Formal and Informal Home Care Service Provision



A novel statistical approach is proposed that encompasses survival analysis, causal modelling and correction for selection bias. Instrumental variable estimation may be used to reduce bias through the introduction of additional information (11, 22, 41, 57, 59). The primary requirement is that the additional information or independent variables be highly correlated with the endogenous variable (service intensity) but uncorrelated with the error term (18, 19, 56). Fitted instruments, variables constructed by a prior regression, are one source of additional information that meets this criteria. The newly created (predicted) value is thereby "purged" of its correlation with the error term.

As a result three equations (corresponding to the relationships depicted in Fig 1) are proposed. The estimation procedure takes place in two stages. In the first stage the service intensity equations (E2 and E3) are estimated. In the second stage survival analysis is performed on their predicted values (FS′, IS′). The three equations are:

E1 $h_m(t) = [h_0(t)]e^{bX}$ where $\beta X = \beta_1 AGE + \beta_2 SEX + \beta_3 FS' + \beta_4 IS' + \beta_5 PFN + \beta_6 MFN + \beta_7 WCI + \varepsilon_1$

E2 $FS = \delta_0 + \delta_1 AGE + \delta_2 SEX + \delta_3 IS + \delta_4 PFN + \delta_5 MFN + \delta_6 WCI + \delta_7 RHA + \delta_8 WTL + \delta_9 RUT + \varepsilon_2$

E3 $IS = \gamma_0 + \gamma_1 AGE + \gamma_2 SEX + \gamma_3 FS + \gamma_4 PFN + \gamma_5 MFN + \gamma_6 WCI + \gamma_7 ENG + \gamma_8 MS + \gamma_9 LIV + \gamma_{10} FAM + \gamma_{11} INC + \varepsilon_3$

Estimate of Formal and Informal Sector Response

In the first stage, equations E2 and E3 are estimated with ordinary least squares (OLS). δ_3 and γ_3 summarize the interrelationship between the formal and informal service sectors. Positive values are indicative of a complementary relationship while a negative coefficient means that the formal and informal services are substitutes. The coefficients can be used to estimate the magnitude of this effect.

Estimate of Total Effect

Equation E1 estimates the hazard of discharge from the home care program using Cox's proportional hazard models (8) where the dependent variable is length of service. Separate equations are estimated for each type of discharge (*m* = death, discharge to a nursing home, discharge due to other reasons, and total discharges). These reasons for discharge are referred to as competing hazards. In equation E1, LOS is regressed on predicted FS and IS (FS′, IS′). The Cox proportional hazards regression (E1) requires certain underlying assumptions to hold. Several diagnostic tests were applied to the Cox model to test these underlying assumptions (34, 40, 55).

Incremental cost effectiveness ratios are calculated as a function of the Cox coefficients on formal service intensity (α_3, β_3) in equation E1. The treatment comparator consists of varying levels of formal service intensity. Rather than arbitrarily categorize formal service intensity into high versus low or high-medium-low, a continuous risk-adjusted treatment intensity is specified.

The risk-adjustment refers to the other six covariates: age, gender, informal support, physical functioning, mental functioning and disease burden. The relevant time horizon is time to discharge from the home care program.

A partial ministry of health perspective is adopted. Identification, measurement and valuation of costs and benefits are derived from the home care program administrative database. Ministry of Health costs including acute care, physician services and medication are not included. Measurement of home care services is captured in the home care database as hours by provider and service type. Formal service intensity is dependent on home care support and caregiver resources. A standard cost list was used for valuation purposes (26). The principle outcome measurement is institutional free survival as a function of time-to-institutionalization (discharge to a nursing home) or death.

RESULTS

Descriptive Statistics

Descriptive statistics for the service intensity (dependent or endogenous) variables including the minimum, maximum, mean and standard deviation are included in Table 3. The minimum of zero formal service intensity means that some individuals have no recorded resource usage during the study period. On the other hand, one individual has received up to 23 hours per day (observed) which works out to the equivalent of thirteen visits per day (based on the type of services that individual received). The maximum observed cost for an individual was $315/day. On average clients receive 0.96 hours per day of from services which cost slightly over $13 which corresponds to a visit about every 2.5 days.

Descriptive statistics including the minimum, maximum, mean and standard deviation are also included in Table 3 for all independent variables. The independent variables are grouped according to the Andersen framework nomenclature (1). The typical home care client is 73 years of age and is more likely to be female (63%). They typically speak English as a first language (93%), do not have a partner (65%), live with someone else (54%), have a family size of 1.4 persons and average $15,988 in income. The average ratio of urgent to total referrals over the home care episodes is 39%. Finally, 62% of the episodes took place under new management (the Capital Health Authority took over from the Edmonton Board of Health during this period).

The Model

Table 4 reports the number of observations (N), number of events (E), censorship rate, log-likelihood function, likelihood ratio test and the score statistics for the 4 Cox proportional hazard model (CPH) regressions. As can be seen 90.6% of observations either were not discharged at the end of the study period or were discharged for reasons other than death. Examination of the likelihood ratio test statistic and the score (also known as the global chi-square) statistic reveals that the model fit is best for the discharge to institutionalization followed by discharge for all reasons.

Table 3: Descriptive Statistics for Dependent and Independent Variables

Variable		Min	Max	Mean	SD
Formal Service Intensity					
	$/Day	0.00	315.02	13.06	19.86
	Hour/Day	0.00	23.16	0.96	1.68
	Visits/Day	0.00	13.53	0.41	0.57
Informal Service Intensity					
	HCIS Score	1	5	3.12	1.22
	$/Day	0.00	117.96	4.55	9.22
Predisposing Characteristics					
	Age	16.33	101.51	73.32	16.31
	Gender	0	1	0.63	0.48
Enabling Resources					
	Predicted FS	-2.89	134.99	13.06	13.07
	Predicted IS	-7.01	85.02	4.55	5.35
Client Need Variables					
	HCS	0	9	5.45	2.83
	HCFN	1	5	3.05	1.38
	PFn	-3.42	1.25	-.003	.9912
	MFn	-3.47	2.57	-.06	1.0177
	WCI	0	10	5.15	1.52
External Environment					
	English	0	1	0.93	0.26
	Marital Status	0	1	0.35	0.48
	Living	0	1	0.54	0.50
	Family Size	1	7	1.40	0.63
	Income	7,860	81,645	15,988	13,275
Health Care System					
	RUT	0.26	0.57	0.39	0.04
	IWL	0.85	1.18	1.04	0.04
	CHA	0	1	0.62	0.31

Table 4: Cox Proportional Hazard Summary Statistics

HAZARD	N	E	CENSORED	LNLF	C (LR)	C(SCORE)
Death	2902	274	90.6	3879.4	165.3	169.0
Institution	2896	397	86.3	5579.6	243.9	269.0
Other	2914	538	81.5	7839.5	108.8	76.8
All	2914	1209	58.5	17630.7	185.9	182.0

Table 5 summarizes the regression results for equation E1 for all hazards. The coefficient is reported as a hazard rate where a positive coefficient corresponds to a hazard greater than 1. Likewise, a negative coefficient corresponds to a hazard less than 1. For example females are 33% less likely to be discharged dead. Each year in age results in an additional 3.2% probability of being discharged to a nursing home. The p-values associated with significance of the covariates are also provided. With the exception of formal and informal service intensity, all other variables are significant and of the expected signs. Of the four reasons for discharge, only 'other discharges' yields inconsistent findings. This is to be expected as the reasons for other discharges are both numerous and diverse. Of significance however, is that the coefficient on formal and informal service intensity is significant when selection bias is addressed for 'all discharges' (p value of 0.7 and 3.6% respectively).

The hazard rate illustrates a very important assumption, that of proportionality. By assumption and for any two individuals, the ratio of hazards is a constant (i.e. independent over time). Four graphical tests are employed to test this assumption: stratified survival, log-minus-log (LML) survival, Schoenfeld's partial residual, and Therneau's martingale residual plots (43, 52, 58). These tests for proportionality are graphical in nature, and therefore are subject to investigator bias. Yet these tests are necessary due to the importance of the of the proportionality assumption and the fact that violation of this assumption would require another statistical modelling strategy. Visual inspection of these graphs did not provide evidence that the proportionality assumption was violated.

Estimate of Formal and Informal Sector Response

The formal and informal service responses to a $1 change are provided in Table 6. They are reported as a total and by five service categories and four service provider types: assessment, case management, direct (nursing) services, personal care, home support, nurse, licensed practical nurse, home care aide and social worker.

A $1 increase in the informal care (per day) results in a $1.09 increase in formal sector costs. Most of the increase is personal care ($1.01) and home care aide ($0.78). A $1 increase in the formal service care intensity results in a more modest $0.30 increase. With the exception of licensed practical nursing costs, all cost categories exhibit complementarity. The degree of complementarity depends however on the type of client. In Table 7, the responses are provided by the resident classification score (RCS). The findings are significant and decreasing for levels A through F. That is to sway that the strength of the complimentarity decreases as the functional status of the client decreases and the risk for institutionalization increases.

At any rate, the evidence suggests that formal and informal home care services are complementary goods. The implication is that increasing formal care services will result in a commensurate increase in the informal sector response.

Table 5: Cox Proportional Hazard Parameter Estimates and Significance

	Death		Institutionalization		Other Discharges		All Discharges	
	Exp(B)	Sig	Exp(B)	Sig	Exp(B)	Sig	Exp(B)	Sig
Age	1.034	0.000	1.032	0.000	0.985	0.000	1.011	0.000
Sex	0.672	0.001	0.795	0.027	0.911	0.306	0.819	0.001
FS	0.999	0.896	1.002	0.660	0.960	0.000	0.989	0.007
IS	1.007	0.537	1.003	0.772	0.945	0.000	0.985	0.036
PFn	0.679	0.000	0.614	0.000	0.978	0.790	0.762	0.000
MFn	1.245	0.000	0.710	0.000	0.952	0.297	0.923	0.004
WCI	1.303	0.000	1.087	0.025	1.009	0.778	1.100	0.000

Table 6: Response of Formal and Informal Sectors to $1 Increase by Cost Category

Cost Category	Formal Sector Response	Informal Sector Response
Total Costs	1.09	0.30
Assessment	Ns	Ns
Case Management	0.02	0.60
Direct (Nursing) Services	Ns	Ns
Personal Care	1.01	0.40
Home Support	0.08	0.80
Nurse	Ns	Ns
LPN	-0.01	-0.10
Homecare Aide	0.78	0.30
Social Worker	0.01	0.20

Table 7: Response of Formal and Informal Sectors to $1 Increase by RCS Score

RCS	N	%	Formal Sector Response		Informal Sector Response	
			B	P-value	B	P-value
A	1,564	31.5	1.17	0.000	0.51	0.000
B	1,827	36.8	1.30	0.000	0.54	0.000
C	655	13.2	1.08	0.000	0.31	0.000
D	395	8.0	0.74	0.000	0.24	0.000
E	356	7.2	0.80	0.000	0.16	0.000
F	134	2.7	0.66	0.009	0.10	0.045
G	31	0.6	0.76	0.279	0.01	0.954
	4,962	100.0	1.09	0.000	0.33	0.000

Estimate of Total Effect

Table 8 summarizes the incremental cost effectiveness ratios derived from the model coefficients and the associated p-values. The ratios are expressed in formal service dollars per day required for an additional institutional free day. By convention, a p-value exceeding 0.05 is considered insignificant. In the context of calculating efficiency however, insignificance means that the cost effectiveness ratio is uninterpretable. In other words, when the coefficient on FS is insignificant, then increasing service intensity does not result in postponement of death or institutionalization. Increasing service intensity does result in accelerated discharges for other reasons. The main significant finding is that the current level of home care does not postpone death or institutionalization. $89 of formal home care services per day will however result in the postponement of discharges regardless of the reason.

Table 8: Estimates of Incremental Cost Effectiveness

MODEL	HAZARD	C/E RATIO	SIGNIFICANCE
Correction	Death	$1,111	0.8958
	Institution	-$417	0.6603
	Other	$25	0.0000
	All	$89	0.0067

DISCUSSION

The evidence seems to support the US experience and suggests that formal and informal services are complementary. One explanation is that informal resources enable clients to better utilize the formal home care system. As well, formal resources appear to encourage participation by caregivers. In this last respect the bulk of participation is home support, case management and personal care services.

The evidence does however suggest that LPN services can be substituted, in small part, by informal care. It is unclear why this is not observed for home care aides as many of their functions are carried out by caregivers. The evidence also suggests that the strength of this response decreases with diminished functional status of the client. The formal sector response is halved when comparing a level A to a level F client, as measured on the RCS scale. Even more striking is that the informal sector response falls from approximately $0.50 to $0.10 over the same range.

Although not measured in this study, it is reasonable to assume that caregivers caring for clients with diminished functional status have done so longer. One possible explanation is that that the diminished ability or willingness to provide informal services is due to ‘burnout’ associated with caregiving over an extended period. Another possibility is that caregivers of clients with diminished functional status have less capability to provide support. They themselves may be older and in poorer health. At any rate, this observation has important consequences if the percentage of client types D, E, F and G are to change in the future.

The interpretation of the net effect (cost effectiveness ratio) bears some discussion. It is interpreted as incremental cost (of home care) to avoid one day of an alternative activity (nursing home or death). As can be seen from the regressions, the cost effectiveness of home care as an alternative to nursing home care or death is inconclusive. Home care as an alternative to discharge for other reasons and all discharges together however is significant and varies from $25 per day for other discharges to $89 for all discharges. Home care does not appear to be cost effective in postponing death.

The benefit or value associated with the alternative activities however varies depending on the competing hazard. For example, 'other discharges' includes return to the community and the lower incremental cost associated with that hazard is in agreement with expectations. Interpretation of 'all discharges' is a reflection of the entire program and since the *a priori* expectation is institutionalization, then an argument may be made for evidence supporting effectiveness of home care services. However, these results are dependent on the eligibility criteria. If the cohort included different proportions of individuals at high risk for institutionalization, then we would expect different results.

One of the major limitations of correcting selection bias is that we cannot calculate the extent to which the bias is corrected. Therefore, the interpretation should be considered preliminary in the sense that there may be better instruments for the unobservable influences. This is entirely reasonable since disease status and functional status at the beginning of the episode may be poor proxies for entire episode. Hence the extent to which the intensity variables can be "purged" of their contribution is unknown. This limitation can only be addressed with better data. In particular repeated measures of need variables (functional status and disease burden).

An efficiency measure has been calculated for the whole program and for all individuals. Even though we reported disaggregated reasons for discharge, we have done so after the fact. A better understanding of the eligibility criteria and *a priori* predictors of risk for institutionalization and required. Further research into the cost-effectiveness ratios by provider and service type stratified by high or low risk individuals is also recommended.

POLICY IMPLICATIONS

The conclusions generated by this study seem to be shared by the US. The immediate policy implication is that increasing the capacity to provide informal care does not generate savings to the formal care sector. Conversely, increasing formal care service intensity increases caregiver burden. Although the mechanisms underlying these observations aren't entirely clear.

Addressing the concern of involuntary conscription into caregiving requires implementation of policies that encourage capacity and willingness to provide care. Other policies include examination of eligibility criteria, scope of services provided, and user fees.

It should be pointed out that these findings apply to the *status quo*, characteristic of a system funded at an average level of approximately $13 per day. The demographics and social values of Albertans may not be shared by other jurisdictions. However, it is safe to assume that the overall trends are common to all Canadians.

REFERENCES

1. Andersen, R. and Newman, J.F. (1973): Societal and individual determinants of medical care utilization in the united States. *Milbank Memorial Fund Quarterly*, 51:95-124.
2. Bass DM, Noelker LS. The influence of family caregivers on elder's use of in-home services: an expanded conceptual framework. Journal of Health & Social Behavior 1987;28(2):184-96.
3. Bauer, EJ (1996) Transitions from home to nursing home in a capitated long-term care program: the role of individual support systems. Health Services Research 31(3):309-326.
4. Branch L, Jette A, Evashwick C, Polansky M, Rowe G, Diehr P. Toward understanding elders' health service utilization. Journal of Community Health 1981;7(2):80-92.
5. Callahan, J. J., Jr., Diamond, L. D., Giele, J. Z., and Morris, R. Responsibility of families for their severely disabled elders. Health Care Financing Review [3], 29-48. 1980.
6. Chappell, N.L. (1994) Home care research: what does it tell us? *Gerontonlogist* 34(1):116-120.
7. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *Journal of Chronic Diseases* 1987;40(5):373-83.
8. Cox, D.R. (1972). "Regression Models and Life Tables," *JR Stat Soc (Series B)*, 34: 187-202.
9. Davidson, G., Moscovice, I., and McCaffrey, D. Allocative efficiency of case managers for the elderly. Health Services Research 24(4):539-554, 1989.
10. Doty, P. Family care of the elderly: the role of public policy. Milbank Quarterly 64[1], 34-75. 1986.
11. Ellenberg JH. Selection bias in observational and experimental studies. *Statistics in Medicine* 1994;13(5-7):557-67.
12. Ettner SL. Do elderly Medicaid patients experience reduced access to nursing home care? Journal of Health Economics 1993;12(3):259-80.
13. Ettner SL. The Effect of the Medicaid Home Care Benefit on Long-Term Care Choices of the Elderly. Economic Inquiry 1995;32(1):103-27.
14. Evashwick C, Rowe G, Diehr P, Branch L. Factors explaining the use of health care services by the elderly. Health Services Research 1984;19(3):357-82.
15. Fassbender, K. 1998. An Economic Evaluation of Home Care Services in Edmonton, Alberta as an Alternative to Nursing Home Care. Unpublished PhD Dissertation, Edmonton: University of Alberta.
16. Gaumer, G.L., Birnbaum, H., Pratter, F., Burke, R., Franklin, S., and Ellingson-Otto, K. (1986) Impact of the New York Long-Term Home Health Care Program. Medical Care 24(7):641-653.
17. Greene VL. Substitution between formally and informally provided care for the impaired elderly in the community. Medical Care 1983;21(6):609-19.
18. Hausman, J. A. (1978), "Specification Tests in Econometrics," *Econometrica,* 46(6), 1251--1271.
19. Hausman, Taylor (1981) Hausman, J.A. and Taylor, W.E. (1982), "A Generalized Specification Test," *Economics Letters,* 8, 239--245.
20. Headen A.E.J. (1992) Economic disability and health determinants of the hazard of nursing home entry. The Journal of human Resources 28(1):80-110.
21. Health Canada. Public Home Care Expenditures in Canada, 1975-76 to 1997-98. HTTP://www.hc-sc.gc.ca/homecare/english/Stat_1.htm, accessed April 1, 2001.

22. Heckman JJ. Sample selection bias as a specification error. *Econometrica*, 47(1):153-161, 1979.
23. Hollander MJ. The costs, and cost-effectiveness, of continuing-care services in Canada. Queen's University of Ottawa Economic Projects #94-10, June, 1994.
24. Hornbrook MC, Hurtado AV, Johnson RE. Health care episodes: definition, measurement and use. *Medical Care Review* 1985;42(2):163-218.
25. HSURC (Health Services Utilization and Research Commission). The cost-effectiveness of home care: a rigorous review of the literature. HSURC Background Paper #2, September, 1996.
26. Jacobs P, Bachynsky J, Hall E. 1995. A manual of standard costs for pharmacoeconomic studies. Ottawa: Canadian Coordinating Office for Health Technology Assessment.
27. Kempen GI, Suurmeijer TP. Factors influencing professional home care utilization among the elderly. Social Science & Medicine 1991;32(1):77-81.
28. Kempen GI, Suurmeijer TP. Professional home care for the elderly: an application of the Andersen-Newman model in The Netherlands. Social Science & Medicine 1991;33(9):1081-9.
29. Kemper P, Applebaum R, Harrigan M. Community care demonstrations: what have we learned? *Health Care Financing Review* 1987;8(4):87-100.
30. Lane D, Uyeno D, Stark A, Gutman G, McCashin B. Forecasting client transitions in British Columbia's Long-Term Care Program. Health Services Research 1987;22(5):671-706.
31. Lane D, Uyeno D, Stark A, Kliewer E, Gutman G. Forecasting demand for long-term care services. Health Services Research 1985;20(4):435-60.
32. Lazarus, R. and Gray, L. Clinical characteristics and outcomes in a cohort of patients who were assessed as in need of nursing-home care. Medical Journal of Australia 149(8):410-411, 1988.
33. Liu, K., Coughlin, T., and McBride, T. Predicting nursing-home admission and length of stay. A duration analysis. Medical Care 29(2):125-141, 1991.
34. Lunn M, McNeil D. Applying Cox regression to competing risks. *Biometrics*. 1995;51(2):524-32.
35. Max W. Webber P. Fox P. Alzheimer's disease. The unpaid burden of caring. *Journal of Aging & Health*. 7(2):179-99, 1995 May.
36. McKenzie DA, Capuzzi CF, Will SJ. Alberta assessment and placement instrument: description and interrater reliability. *Medical Care* 1989;27(10):937-941.
37. Mohr RA. A causal modelling approach to instituttionalization. Health Services Management Research 1994;7(2):79-90.
38. Moscovice I, Davidson G, McCaffrey D. Substitution of formal and informal care for the community-based elderly. Medical Care 1988;26(10):971-81.
39. National Forum on Health; Values Working Group Synthesis Report. HTTP://wwwnfh.hc-sc.gc.ca/publicat/finvol2/values/care.htm, accessed April 1, 2001.
40. Ng'andu NH. An empirical comparison of statistical tests for assessing the proportional hazards assumption of Cox's model. *Statistics in Medicine* 1997;16(6):611-26.
41. Pagan, A. Econometric issues in the analysis of regressions with generated regressors. *International Economic Review* 1984;25:221-247.
42. Romano PS, Roos LL, Jollis JG. Adapting a clinical comorbidity index for use with ICD-9-CM administrative data: differing perspectives. *Journal of Clinical Epidemiology* 1993;46(10):1075-9 discussion 1081-90.

43. Schoenfeld, D. (1982), "Partial Residuals for the Proportional Hazards Regression Model," *Biometrika*, 69, 239 -241.
44. Siegel C, Laska E, Meisner M. Statistical methods for cost-effectiveness analyses. *Controlled Clinical Trials* 1996;17(5):387-406.
45. Smith, K. and Wright, K. Informal care and economic appraisal: a discussion of possible methodological approaches. Health Economics 3[3], 137-148. 1994.
46. Stark AJ, Gutman GM, McCashin B. Acute-care hospitalizations and long-term care: an examination of transfers. Journal of the American Geriatrics Society 1982;30(8):509-15.
47. Stark AJ, Gutman GM. Client transfers in long-term care: five years' experience. American Journal of Public Health 1986;76(11):1312-6.
48. Starrett RA, Rogers D, Walters G. Home health care utilization: a causal model. Home Health Care Services Quarterly 1988;9(4):125-40.
49. Tennstedt, S. L., Crawford, S. L., and McKinlay, J. B. Is family care on the decline? A longitudinal investigation of the substitution of formal long-term care services for informal care. Milbank Quarterly 71[4], 601-624. 1993.
50. Tennstedt SL, Harrow B, and Crawford S. Informal vs. formal services: Changes in patterns of care over time. *Journal of Aging and Social Policy* 1996; 7(3/4):71-92.
51. Temkin-Greener H, Meiners MR. Transitions in long-term care. Gerontologist 1995;35(2):196-206.
52. Therneau, T.M., Grambsch, P.M., and Fleming, T.R. (1990), "Martingale-Based Residuals and Survival Models," *Biometrika*, 77, 147 -160.
53. Trisolini MG, Thomas CP, Cashman SB, Payne SM. Resource utilization in home health care: results of a prospective study. Home Health Care Services Quarterly 1994;15(1):19-41.
54. Tsuji, I., Whalen, S., and Finucane, T.E. Predictors of nursing home placement in community-based long-term care. Journal of the American Geriatrics Society 43(7):761-766, 1995.
55. Valsecchi MG. Silvestri D. Sasieni P. Evaluation of long-term survival: use of diagnostics and robust estimators with Cox's proportional hazards model. *Statistics in Medicine* 1996;15(24):2763-80.
56. Wu, D. M. (July 1973), "Alternative Tests of Independence Between Stochastic Regressors and Disturbances," *Econometrica ,* 41(4), 733--750.
57. Zellner, A. Estimation of regression relationships containing unobservable independent variables. *International Economic Review* 1970; 11:441-454.
58. Zhao Y. Lee AH. Hui YV. Influence diagnostics for generalized linear measurement error models. *Biometrics* 1994;50(4):1117-28.
59. Zohoori N, Savitz DA. Econometric approaches to epidemiologic data: relating endogeneity and unobserved heterogeneity to confounding. *Annals of Epidemiology* 1997:7(4):251-7.