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TITLE: COST FUNCTION ANALYSIS: IS IT REALLY ECONOMICS?

AUTHORS: Weatherly, H., Byford, S.
Centre for Health Economics,
University of York,
Heslington Road,
York, YO10 5DD

ABSTRACT

SUMMARY: Cost function analysis (CFA) uses multivariate regression techniques to explore cost variation across particular populations or programmes under investigation. The approach shares a number of similarities with traditional economic evaluation techniques, for instance both techniques permit investigation of efficiency in resource allocation by linking costs to outcomes. However, CFA is sometimes criticised for focusing on inputs and process to the detriment of outcomes.

AIM: This paper aims to investigate the contribution of CFA to health economics and the appropriateness of its use as an economic tool.

METHODS: This paper begins by reviewing published CFA, assessing the rationale and methodology used as well as the health economics information provided. The paper then compares CFA to traditional economic evaluation methodologies.

FINDINGS: Review of the literature reveals numerous published CFA applications, particularly in the mental health care field. The aim of these studies varied and included assessment of current service distribution patterns, exploration of cost variation across programmes and the cost implications of particular populations given a set of baseline characteristics. Through CFA the researcher is able to determine causation in a way that traditional economic evaluation does not allow for. In addition, it provides a broader framework to explore the processes through which inputs relate to outputs thus enabling a deeper understanding of why, for whom and under what circumstances a programme is cost-effective. This is especially useful for the evaluation of complex programmes with multiple inputs and outputs.

CONCLUSION: CFA is a useful and flexible technique that provides additional information to that gained through traditional economic analysis approaches. The two techniques should be seen as complimentary tools to aid resource allocation decisions.

COST FUNCTION ANALYSIS: IS IT REALLY ECONOMICS?

BACKGROUND

Introduction

This paper explores Cost Function Analysis (CFA); what it is, how it is used and what information it can provide. Both the authors have a keen research interest in the economics of social care and mental health care and CFA is a technique that is used often within this field, particularly in the mental health care sector. Traditional economic evaluations, including Cost Effectiveness Analyses (CEA) and Cost-Benefit Analyses (CBA), are common in the health care field and are used to investigate the resource implications of interventions. This type of economic analysis, however, is less prevalent in the broader social care field and alternative techniques are needed to explore economic issues, at least in the short term.

The purpose of this paper is threefold. First, to understand what CFA is and second to review the CFAs that have been undertaken to date. The third aim is to examine why CFA rather than traditional economic evaluations tend to be conducted in the social care field and to investigate what economic arguments CFA can contribute – and if indeed we really can say that CFA is a form of economic analysis. This research is in the early stages of development and therefore any comments or criticisms that are made are most welcome.

SECTION ONE

What is cost function analysis and when and why is it used?

Cost Function Analysis (CFA) is a multivariate regression technique with cost as the dependent variable (Y_i) and with two or more explanatory variables (e.g. X_{2i} , X_{3i} etc) used to independently predict cost. The regression equation below shows this relationship, with Ξ_1 as the intercept term, Ξ_2 and Ξ_3 as the regression coefficients and u_i as the stochastic disturbance term.

$$Y_i = \Xi_1 + \Xi_2 X_{2i} + \Xi_3 X_{3i} + u_i$$

From this regression equation it is clear that CFA enables us to separate out predictors of cost and the observed variation explained by the model from the stochastic element of the estimation. Assuming the availability of data and the validity and reliability of the model, the relative contribution of each of the sources of variation can be calculated and their marginal effect on cost explored (Bairam).

Any researcher undertaking cost analysis of any type will find that costs vary according to such factors as location of provision and supplier and users characteristics. Cost variation is particularly pronounced in the social care sector due to the more heterogeneous and multi-disciplinary nature of the interventions, as compared to acute medical care. Care provided is thus more difficult to standardize than purely medical treatment. For example, medicines and their clinical effect on the individual are readily quantifiable and separable into distinct, easily divisible units whereas in the broader social care field complex packages of treatments and services make quality control more difficult. In order to provide a meaningful picture of

cost variation it is important to describe this variation, to analyse what it means and to attempt its' interpretation.

In analysing cost data the researcher can take a simple approach and assume that the costs associated with a programme are fixed (deterministic) and in which case assumptions are made about inputs into production of the good which may obscure the true picture. In such a case the stochastic disturbance term in the equation above would be assumed away. Alternatively, assuming data availability, the researcher can estimate the cost of the programme for each user and in this case fewer assumptions are needed about resource use and stochastic analysis becomes possible (Barber et al).

The Randomized Controlled Trial (RCT) provides a way of over-coming potential biases as this study design aims to remove all sources of variation apart from the intervention in question through the random allocation process. However, scientific, randomised trials are rare in the social care field, for a number of reasons:

- Ethical problems – it is impossible to randomise children in care, for example, between placement types (foster care, residential care, adoption or reunification home), due to a lack of control over the alternatives and the inappropriateness of some placement types for some young people.
- Practical constraints – some social welfare interventions are carried out on a small scale or vary enormously between location. For example, schemes to aid urban regeneration can involve extremely variable and small scale projects within local areas, such as community gardens, youth clubs, market gardens, community centres, etc.
- National policy – many social care interventions are national requirements, such as the recent changes to the Leaving Care legislation and the policy of psychiatric reprovizion, making comparative trials impossible.
- Lack of familiarity – social care research tends to be dominated by qualitative, rather than quantitative, research. A greater understanding of quantitative research is needed in the field, before RCTs become more common.
- Lack of tools – final outcome measures, particularly generic ones, are rare in this field, and scales would need to be developed in order to carry out meaningful economic evaluations within RCTs.

Although these problems are not insurmountable, solving them will take time, and in the meantime CFA may be a useful substitute. In complex areas where RCTs are more common, such as mental health care, CFA is likely to prove useful as an additional tool to help unravel the complex relationships between inputs and outputs. Assuming that the researcher is aware of the factors that impact on costs and that the data required is available, CFA provides a means of investigating the multiple marginal effects of the intervention on costs – after influences that are not of interest have been controlled for.

CFA has been used in many disciplines including agricultural economics (Farman et al, Babcock et al, Sarikaya), environmental economics (Antle) and statistics (Al Sultan et al, Atkinson et al), among others. Applied to the health and social care setting, CFA has been defined as: “*the estimated relationship between the cost of providing care or treatment, the characteristics of users, the outcomes for the user or others, the prices of the*

resources employed and other factors with hypothesised influences suggested by the context and purposes of the care mode under examination (Knapp, 1995b).

Typically CFA is used to quantify cost variation associated with a programme at one of three levels of provision, that is at the macro (systems), the mezzo (facility) and the micro (individual) level (Knapp 1995b). Further to this, at each of these levels CFA can be used to explore within sample and between sample variation.

CFA is not just used to understand cost variation. The technique can also be used to link costs and service utilization patterns to need and to outcomes, with the latter two variables being introduced as explanatory variables within the model. For instance, CFA can be used to estimate the relationship between the cost of care according to patient characteristics and according to delivery outputs such as the organisation of provision or the change in health status of the sample population. In doing this CFA links inputs to outputs and hence can be used to say something about the efficiency with which the programme is provided. One would expect a positive relationship between need and cost as presumably provision should at least partly reflect user demands. Potentially then, CFA is a flexible technique for exploring predictors of cost.

The theoretical underpinning of CFA

CFA is based on the economic theory of production. This framework ties key elements in the provision of services together, that is it describes the relationship between resource and non-resource inputs and associated costs with intermediate outcomes and final outcomes. Intermediate outcomes include influences such as the quality of services whereas final outcomes involve meeting the objectives of the programme, for example improved well-being of the patients.

The production of welfare approach provides a means to explore the simultaneous impact of multiple variables on cost. It can determine which are the significant predictors of costs and it can indicate the relative strength of these predictors compared to one another. Depending on the variables incorporated within the CFA, the model can provide information on economies of scale, on the marginal cost of the treatment and the relative efficiency of one intervention in relation to another.

Traditional CFA is based on the assumption of cost-minimization so, given the lack of profit motive in public sector provision, another form of CFA evolved called behavioural cost function analysis (Zweifel et al). This term was first used by Evans and it can be used to help explain systematic deviations from minimum cost. In this form of CFA the function is designed to estimate the costs resulting from observed behaviour and it is this behavioural interpretation of CFA that is of interest in the studies reviewed here.

SECTION TWO

Review of CFA studies in the mental health care and community care setting

Initially we aimed to review all CFA studies that have been conducted to date. We searched seven databases (on 10/11/00), and the number of studies collected from each of these are reported in table 1 below. CFA has a number of alternative names and therefore to undertake a comprehensive search we used the following search terms; #1: cost

function, #2: predict* near2 cost*, #3: #1 or #2, #4: analys* or regression* or multivariate* or multi* variate*, #5: #3 and #4. After this we limited the search to the year 1980 onwards for articles written in English only, and all animal studies were excluded. Using this search strategy over 700 references were retrieved. After all references were imported into Endnote 4 and duplicates were eliminated this number was reduced to around 500 studies.

Table 1: Literature search results

Database name	Number of studies found
EconLit 1969-2000/09	262
EMBASE 1980-2000/09	231
HMIC: Dhdata/HEMLIS/King's Fund Database	44
MEDLINE EXPRESS 1966-2000/10	210
PsychLit	29
OHE HEED	18
NHS IED	77

Following this we read through each abstract separately to ensure that all the studies collected looked highly likely to involve CFA and that they related to either health or social care. This search strategy left us with a total of 172 studies on CFA and the different types of areas in which they were undertaken is illustrated in table 2 below.

Table 2: Types of mental health and social care studies retrieved.

Type of study	Number
A mixture of systems & facility level studies	69
Cardiology / Psychiatric and community care	23 of each
ICU	12
Medical instruments	9
Liver related, Cancer	6 of each
Trial design	4
Arthritis / Methods	3
Orthopaedic	2
Rabies, Back pain, Oxygen physiology, Diabetes, Dental, Pressure ulcers, Occupational stress, Hysterectomy, Peripheral vascular disease, Osteoporosis, Neurosurgery, Malnutrition	1 of each

Due to time limitations, to narrow down our review further we focused on psychiatric, social or community care type CFAs as these were amongst the dominant type of CFAs and of particular interest to the authors. Worthy of note here is that our review in no way attempts to make statements about CFA generally as our comments relate only to the studies reviewed. We regard mental health and social care as distinct from other types of care programmes (more will be said on this in section 3) and therefore argue that this area of provision requires a different approach to its analysis than conventional health care disease areas. In the mental health and social care field 23 CFA studies were obtained and after reviewing copies of each article the total included in this review was reduced to 17 CFA as the other six studies either did not actually contain CFA or they were methodological papers.

Findings

Review of the literature reveals numerous published CFA applications involving applied and methodological work, particularly in the mental health care field. The main results of our findings are given in table 3. We extracted a standard set of information from each article including: the study question and the study aim, information on the sample characteristics, the

types of dependent and independent variables used within the CFA, the method of multiple regression used, the analysis undertaken and the main findings reported.

Sixteen out of the 17 studies reviewed examined psychiatric care and costs, the odd one out was a study by Hughes on the factors influencing the cost of residential child care provision. There were three main aims of the studies reviewed and they were: to assess current service distribution patterns (Beecham et al, Bonizzato et al, Hallam et al), to explore cost variation across programmes (Knapp et al 1995b) and to examine the cost implications of particular populations in relation to a set of baseline characteristics (McCrone et al, Amaddeo et al).

The sample size used ranged from 13 residential treatment facilities (Prentice Dunn et al) to 1904 individuals (Chisholm et al). All CFAs were based on observational datasets apart from two studies. In one study people with serious mental illness were randomly allocated to either a home based Daily Living Programme or standard inpatient care (Knapp 1995b) and in the other study people with severe psychotic illness were randomized to either standard or intensive care management in (Byford et al). The observational data sets included cross-sectional and longitudinal data and the majority of studies took place in the UK (59%).

The dependent variable involved in each CFA was either a total or an average cost and the unit of analysis varied from the micro level, that is at the level of the individual (Bonizzato et al, Byford et al), to the mezzo level of the facility (Hughes), to the systems, macro level (Beecham et al). The Client Service Receipt Interview was used in a few of the studies (e.g. McCrone et al, Knapp 1995b). The sources of costs varied from accounting systems that were expenditure (Ernst et al) or budget based (Salize et al) to micro-costing based studies (Byford et al) where unit costs for all areas of the service are collected separately and then aggregated. In terms of the explanatory variables included there was a high degree of overlap. All studies incorporated patient characteristics, socio-demographics, quality of life instruments and clinical indicators, apart from the Prentice Dunn study on residential treatment facilities which included variables relating to the provision of care.

All CFA studies reviewed used Ordinary Least Squares (OLS) regression analysis to analyse the data. However, a variety of approaches were taken to build the regression model. Some studies used forward regression techniques (Hughes), others used backward selection procedures (Kendig et al) and some studies did not mention the approach taken for the analysis (Chisholm et al). In most of the cases where the information was reported, costs were not normally distributed and in some cases natural logarithms of cost were undertaken to normalize the distribution (McCrone et al), meanwhile some researchers involved in other studies chose to leave costs untransformed (Byford et al), with bootstrapping techniques used to test the appropriateness of this method. Generally in the analysis P values to demonstrate statistical significance were set at 0.05 or 0.01. To remark on the total observed variation explained within the model, the R^2 was used (Bonizzato et al) and in some cases the adjusted R^2 (Byford et al, Ernst et al, Knapp 1995b) was also reported.

The results of the studies differed from one study to the next depending on the aims of the studies and the dependent and explanatory variables included within the analysis. However,

some common findings emerged. Generally service distribution did vary according to diagnostic group but this explained only a small proportion of the total variation observed. Other factors used to predict costs included the patient's personal characteristics and their previous mental health service history (Amaddeo et al).

Review discussion

The use of CFA in the mental health care field is relatively new (only over the last decade or so) and the methodology continues to be refined and this is evident given the variety of methods used and the adjustments made to the methodology over time. To enable more cross study comparisons, consensus is needed on how best to undertake the analysis. From review of the literature a number of observations were made.

1. The stepwise procedures used in many of the studies reviewed (e.g. Bonizzato et al, Slaize et al) have been criticised for using strict cut-off P-values, for taking control of the analysis process from the analyst and for producing unstable models (Altman et al). It is argued that more flexible methods of analysis such as backward elimination and then forward selection be used without the use of strict P-value cut off points (Collett).
2. A few of the analyses used OLS methods on untransformed costs (Byford et al, Bonizzato et al) even though the cost data has a skewed distribution. The benefit of not transforming costs as compared to the use of conventional non-parametric tests or logarithmic transformation is that inferences can then be made about arithmetic mean (Barber et al).
3. It remains unclear as to the direction of causality within the CFA. The question is whether increased costs reflect or indicate variation in need and/or outcomes. Attention to detail is required to ensure that there is no tautological relationship between the dependent and the explanatory variables otherwise the arguments in the estimation become circular. For instance, it is appropriate that total costs be used instead of average costs because it is important to separate out influences on the dependent variable from those impacting on the explanatory variables. The number of units being analysed influences the average cost but not the total cost.
4. In those studies reviewed rarely was the adjusted R^2 reported. The unadjusted R^2 is a non-decreasing function of the number of explanatory variables introduced within the model so that it invariably increases as the number of variables increases (Gujarati) and for this reason the adjusted R^2 should be reported.
5. CFA is a data hungry technique and so data collected specifically for this kind of analysis can be expensive to gather. For most of the studies reviewed only units of analysis for which there was full information were incorporated within the model and this reduces the power of CFA. However, the technique is still being developed and for instance Bonizzato et al have recently published an article in which weights were attached to each patient in the sample in order to overcome the inefficiencies of using complete-case analysis.

SECTION THREE

Cost Function Analysis and traditional economic evaluations

The CFA approach shares a number of similarities with traditional economic evaluation techniques, for instance both techniques permit investigation of efficiency in resource allocation by linking costs to outcomes. However, CFA is sometimes criticised for focusing on inputs and process to the detriment of outcomes. This section explores some of the advantages and disadvantages of each and it attempts to understand the contributions that each could make in relation to the evaluation of mental health and social care.

For CBA it is assumed that over the long term if a programme succeeds there will be a positive relationship between cost and outcome. However, for mental health care in particular, rarely can the illness be reversed and often care can only help to either slow down the rate of cognitive decline or at best stabilise it. In this case, over time higher costs can be associated with increasing need and this is not related to the efficiency of the programme.

CFA is exploratory in nature, investigating the impact of any of the independent variables included within the model. CBA, on the other hand, is used to evaluate interventions. CFA can be used to identify how improvements may be made to a service, whereas CBA describes the interventions concerned.

Both CFA and CBA can be used to analyse issues relating to choice and rationing. Additionally both forms of economic analysis can be used to explore cost-minimisation arguments. In theory the main difference between them is that CBA can be used to analyse net benefits and CFA cannot. On the other hand, CFA can be used to explore the concepts of economies of scope and scale and the pattern of service distribution whilst CBA cannot.

Through CFA the researcher is able to determine causation in a way that traditional economic evaluation does not allow for. This is not to say that CFA denotes the direction of causality, rather that the separate influences of each of the explanatory variables included in the model can be related to cost within the single model.

In general, the range of outcomes examined in mental health and social care are greater than in the narrower health care sector, including physical and mental health status, family and social functioning, needs, quality of life of patients and carers. Whether this is based on resistance to the use of a single, distilled measure or the lack of an appropriate single outcome measure available, a tool which can incorporate a number of explanatory variables, such as CFA, is useful. CFAs undertaken in the mental health and social care fields, therefore, are most similar to cost-consequence analyses.

CFA provides a broader framework than CBA to explore the processes through which inputs relate to outputs thus enabling a deeper understanding of why, for whom and under what circumstances a programme is cost-effective, whether costs are related to need, intermediate or final outcomes. This is especially useful for the evaluation of complex programmes with multiple inputs and outputs and intricate sub-group analyses are possible. In the mental health care field interpretation of cost information is increased due to the variety of potential influences on costs. CFA seeks to provide some kind of explanation of

multiple variations and such multivariate analysis might be the only option for exploring cost variation in data sets that are not randomised (Knapp, 1995).

It is difficult to standardise provision in social and mental health care because it is more usual for the service provided to differ on a case-by-case basis. CFA tends to be applied to observational data sets where cross-sectional data is taken at baseline and may possibly be compared with another set of cross sectional data at some later time point. CFA models, if specified correctly, are useful for eliminating potential confounders so that the relationship between cost and inputs and/or outputs are not biased. In practice it is the norm to use CBA to explore experimental data sets and to use CFA to explore observational data sets. A large number of exogenous variables influence the outcome of mental health and social care activities and only very large RCTs enable like-with-like comparisons to be made.

Is CFA really economics?

As part of this paper we aim to investigate the contribution of CFA to health economics and the appropriateness of its use as an economic tool. One criticism levelled at CFA is the focus on costs to the detriment of outcomes. Certainly the relationship between costs and outcomes is core to the study of economics. While we would agree that the focus is on costs, in the sense that CFA aims to explore what influences cost, it is not clear whether change in cost reflects or indicates needs or outcomes. Just as the direction of causality is not clear, neither is the assertion that costs are pre-eminent. In the multiple regression equation all variables are analysed simultaneously even though it makes sense that the outcomes for an intervention be felt after the use of the resources to produce the programme.

To examine what economic arguments CFA can contribute to research it is helpful to define what economics is. Economics contains a set of techniques to aid the choice between producing one good rather than another and in part this involves comparing resource use to output produced. In a broad sense then, yes, CFA is a form of economic analysis as it deals with inputs and outputs of provision and it does concern choices. CFA is about choice because it enables comparison of the impact of the programme on different sub-groups included within the analysis. For instance, the cost of a Daily Living Programme based on home care was compared to standard inpatient care and within this analysis the impact of variables such as gender, ethnic group and a number of clinical indicators was assessed (Knapp, 1995b). As with many other health economics tools, CFA relies on the input of a number of other disciplines – primarily econometrics but also psychology based outcome instruments, and disciplines such as sociology, demography and medicine for identifying patient characteristics – still economic messages can be made based on CFA.

Mental health and social care tend to rely on a mixed economy of provision and, in terms of the analysis, inter-sectoral comparisons are essential. As yet there are no widely available or well-validated techniques for making such comparisons. CFA has been applied successfully to community re-provision involving entry of previous long stay hospital patients into the community (Beecham et al, Knapp 1995a). In theory, applied to mental health and social care, CBA may also be used to aid allocative efficiency decisions but in practice CFA has provided a stronger framework to date.

Beyond the debate about the advantages and disadvantages of CFA and CBA, another issue relates to whether CFA can be considered a substitute or a compliment to CBA? It appears that CFA may be used to aid the design of RCT, although no examples from the literature have been found. By undertaking a CFA pre the RCT phase, CFA should enable the researcher to explore which variables are likely to influence cost. As an input to the RCT design, CFA could be used to adjust for covariate imbalance before the patients were allocated to one of the two or more interventions being examined. By identifying the main cost drivers in advance of undertaking the study, the data collection effort and related expenses may be reduced.

CFA can also be used to provide a deeper understanding of the results of an RCT, e.g. Byford et al which used data from a large, multi-centre RCT comparing intensive with standard case management for patients with severe psychotic disorder (UK700 Group: Byford et al, 2000). Traditional economic evaluations carried out within randomised designs, provide important information about the relative cost-effectiveness of interventions. However, they tend to be somewhat limited (often by sample size) in their ability to answer more detailed questions such as why an intervention is more cost-effective, which sub-groups it is particularly useful for and which elements of complex care packages are driving the cost-effectiveness results. CFA can help to disentangle these more detailed relationships and give some insight into the 'black-box' between inputs and outputs. Potentially these answers are also limited by issues of statistical power and here CFA provides a more detailed exploration (as opposed to explanation) of the relationships involved, that can help in a hypothesis-generating fashion.

Overall then, the approach shares a number of similarities with traditional economic evaluation techniques, for instance both techniques permit investigation of efficiency in resource allocation by linking costs to outcomes. The two approaches may be used as compliments or substitutes, primarily depending on the trial design. From review of the literature CFA has a particular strength over CBA when applied to observational data.

Conclusion

The CFA technique can provide valuable information on the sequence of factors included within the model, the combination of explanatory factors incorporated and the marginality of stimulus they bring to the care setting. While CFA needs to be used with caution to avoid data dredging and at worst to avoid incorrect specification and interpretation of the data, used correctly the technique provides some clear answers to policy makers planning and assessing provision of care.

In summary, CFA is a useful and flexible technique that provides additional information to that gained through traditional economic analyses. The two techniques should be seen either as tools for analysing different things or as complimentary tools to aid resource allocation decisions.

Summary points

- Practicalities

Mental health and social care provision are particularly complex and the standard RCT study design is not always optimal for the analysis of these types of care. While examples of RCTs were found (Knapp 1995; Byford et al), one advantage that CFA has over traditional economic evaluations is that it enables the separate influences of all the explanatory variables to be tested, controlling for interaction terms. In traditional economic evaluations sensitivity analyses are used to undertake sub-group analysis and to test for variation in benefits and costs. However, the technique does not allow the researchers to say that X% of the observed variation is explained by variable Y, unlike CFA.

- The methodology

Different types of regression techniques have been used to conduct CFA and no consensus has emerged as yet, which adds to the difficulty involved with making cross study comparisons.

Total cost rather than average costs should be used as the dependent variable.

Cost variation should be explained in terms of the adjusted R^2 rather than the R^2 .

- It is the opinion of the authors that CFA can make a contribution to the economic analysis of mental health and social care. However, further research is required both to refine the technique and to improve on study designs for the analysis of mental health and social care data.

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Table 3: Mental health, child, social and community care CFA studies (I)

Refs	Question / aim	Sample	Dependent variable and costs included	Explanatory variables	Methods	Analysis	Main findings
Amaddeo et al	Explores the association between patient's characteristics & the direct costs of psychiatric care provided	n = 706. Observational data set – longitudinal. ICD-10 diagnosis. Data from South Verona psychiatric case register.	Total costs. In-patient, sheltered accommodation, day-care, out-patient & community costs.	Patient characteristics (age, duration of contact with psychiatric services & level of education), diagnostic group (affective disorders, neurotic & somatoform disorders, schizophrenia & related disorders, other).	Estimates for 1 year from 1992. Separate equations estimated for the 4 diagnostic groups involved. OLS estimation was used. Test to see if residuals were normally distributed. Logarithms of total costs were used so that the residuals for each equation were normally distributed.	Generally a P value of 0.01 or smaller was taken to signify statistical significance. Regressions of total costs on characteristics; $R^2 = 0.397$ for affective disorders, 0.372 for neurotic disorders, 0.395 for schizophrenia and related disorders & 0.530 for other diagnoses.	Costs by service group differed between diagnostic groups ($P < 0.01$). Costs were significantly higher for patients diagnosed as having schizophrenia than other diagnostic groups. Diagnostic group explained only 6% of the variation. 40%-50% of the costs of mental health care was predicted by patient's personal characteristics and other measures recorded on the case register.
Andersen et al	Use of CFA to estimate the annual health care costs of dementia.	n = 735. Observational, longitudinal study. Random sample of 245 demented patients & 2 controls per demented case. Municipality of Odense.	Total costs. Costs associated with GP consultations, medical specialists, dentists, chiropractors, physiotherapists, in-patient & out-patient visits.	Degree of dementia, personal characteristics (sex, age, marital status) and the presence of any other co-morbidity apart from dementia.	Use of a log-linear single-equation model in which the dependent variable is not transformed. Also use of a two-part model where first the model is used to estimate the probability of incurring any cost and second the model is used to estimate the level of the cost, provided that a non-zero cost is observed.	P values of 0.05 and 0.01 were reported as statistically significant. In the two-part model log-linear regression model the $R^2 = 0.297$. The predictive validity of the regression equations was checked using the root mean square error, the mean absolute error and the Theil U statistic. The bootstrap was used to estimate confidence intervals of the cost predictors.	The type of model impacted on the predicted health care costs made e.g. the estimated annual health care cost for a mildly demented patient ranged from DKK 71,273 – DKK 90,940. The two-part model without interaction terms was the best model.

<p>Beecham et al</p>	<p>Examination of cost differences associated with the care of patients with long-term mental health patients moving from hospital to the community. Analysis of association between costs, needs and outcomes</p>	<p>n = 216. Observational data set – before and after study. Sample included patients from 2 mental health care hospitals in North London.</p>	<p>Average cost per week for psychiatric re-provision. Comprehensive costs – not specified individually.</p>	<p>Personal characteristics (gender, age, ethnic group, marital status), psychiatric characteristics (previous inpatient care and initial diagnosis) outcome instruments; Present State Examination, Social Behaviour Schedule, Basic Everyday Living Skills, Social Network Schedule, Physical Health Index, Patient Attitude Questionnaire</p>	<p>OLS regression.</p>	<p>A P value of 0.1 or smaller was reported to signify statistical significance. Variation in costs was measured using the adjusted R² statistic = 0.50 without sector type, 0.59 with sector accommodation type.</p>	<p>Overall higher community cost were related to better outcomes, community services appear to respond to the needs of clients.</p>
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Table 3: Mental health, child, social and community care CFA studies (II)

Refs	Question / aim	Sample	Dependent variable and costs included	Explanatory variables	Methods	Analysis	Main findings
Bonizzato et al	Examination of community based mental health care services with clinical, social & service history variables	n = 339. Observational data set – longitudinal study. South Verona, Italy.	One year average and total costs per person by diagnostic group (i.e. affective disorders, neurotic and somatoform disorders, schizophrenia & related disorders, other diagnoses).	Socio-demographics (gender, age, marital status, living condition, educational level, working status) and clinical measures (Global Assessment of Functioning Scale, Brief Psychiatric Rating Scale, Disability Assessment Scale, Camberwell Assessment of Need, Lancashire Quality of Life Scale, Verona Service Satisfaction Scale).	Weighted backward regression analysis on logarithm of psychiatric costs. Weights were attached to each patient in the sample in order to produce approximately unbiased estimates of parameters for the target population – this overcomes the inefficient use of data used in complete-case analysis. It was assumed that the log of psychiatric costs was normally distributed and when the distribution of the residuals was analysed this proved to be the case.	P values of 0.05 or smaller were reported. $R^2 = 0.66$.	As one would hope, more resources for community based services were targeted at the most disabled patients. Strong predictors of psychiatric costs included intensity of psychiatric contacts and number of admissions in the previous year.
Byford et al	What influences the cost of caring for patients with severe psychotic illness.	n = 667. Random allocation of patients to standard case management or intensive case management . UK.	Two year total costs per patient. Costs relate to the cost of caring for patients with severe psychotic illness.	Socio-demographics (age, marital status, months independent living), severity of illness (duration of illness, days in hospital for psychiatric reasons over the previous 2 years), Camberwell Assessment of Need, Abnormal Involuntary Movements scale, Scale of Assessment of Negative Symptoms, Comprehensive Psychiatric Rating Scale, Lancashire Quality of Life profile & the Disability Assessment Schedule.	OLS on untransformed costs. Results from this were compared to those from non-parametric bootstrap regression and to those obtained from a generalised linear model where a non-normal distribution was assumed for costs (gamma distribution was used).	Generally a P value of 0.01 was used. Adjusted $R^2 = 0.23$	Total costs were influenced by age, duration of illness, & past levels of dependency on statutory services. The impact of these variables on costs was higher than the impact of illness severity.

Table 3: Mental health, child, social and community care CFA studies (III)

Refs	Question / aim	Sample	Dependent variable and costs included	Explanatory variables	Methods	Analysis	Main findings
Chisholm et al	Predicting costs from resident characteristics of people with mental health problems.	n = 1904, Observational data set – cross-sectional survey. London & non-London residential services UK.	Total cost per week for individual residents. Broad costs of the facilities themselves (revenue, capital & overheads) & non-residential services used (e.g. inpatient, outpatient, day care, sheltered workshop attendance, GPs, community psychiatric nurses & psychiatrists & social workers + residents' living expenses.	Socio-demographics (age, gender, ethnic group, marital status), previous living situation, previous psychiatric service history, symptoms, current & previous legal status.	Method of multiple regression not described.	Generally P = 0.05. Adjusted R ² = 0.187 for London community residents & 0.175 for non-London community residents.	Comparison of London to non-London facilities. In general community care services responded positively to needs. Costs were higher in the public rather than private sector facilities ceteris paribus.
Ernst et al	To estimate cost savings obtainable from Alzheimer Disease (AD) treatments that stabilize or reverse patients' cognitive decline.	n = 64. Observational data set - longitudinal. California, US.	Average cost per patient. Costs included inpatient, outpatient, nursing home, GP, residential care, ambulance, adult day-care, paid in-home care, purchased meals, unpaid in-home care, medications.	Socio-demographics (e.g. age, education. Gender) and the Mini Mental State Examination.	OLS, expenditure data appeared to be log-normally distributed so cost functions were specified in semi-log form.	Generally P = 0.05. According to the regression observed and the type of costs included, the adjusted R ² varied from 0.503 – 0.002.	Associations between costs of AD and patient cognitive status were first explored then these were used to project potential savings in costs to society if treatments for AD stabilized or reversed the patients' cognitive decline. It was found that savings in costs of caring for moderate – severely demented home-dwelling patients with AD could be made even if the interventions only had a minor effect on the patients' cognitive status.

Hallam et al	Prediction of community care costs based on assessments of clients before they left mental health care hospital	n = 428. North London. Observational – longitudinal data set.	Average cost per week of community support. Costs included; accommodation facility, inpatient, outpatient, day care, community psychiatry, nursing services, chiropody, psychology, physiotherapy, OT, GP, dentist, optician, pharmacy, social services day care, field social work, voluntary organization day care, social club, volunteer inputs, education, police, client's travel, miscellaneous services.	Personal characteristics (gender, age, ethnic group, marital status), psychiatric characteristics (previous inpatient care and initial diagnosis) outcome instruments; Present State Examination, Social Behaviour Schedule, Basic Everyday Living Skills, Social Network Schedule, Physical Health Index, Patient Attitude Questionnaire.	OLS regression.	Generally P = 0.05. R ² = .0.568 and 0.642 reported (adjusted R ₂ were presented but not reported to explain the cost variation).	Link between costs & outcomes were found to be strong. Higher levels of spending in the community were found to be related to increased improvements in health & welfare of former long-stay patients. Costs were found to be sensitive to client characteristics. Voluntary & private sector care was found to be more cost-effective than Local Authority care and this was reported to be more cost-effective than Health Authority care.
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Table 3: Mental health, child, social and community care CFA studies (IV)

Refs	Question / aim	Sample	Dependent variable and costs included	Explanatory variables	Methods	Analysis	Main findings
Hughes	Use of a stochastic frontier function to estimate the cost influencing factors for residential child care provision.	n = 351. Twenty-five English Local Authorities. Observational data.	Total weekly costs of operating the home. No breakdown of costs was given.	Quasi-inputs e.g. Socio-demographics (age, gender, whether mentally handicapped) and intermediate outputs (number of places in home, number of self-contained living units, presence of a workshop, library area, laundry, transport, social work undertaken by staff, provision of preventive/at-risk day care).	OLS. Multiplicative model including logged costs. Forward regression techniques used. The aim was to fit a frontier rather than an average cost function but an average cost function was estimated first.	P = 0.05. R ² not reported.	Primarily a methodology study to develop measures of inefficiency for individual local authorities.
Kendig	What variables predict costs of community care services for individuals with complex needs?	n = 497. Australia. Longitudinal data set.	Estimated total weekly cost to the government by of all community services used by the client. Direct costs (home nursing, health aides, home care, home maintenance, meal services, transport services, adult day care). "Indirect" costs of case management & administration costs were included.	Socio-demographics (age, gender, whether client had a carer – and gender of them), ethnicity, pension status), client & carer need (Barthel scores indicating level of dependency, cognitive impairment, incontinence, behaviour problems & inability to take medication & inability to walk) & time spent receiving care.	OLS – multiple regression backward selection procedure. Additive and interactive effects were tested using hierarchical multiple regression.	P = 0.05. R ² = 0.28.	Client dependency was a significant predictor of costs though' it accounted for only 4% of the variance in service costs. Less than a third of the variation in service costs was predicted by client & carer characteristics. The longer the time in the scheme the more costs were incurred. Factors predicting increased costs were client dependency, male carers, lack of a co-resident carer & client incontinence.
Knapp et al, 1995a	Prediction of service needs & costs in the community following closure of long stay mental health care hospitals	n = 341. Cross sectional data set. London, UK.	Total cost per week of community support for each individual. Costs included inpatient, outpatient, day centre, social clubs, case review, education, police, GPs, drugs, nursing care, psychiatry, social work, chiropody, dentists, opticians, OT, pharmacy, psychology, psychotherapy, travel, volunteers, miscellaneous.	Socio-demographics (age, gender, ethnic group, marital status, inpatient experience), clinical, social & behavioural characteristics (Present State Examination, Social Behavioural Schedule, Social Network Schedule, Physical Health Index).	OLS model. Baseline characteristics were included singly & in multiplicative combinations to capture any non-linear effects.	Generally P value = 0.05. R ² = 0.35.	Clinical diagnosis was not a strong predictor of cost/service utilization. Over a third of the variation in costs was predicted by the behaviour, symptoms & personal characteristics of clients at least one year earlier (in this case when in the mental health care hospital).

<p>Knapp et al 1990</p>	<p>An examination of the costs of community reprovion for clients leaving mental health care hospital.</p>	<p>n = 136 leavers for whom full cost / service use data sets were available & baseline descriptions of 964 patients in hospital. London, UK. Longitudinal data set .</p>	<p>Total cost per week per person. Costs included; accommodation and living expenses, inpatient, outpatient, day care, education, police, GPs, injections, nursing, psychiatrist, social worker, miscellaneous professional, travel, volunteer inputs.</p>	<p>Mental health status (Present State Examination, Social Behaviour Schedule, Physical Health Index), personal characteristics (patient attitudes, information on patients' social networks – Social Network Schedule) & assessment of living environment.</p>	<p>OLS. Link of hospital-assessed characteristics to subsequent cost of community care.</p>	<p>Cut-off level of significance based on P value ≤ 0.125. $R^2 = 0.38$, adjusted $R^2 = 0.326$.</p>	<p>Based on predictions of the model community care costs were estimated to be lower than hospital costs.</p>
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Table 3: Mental health, child, social and community care CFA studies (V)

Refs	Question / aim	Sample	Dependent variable and costs included	Explanatory variables	Methods	Analysis	Main findings
Knapp 1995b	Exploration of cost variations among people with serious mental illness in hospital based & home based care.	RCT with longitudinal observations. People with serious mental illness was randomly allocated (equal probabilities) to a daily living programme (DLP) based on home care (n = 92) or standard inpatient care (n = 97). UK.	Average weekly costs per patient for the DLP & average cost per inpatient day for the hospital example. A second study was included using average revenue cost per inpatient day as the dependent variable. Marginal cost per inpatient day was included also. Broad costs/service use not listed in article but collected using the Client Service Receipt Interview.	Patient characteristics (e.g. Global Assessment Scale, Present State Examination, Brief Psychiatric Rating Scale, Social Adjustment Scale, daily living skills rating, patient & relatives satisfaction with the service).	OLS.	Generally P value = 0.01. R ² = 0.41 for DLP sample & 0.34 for control group of individuals receiving standard hospital care. Adjusted R ² for second study on psychiatric hospital cost variations = 0.326.	For the first study, greater needs at entry were less likely to be associated with higher costs for the DLP group than for the standard care group. Cost for the DLP group were lower for females and higher for people of Afro-Caribbean ethnic origin. CFA was then used to observe between treatment option variation. In terms of the second study involving psychiatric hospital cost variations, as inpatient numbers declined hospital cost savings were predicted, even in the short term.
McCrone et al	Identifying factors that could explain variation in the cost of mental health services for people with psychosis.	n = 147. Observational data set – longitudinal analysis. London, UK.	Mental health care costs (inpatient, day hospital, other contacts with mental health staff & medication). Use of Client Service Receipt Interview.	Socio-demographics (marital status, living arrangements, ethnic group, whether patient has children, police, where born, other family members psychiatric history, gender, whether known to be a suicide risk, history of violence, staff concern regarding violence). Psychiatric characteristics (ICD-10, alcohol/drug problems, living in supported accommodation, day patient, inpatient, outpatient, CPN contact in index year, emergency clinic).	OLS linear regression model. The distribution of the untransformed cost residuals was found to be skewed. Natural logarithms of cost were used to normalize the distribution. Initially all eligible variables were included in the model and those that were non-significant were removed by backward elimination.	Generally P value = 0.01. R ² = 0.32	Previous resource use and patient characteristics of patients with psychosis can be used to predict service use, particularly the degree of social disability. Social functioning was highly negatively associated with costs.

<p>Prentice Dunn 1985</p>	<p>What factors may be used to predict the cost of behaviourally orientated residential treatment for emotionally disturbed children? What programme characteristics were predictive of cost?</p>	<p>n = 13 residential treatment facilities for emotionally disturbed children. Observational – cross sectional data set</p>	<p>Average daily living cost per child across 13 residential treatment facilities for children. Breakdown of costs not provided.</p>	<p>Predictors taken from “Program Characteristics Questionnaire”. 10 categories of variables; accreditation, inservice, full time staff, part time staff, intern training, treatment conferences, records, therapy, child’s treatment involvement, importance of various programme components.</p>	<p>Initially there were 146 explanatory variables & these were reduced to 11 for each of the 10 programme category (= 110 in all).</p>	<p>P value not given. R² = 0.89.</p>	<p>Key predictors of cost included; involvement of special education teachers in devising treatment plans, involvement of children in devising their own treatment plans, number of full time special education teachers, whether programme licensed by the State Department of Mental Health, involvement of psychologist in devising treatment plans.</p>
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Table 3: Mental health, child, social and community care CFA studies (VI)

Refs	Question / aim	Sample	Dependent variable and costs included	Explanatory variables	Methods	Analysis	Main findings
Salize et al	Predicting the cost of community care for people with Schizophrenia	n = 66. Observational –longitudinal data set. Mannheim, Germany.	Psychiatric care costs. Total costs of care following discharge from hospital. Use of Mannheim Service Recording Sheet (includes psychotherapeutic, biological psychiatric & supportive interventions, interventions regarding activities of daily living, problem assessment, general advice, interventions regarding occupation & accommodation, sheltered occupation, crisis intervention & somatic treatment when related to mental illness).	Socio-demographics (age, gender), outcome parameters (Needs for Care Assessment, quality of life (Munchner Lebensqualitäts-Dimensionen-Liste, Social Support Questionnaire)).	OLS. Stepwise multiple regression analysis.	P = 0.05. R ² = 0.45.	Variables that were significant predictors of total cost of community care were the number of rehabilitative problems at the beginning/end of the study, the type of accommodation before index hospitalization & the gender of patients.
Shiell et al	Exploration of the question – have community residential facilities delivered the expected quality of service at appropriate cost?	A random sample of 123 facilities in the UK.	Total cost per resident day. Costs of those in residential care including costs of services not attributable to the facility. No breakdown of costs was provided.	Patient dependency (the Behavioural Development Survey), quality of life instruments (the Index of Participation in Domestic Living, the Index of Adult Autonomy, the Index of Community Involvement, the Group Homes Management Scale, measure of the physical environment of the facility (OREQY) & a single process-quality of care variable (QUALITY), capacity & utilization variables.	Two models were used; a short (interactive) model and a full model. Four versions of each of these models were tested; linear, semi-log, log-linear & double-log forms.	P = 0.1. Adjusted R ² = 0.65.	Factors that were most significant in explaining costs were case-mix factors relating to client age, dependency & length of stay. Generally quality of service measures were significantly associated with costs. Private, for profit sector facilities were less expensive than other agencies.