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Chiatti, Carlos; Iwarsson, Susanne

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Carlos Chiatti, PhD[1, 2] & Susanne Iwarsson, PhD, Professor, reg. occupational therapist[2]

[1] *Scientific Direction, Italian National Research Centre on Aging (INRCA), Italy*

[2] *Department of Health Sciences, Faculty of Medicine, Lund University, Sweden*

Corresponding author:

Carlos Chiatti, PhD

Italian National Research Center on Aging (INRCA)

Via Santa Margherita, 5

60121 - Ancona, Italy

Tel.: +39-071-8004787

Fax: +39-071-35941

E-mail: c.chiatti@inrca.it

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Abstract

The home environment is a key determinant of health, quality of life and well-being. Given its relevance for such aspects, the scarcity of evaluations of Housing Adaptation (HA) interventions aimed at removing environmental barriers and accessibility problems in the homes of people with disabilities is surprising. This paper aims to contribute to the development of strategies for economic evaluations of HA interventions, by stimulating the dissemination and application of the concepts of effectiveness, cost and cost-effectiveness as used within health economics. We limit our focus to three overarching questions for the evaluation of HA interventions. Considering X and Y as two hypothetical interventions for the same individual case, we ask: 1) Will X be more effective than Y?; 2) Will X cost more than Y?, and 3) Will X be more cost-effective than Y? We use vignette-like descriptions of fictional cases to exemplify the economic concepts explained in the paper. In the conclusion, we stress the need for new experimental data regarding both costs and outcomes of HA interventions, in order to realize sound evaluations with the potential to inform policy and professionals in this field. Given the heterogeneity among national contexts, systematic approaches applied in a coherent manner could strengthen cross-national research and collaborations.

Key words: Economic Evaluation; Outcome research; Cost-analysis

Housing Adaptation Interventions: Definition, Theoretical Background and Relevance

Studies in a range of disciplines confirm that the home environment is a key determinant of health, quality of life and well-being, regardless of age, gender, area of residence, and/or nationality *(1,2,3)*. The home environment becomes particularly important for older individuals, those living with a chronic disease or the consequences of a serious injury, and who experience a process of functional and cognitive deterioration. For people with moderate to severe disability (who constitute around 15% of the general population and 50% among those aged 60+ *(4)*), even a familiar home environment may become inappropriate and too demanding in relation to changing needs. Thus, it is not surprising, that the importance of home environments is high on political and scientific agendas and is increasingly being investigated by researchers in the field of ageing. Recently in Europe, the FUTURAGE Roadmap for ageing research *(5)* identified the generation of new knowledge on key enabling and constraining environments, as a main priority to address the challenge of demographic ageing.

Today, environmental barriers and accessibility problems in the home can be considered as part of an individual rehabilitation plan or in conjunction with preventive measures, for example, in the form of a Housing Adaptation (HA). HA interventions can be defined as those "*alterations of permanent physical features in the home and the immediate outdoor environment*" *(6)* that aim at *"reducing the demands of the physical environment in the home and its close surroundings" (7)*. That is, the physical home environment is altered, and the intervention is tailored to meet the specific needs of an individual who is experiencing limitations in activity performance in his/her home. The underlying assumption that reducing physical barriers in the home will enhance activity and participation *(8)*, is based on the theoretical underpinnings of the transactional person-environment-occupation (PEO) model *(9)* and the so-called docility hypothesis stating that individuals with lower capacity are more vulnerable to environmental press *(10)*. Typically in health care contexts, interventions targeting individual needs for HA are initiated by rehabilitation specialists, most often occupational therapists. It should be noted that in the international literature,

the term HA is being used interchangeably with the expression "home modification" (HM), although in some contexts (for example, in the U.S.), HM includes a wider range of interventions (e.g. the use of assistive technology and ADL training) (see e.g. *11,12*).

There are considerable cross-national differences in terms of HA/HM availability, financing, construction, delivery standards and integration with other types of interventions: in some countries HA/HM are recognized as publicly financed services, while in other national contexts citizens themselves are responsible for financing their HA/HM, even if tax deduction systems, when available, can cover a portion of the expenses (*7*). According to current Swedish legislation *(14)*, HA grants are provided by the municipalities, and a grant covering the full costs of the intervention can be requested. The grant is provided irrespective of the applicant's financial situation, and independently of whether the dwelling is rented or owned. HA interventions can be implemented in three different contexts of care, characterized by different "therapeutic goals" *(13)*: a) *preventive*, to prevent loss of autonomy and/or acute events; b) *rehabilitative*, to support the regaining of activity and participation after illness or injury; c) *long-term care*, to compensate for loss of autonomy and make it possible for the individual to remain in his/her current house. The largest majority of clients requiring HA are older people with a progressive age-related deterioration of physical and/or cognitive abilities. Currently, approximately 73,000 HAs are granted each year in Sweden, at a total cost of close to SEK 1 billion (around € 115.5 million) *(14)*.

Knowledge gaps regarding HAs

Given the prominence of housing environments in the everyday lives of people with disabilities and the increasing relevance of HA in public welfare systems, the paucity of systematic evaluations of these interventions is surprising *(15)*. According to a recent review *(12)*, the most common outcomes targeted are functional ability and falls. Surprisingly, few studies containing economic appraisals can be found, and these mostly can be retrieved in the "grey literature" (16). In Sweden, economic evaluations of HA have hitherto been restricted to financial follow-ups conducted by the

authorities *(17)*. Recently a paper investigated the cost-effectiveness of an intervention entailing the use of HM and ADL training using outcome data from a 2003 trial and retrospectively estimating the associated costs *(18)*.

The heterogeneity of HA interventions can be considered among the reasons that so far have hindered their systematic evaluation. HA interventions are not easily standardized as they have to be customized to the needs of each single client, in his/her actual housing environment. The most common HA interventions concern immediate outdoor or entrance areas and kitchen and hygiene facilities, in more or less complex combinations. These can include the installation of lifts and ramps, handrails for stairs, the removal of thresholds and bathtubs, the installations of grab bars in hygiene facilities, as well as the installation of timers for stoves/ovens in the kitchen. Other measures target general accessibility problems in the house and its close surroundings, for example changes in door swings, replacement of ironwork at doors/windows, installation of automatic doors and moving the wardrobe or mailbox *(19)*. In addition, HAs often are combined with (or even dependent on or caused by) other types of interventions, in particular the provision of mobility devices.

It is, thus clear that HAs can be labeled as "complex interventions" according the UK Medical Council of Research definition (20) as they are characterized, at least, by the following dimensions of complexity: a) the number and difficulty of behaviors required by those delivering and receiving the intervention; b) the number of groups or organizational levels targeted by the intervention, c) the degree of flexibility or tailoring of the intervention permitted, d) the number and variability of outcomes. Such complexity clearly makes evaluation efforts complicated and require proper methodological adjustments in order to provide reliable and generalizable results.

Three overarching questions for a comprehensive evaluation of HA interventions

This paper aims at contributing to the development of strategies for economic evaluation of HA interventions, by stimulating the dissemination and systematic application of the concepts of effectiveness, cost and cost-effectiveness used in the field of health economics.

Drawing on a review of the health economic literature, integrated with extensive discussions with expert occupational therapists (OTs) employed in Swedish municipalities and ongoing research on HAs, we start out from a hypothetical situation in which an OT faces the choice between two alternative HA interventions for the same individual case, called "X" and "Y". Observing this situation carefully, according to Øvretveit (*21*), at least three overarching questions can be spelled out:

1. Will X be more effective than Y?
2. Will X be more costly than Y?
3. Will X be more cost-effective than Y?

The three preceding questions are all equally relevant when making decisions in OT practice, although answering them presents a gradient of complexity. For instance, not many OTs will be familiar with the third question, which is the most challenging to address in real-life contexts. At the very least, familiarity with the concepts underlying this question *per se*, regardless of the feasibility of sound scientific evaluations, will be beneficial for professionals operating with scarce resources. That is, the third question suggests the opportunity to increasingly monitor the actual value of the money spent on HA interventions.

Throughout the paper, we will make use of vignettes describing situations experienced by an OT (see Vignette 1, 2 and 3) and a manager working in an imaginary Swedish municipality (see Vignette 4), in order to exemplify and explain the three questions and link them to real-life OT practice. The rationale underpinning the use of vignettes is that of the "case teaching method" (22). This method, widely used in several disciplines (including medicine and business administration), relies on the use of case studies that depict real life situations that present readers with a dilemma or uncertain outcome. Thus, the aim of using vignettes is that of describing fictional scenarios (see

Vignette 1), enabling readers to identify themselves with those professionals involved (23). The cases described in the vignettes presented in this paper are based on the experience of the authors and expert OT practitioners and do not represent situations of real clients.

(Vignette 1 about here)

Before proceeding to the analysis, however, we have to remind that at least three aspects have to be clarified when crafting sound research questions in the field of evaluation science *(24)*, to guarantee what some have called the "question answerability" *(25)*:

a) *Deciding on the perspective of the evaluation*, i.e. the viewpoint of the analysis, is crucial to identify the relevant costs and outcomes. Typical perspectives used in evaluations are those of individual patients/clients, those of institutions (e.g. the Ministry of Health or Social Services, the National Health System or the municipality), those of specific service target groups, those of Government and those of society at large. The viewpoints of various stakeholders are important, because they perceive the costs and outcomes differently. For instance, if a single client decides to purchase extra hours of help for house cleaning, this is indeed a cost for the user but not for the municipality. The same distinction holds for the *outcomes* of the interventions. An intervention (e.g. a new policy) can produce outcomes with no interest for some of the stakeholders.

b) *The content of the interventions being evaluated (and compared).* Given the complexity of HA interventions, it is imperative to give an accurate description of what intervention is being evaluated, and clarify the alternative interventions being considered. For example, an evaluation could compare a HA that includes the installation of ramps in an old apartment with an alternative HA which implies the installation of a new lift. It is also possible to make comparisons with a “before” condition, i.e. the situation prior to the intervention, and (in countries where HA is not an eligible service provided by the society) comparisons can be made with a “usual care”/"no intervention" condition.

c) *The time frame.* When making a decision for a HA which might influence the rehabilitation process or the long-term living conditions of the client, the time frame under consideration should be clarified. Neither outcomes nor costs will occur at the moment of the decision, but will likely be generated throughout a prospective time frame.

Question 1. Will X be more effective than Y?

In line with Donabedian's definition (*26*), the term *outcome* refers to those consequences occurring during and after the implementation of a HA that can be attributable to the intervention itself. In a best case scenario, systematically gathered information regarding intervention outcomes is available as part of the routinely collected data. As this is often not the case and in many cases data are lacking, ad-hoc surveys or trials can be used to obtain outcome data. One of the main challenges to the evaluation of outcomes in HA interventions is represented by the fact that most of the outcomes hitherto used in HA research are multidimensional concepts, such as user satisfaction, functional status, activity, participation, and health. Measuring and evaluating these types of outcomes is more demanding compared to other types of outcomes, such as mortality and morbidity, as they often require the use of validated and (relatively more) time-consuming assessment instruments. In rehabilitation research, the International Classification of Functioning, Disability and Health (ICF) is often recommended as the overarching conceptual framework (*26*), using the activities and participation component to assess the outcomes of different types of interventions. As an example of the outcomes applied in occupational therapy research, Stein et al. (*28*) listed different types of outcomes that to a large extent could be applied to the field of HA interventions, such as ability to perform activities of daily living (ADL), satisfaction with occupational performance, independence in self-care activities, quality of life, well-being, satisfaction with current health status, internal adaptation to impairment or disability, compliance with interventions, and satisfaction with appropriateness.

When choosing the outcomes of a HA intervention, it should be noted that a restricted interpretation of outcome is likely to underestimate the impact of the intervention, while a broad interpretation can lead to the opposite result. In addition, in this field, multiple contributing variables as well as the heterogeneity of the environmental, social, and physical conditions in which clients live, can affect their situation. HAs are often used together with care services and other interventions that are likely to affect the outcomes of interest. This makes it difficult to detect and isolate the effect and directly attribute it to the HA itself through a cause-effect relationship. In statistical terms, this means that when estimating the effect of an HA intervention, one should always be able to adjust for potential "mediator" and "moderator" variables. Mediators can be defined as those "intermediate outcomes on the causal pathway" between the receipt of HA and final outcomes, being moderators those baseline characteristics that influence the effect of HA on intermediate or final outcomes (29).

Regarding the link between measurement of outcomes and economic evaluation, it is useful to become familiar with the distinction between two broad categories of outcome measures (*24*), namely those expressed in "natural units" and those expressed in terms of quality of life (QoL) or health-related quality of life (HRQoL) (see Table 1). The relevance of this distinction will be clear when calculating cost-effectiveness and cost-utility ratios.

The effects of an intervention can be expressed in "natural units" when outcomes are clinical in nature and unidimensional, for instance, the quantity of lives saved or life-years gained. Outcomes measured in natural units in the context of HA interventions could be the reduction of home help services use, the number of hospitalizations, or number of falls. Alternatively, outcomes can be expressed in QoL or HRQoL changes. QoL is a multidimensional concept used to refer to an individual's total wellbeing, including emotional, social, and physical aspects of the his/her life, while in medicine the concept HRQoL refers to how individual wellbeing is impacted by a disease, disability, or disorder, is more common. Using QoL can be a good solution when we aspire to

compare programs that have different primary outcomes or when there is more than one relevant outcome dimension (*24*). In these cases, assessment instruments can be either generic (i.e. measuring HRQoL in the general population), condition-specific (estimating HRQoL in specific diagnosis groups), or situation-specific (measuring HRQoL of individuals in specific settings) (*30*). Generic HRQoL instruments are, for instance, the EQ-5D (*31*), while an example of a condition-specific instrument is the MSQOL-54 (*32*), designed to assess quality of life in patients with Multiple Sclerosis. HRQoL-type instruments constitute the basis for the measurement of Quality-Adjusted Life Years (QALYs), a measure used to assess the impact of health interventions, but as yet not common in HA research. This measure combines the number of life-years yielded by an intervention and the HRQoL of those years. The reason why the effect of an intervention needs to be corrected in this way is that some interventions might indeed help people to live longer, but might also have serious side-effects or at the very least not improve someone's living conditions. Therefore, the underlying assumptions of this measure are that a year lived in perfect health is equal to one QALY, whereas a year lived in a less than perfect health is worth less. The scores obtained by HRQoL instruments are therefore being used as "weights" in order to calculate the QALYs, which identifies the number of life years spent in good health by the individuals that receive an intervention.

(Table 1 about here)

In order to increase the evaluation of outcomes in HA interventions, professionals must increase their familiarity with the assessment procedure, that is, the process of collecting relevant data that can be measured, scored and interpreted according to standardized criteria (*33*). In this respect, using validated instruments for assessment with guaranteed reliability and validity is a necessary prerequisite for experimental investigation of clinical intervention outcomes (*34*) In this regard, there is room for considerable improvement: according to a recent study on 1,679 Swedish OTs less than half of them use structured assessments or evidence-based methods, and rarely follow-ups are undertaken. (13). At first glance, QoL and HRQoL-related measures might appear difficult to apply,

but there is a wide variety of instruments that can be tested and which provide fundamental information regarding clients' living conditions (see Vignettes 2).

(Vignette 2 about here)

Question 2. Will X be more costly than Y?

A *Cost-analysis* is an activity common to all forms of economic analysis, aimed at measuring the flow of resources in a productive process (*24*). A cost-analysis could also include the comparison of two existing alternatives, in this case realizing a so-called *cost-comparison* or *comparative cost-analysis*. In the case of HAs, a detailed analysis should include all of those costs related to the implementation of the intervention(s).

Each phase of HA interventions requires specific inputs, also called "resources", such as human labor and the equipment installed (e.g. ramps, grab bars, shower boxes, etc.). Resources typically required in this field are "labor" i.e. the working time spent by individuals contributing to the production process) and "capital" i.e. commodities and equipments used in the production process. By assigning a monetary value to these resources it is possible to calculate the "*cost of production*". It is important to stress that "*cost*" is an economic concept, not a financial one. It refers exclusively to the use of specific resources during the intervention, which has to be subsequently valued in monetary terms according to specified assumptions. That is, cost does not consider only the actual expenditures (*20*), but can be identified even if no financial transaction occurs. An obvious example is the assistance provided free of charge by informal carers, which does not represent an expense for the care recipient but is in fact a cost in terms of resource use.

Although some professionals might consider cost-analysis too complex or too demanding, simple and small-scale evaluations could be routinely carried out by people involved in HA interventions, with little effort. The most important practical issues to be resolved relate to: a) the method to identify resource use and costs; b) the estimation of costs of market and non-market items; c) the cost discounting.

Methods to identify resource use and costs. There is no a single scheme to collect and measure cost data. Possible solutions entail the use of "resource use questionnaires", "client diaries" and "case notes". These methods aim at identifying and collecting the so-called "direct costs", that is, those costs that can directly be attributed to the implementation of the intervention. Resource use questionnaires can be very comprehensive and may be tailored by the professional carrying out the evaluation. Limitations are that they rely on clients' recall, they are often perceived as a burden by clients and professionals, and can only retrospectively capture the use of resources made by the intervention. Client diaries can also be used prospectively during the evaluation, as an alternative to or in combination with resource use questionnaires. However, they rely exclusively on active client participation during a set period of time, which sometimes can result in incomplete data. Finally, case notes can be compiled by the professionals implementing the intervention, removing the client burden. Case notes rely on good legibility and completion, and often require access to many sets of records. That is, they come with a substantial data collection burden for professionals and researchers.

In HA interventions, the resources used are mainly those related to the staff employed in activities such as needs assessment, and to the products and goods installed in the dwellings. In addition to these costs, however, there are the so-called *indirect costs*, also known as overhead, that are not directly attributable to a cost object, such as the costs for administration and security, and the cost of heating and maintenance of office buildings. While carrying out a cost-analysis, the evaluator has to choose which method to use in order to associate a reasonable quota of indirect costs to each HA. There are different solutions, the so-called allocation methods, although it is not possible to find one best way which can fit every situation (*24*). A detailed description of such techniques goes beyond the scope of this paper, but a possibility to allocate overheads of a municipal office to the single HA case could be to simply divide these costs equally by the number of HA cases realized in a certain period of time. Another choice, allowing a more precise weighting

of costs, could be to allocate the hours of personnel directly associated with single clients. Again, no best way can be determined in advance. Different options should be tested and results compared. In situations where the provision of an additional intervention is not expected to significantly increase the indirect costs within the organization, some authors consider also the solution of ignoring the indirect costs as acceptable (24).

Estimating the costs of market and non-market items. The aforementioned data collection methods usually gather information on the use of resources, in terms of the number of staff hours, and goods and services. Through the so-called costing activity, in a subsequent step the evaluators need to convert the costs collected by assigning to each resource consumed a proper monetary price. For instance, the hours of staff employed are usually converted using current salary levels and the cost of consumables are valued using an average purchase price. Especially when a broad societal perspective is used to evaluate an intervention, non-market items (such as family caregiving) does represent a cost, even if they do not have an official price. In such cases, caregivers' assistance can be considered as an "opportunity cost", as the hours devoted to caregiving could instead have been used in the formal labor market, thus generating income. A common choice made to estimate this type of cost is to use the market value of unskilled labor. Some authors prefer to use the half price of unskilled labor or the value of the caregivers' working hours if they are still in the workforce or have to reduce their working hours as a consequence of caregiving.

Discounting the costs. An additional issue to consider is that of time. It is intuitive that if we are offered to choose between receiving € 100 today or € 100 in two years, we would immediately accept the sum. However, if we have to choose between € 100 today and € 112 in two years, the choice would become somewhat troublesome. That is, inflation and interest rates have to be considered, because it is clear that identical monetary sums do not have the same real value at different points of time. For this reason, since the costs of a HA intervention are likely to be

incurred at different times (e.g. during a five-year evaluation period), all the cost values have to be "discounted" choosing the most appropriate and feasible method (*24*). Likewise, in more complex evaluations, the outcomes have to be discounted following the same methods chosen for the cost.

Even if the cost analysis represents the basic and preliminary step of all economic evaluation, methodological choices are often discretionary and the level of precision in costing can differ widely (*24*). As different assumptions can dramatically change the results of the evaluation, the solutions chosen must always be clearly stated and justified at the beginning. When making such choices, one must also consider that the generalisability of the results will be influenced by unavoidable differences existing between the contexts where evaluations take place, for example between countries. A sound costing assessment should always include a so-called "*sensitivity analysis"*, reporting how results are likely to vary when some of the assumptions change (e.g. when an extra category of cost is taken into account, the discounting rates or the indirect cost calculation methods change).

As yet, adequate tools for capturing cost in HA intervention research have not been identified. One example that can provide inspiration is the "*Siva Cost Assessment Instrument*" (SCAI), designed by Andrich and colleagues (*35*) to help clinicians estimate the economic aspects of providing Assistive Technology (AT) solutions to individual users. The use of the SCAI involves the compilation of a cost calculation table for each AT solution. Such a table estimates the incremental cost associated with a chosen AT solution over a certain period of time, including four cost categories: "investment" (cost of purchasing the AT, having it installed and personalised, including adequate training), "maintenance" (cost of technical maintenance), "services use" (cost of services that may be needed, e.g. a special minibus instead of a cheaper ordinary bus); "assistance" (the amount of human assistance needed in relation to the device, independently of whether it is paid for or provided for free by relatives or volunteers). Simpler tools can be directly designed and used by OTs in HA interventions, considering, for instance, as a starting point the categories

identified by a cost-analysis of Jutkowicz and colleagues (*18*). These categories are included in Table 2, demonstrating a simple cost-analysis related to the interventions identified in the two fictional cases discussed in the vignettes.

(Table 2 and Vignette 3 about here)

Question 3. Will X be more cost-effective than Y?

When an OT has to choose between the two interventions, X and Y, this choice is self-evident in two cases. When Y is less expensive and more effective than X (Y is "dominant") or when it is more expensive but less effective (in this case X is "dominant"). In the other cases, when Y is both more expensive and more effective or less expensive and less effective, only proper assessment of both outcomes and costs can lead to evidence-based decisions. What is needed, are those type of analyses that according to Drummond's (*24*) classification are called "complete economic evaluations".

- A *cost-benefit analysis* (CBA) includes, whether explicitly or implicitly, a comparison between the total expected costs against the total expected benefits of one or more actions, in order to choose the best or most profitable option. This means that in a CBA the benefits need to be valued in monetary terms by choosing reasonable "prices". The results of a CBA might be a ratio of costs in Euros to benefits, also in Euros, or even a simple sum, possibly negative, representing the net benefit (or loss) of one intervention over another (NEB = Net Economic Benefit).
- A *cost-effectiveness analysis* (CEA) is a form of economic analysis that compares the relative costs and outcomes of two or more alternatives. In CEA, benefits are expressed in natural units of outcome, for instance, by lives saved or the number of life years obtained. It is thus possible to say that CEA is a special type of CBA that assigns a monetary value to a single measure of effect.

- A *cost-utility analysis* (CUA) aims at estimating the ratio between the cost of an intervention and the benefit it produces in terms of the number of QALYs. As the natural units used by CEA ignored QoL or HRQoL, CEA evolved into CUA, allowing for a weighting of the intervention outcomes by an index of QoL or HRQoL.

The results of a CEA and CUA might be the simple ratios between the costs and the benefits, i.e. the so-called Cost-Effectiveness ratio of the intervention and the cost of a QALY. When two alternative interventions are compared, it is possible to obtain an indicator called the "*incremental cost-effectiveness ratio*" (ICER) from CEA/CUA. The ICER (or ICUR, when using data from a CUA) expresses the ratio of the change in costs to incremental benefits of an intervention or treatment. If we again consider the two hypothetical interventions "X" and "Y", the equation for the ICER is:

$$ICER = \frac{C_Y - C_X}{E_Y - E_X}$$

where C_Y and C_X are the Cost of Y and X respectively, while E_Y and E_X are their effects in terms of outcomes (which can be either expressed in natural units or in QALYs).

A useful tool to comprehend the concept of cost-effectiveness is the "cost-effectiveness plane", developed by Black et al (*36*) (see Figure 1). The plane shows the possible situations that a single professional or a policy-maker could face when comparing two alternative interventions. The differences between the effectiveness (x-axis) and the costs (y-axis) of the two interventions are plotted. The intervention X (chosen as a reference) is thus located on the intercept of the axes. As already mentioned, if the costs of Y are higher than those of X, while its effects are lower the choice will clearly show X as "dominant". Likewise, if the new intervention Y is more effective and less costly then X, there is no need to go further into the analysis. There are controversial cases when the new intervention is both more costly and more effective, or both cheaper but less effective. In such cases, the respective ICERs need to be calculated and a critical appraisal of the results should be made. Such an appraisal should also entail ethical, political and economic aspects.

(Figure 2 about here)

Currently, when the UK National Institute for Health and Clinical Excellence (NICE) is evaluating the introduction of new treatments into the National Health System, it considers interventions with ICERs below £20,000 per QALY as cost effective, although all those with ICERs up to around £30,000 merit consideration (*37*).

CBA, CEA and CUA analyses can appear rather complex in nature and difficult to realize outside of a controlled experimental context. However, in vignette 4 and table 3, by means of a naive application of the principles of cost-effectiveness analysis we exemplify a clinical setting application.

A complete cost-effectiveness analysis should be based on data from primary trials, which are feasible only in contexts where testing the outcomes of HA interventions in an experiment is ethically acceptable. This is not the case in those countries where HA do not constitute part of what is routinely offered. In the absence of such conditions, alternative model-based evaluations can be developed to inform professionals and policy-makers. These models can be determined by considering the relationship between the input data (e.g. epidemiological, effectiveness, and costs data) and the resultant information output required by the stakeholders (e.g., number of outcomes, and summary of cost-effectiveness). Brennan et al. (*38*) provided a taxonomy of structures for use in model-based evaluations, covering a) decision trees, b) Markov models, c) cohort models, d) individual level modeling methods; e) methods covering both discrete and continuous time modeling. Despite many caveats on the reliability of this type of evaluation (*39*), in contexts where primary data collection is neither available nor feasible, modeling methods could represent the best way to inform the choices concerning new policies and public strategies.

(Table 3 and Vignette 4 about here)

Future challenges for HA intervention research

During the last decade, the attention of researchers in the field mostly focused on the identification of users needs and preferences, on the definition of a taxonomy of HA interventions, the

identification of environmental risk factors for negative outcomes, and on the evaluation of the effectiveness of home-based interventions (*40*). New directions for research and practice were identified for the development of new measurement tools, the advancement of a theoretical framework in order to better link competencies and characteristics of the users with intervention outcomes, the enhancement of the understanding of person-environment relationships. With this paper, we suggest an additional direction for future studies, that is the progressive integration of HA research with economic evaluations. We also provide a basic description of strategies for economic evaluation that could serve as an inspiration for OTs and researchers involved in HA interventions.

By increasing the familiarity of these professionals and researchers with the concepts of effectiveness, cost and cost-effectiveness as used within health economics, this paper contributes to the development of strategies for more comprehensive evaluation of HAs.

Indeed, the complexity of HA interventions should not be seen as an insurmountable barrier. As mentioned, generally in social services and health care research, interventions tend to be quite complex and there are many aspects that interact in a dynamic way within multi-component interventions (*41*). In these interventions, it is challenging to comprehend and isolate the effects of single programmes (*20*), but HA intervention research can profit from the experiences generated in related fields, such as medicine and nursing (*42*).

Several factors can contribute to the progressive introduction of evaluation procedures in HA research. These include, for example, the increase in the availability of experimental studies (*12*) and the improvement of quality of study reporting, which reflects the recommendations of international statements, such as CREDECI (*42*) and CONSORT (*43*). Likewise, the awareness about the relevance of costs among professionals of the public services, as well as the update of OT curricula at the graduate and post-graduate level can contribute to this goal.

With this paper, we intend to show that, although evaluations do have a cost in terms of resource consumption, they can give professionals an opportunity to improve their services and to advocate for the value of their work. While we made an attempt to describe concepts that are rather

complex in nature, and the vignettes presented might appear a bit naïve, we wish that professionals, managers, and policy-makers would critically reflect on the existing evaluation systems. Since professionals often are burdened by a heavy work load, the contribution of researchers could provide an important stimulus to review work processes and set up new evaluation strategies. Joint working groups that include researchers as well as professionals have already been identified as a way to increase the use of evaluation and research findings in clinical practice (*23*), and might be useful also to introduce economical evaluation in the field of HA intervention research. To the best of our knowledge, Jutkowitz and colleagues (*18*) were the first to provide a cost-effectiveness analysis of a HM intervention program. Their work confirms the relevance of investing in studies in this field and suggests the need for further evaluation efforts. What clearly emerges is the extent to which differences among countries, both in terms of welfare system organization and cost of living, are likely to affect results and the generalisability of the results from such evaluations. Since the cost of labor and other consumables dramatically differ among countries, the parameters used by Jutkowitz et al (*18*) are far from being applicable to other nations. For instance, they estimated the cost of OTs using a per-hour rate of $26 (roughly 173 SEK), and the average cost of a HM intervention equal to $439 (roughly 2,937 SEK). In addition, their study was based on a RCT comparing intervention cases to controls, i.e. older people not receiving HMs. As already mentioned, such a trial could never be approved by ethical committees in countries where HAs are offered to citizens as a public service governed by national legislation, since it would be illegal to deny a HA intervention to people in need. This increases the relevance of economic modeling methods in order to better understand the impact of HA policies (recently, an initial attempt in this direction has been made by Slaug and colleagues (44), and speaks to the importance of cross-national joint efforts in the field of HA intervention research. In addition to the benefits of knowledge transfer between countries with varying levels of HA provision systems, experimental studies investigating different types and complexity of interventions could also be performed.

In conclusion, this paper should be read in the light of the recent European Commission decision to set the target of a two-year Healthy Life Expectancy increase of the Europeans as a cornerstone of the EU policies. This decision will lead to new considerations in the area of health improvement strategies, implying that the EU member states have to reconsider the balance between investments in life-saving interventions and preventive/rehabilitative measures (*45*). This consideration stresses the importance of investing in economic evaluations of HAs. In times of harsh economic constraints, such evaluations hold the potential to support or discourage future investments in this intervention area.

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Figure 1. The cost-effectiveness plane to compare interventions (Black et al 1990).

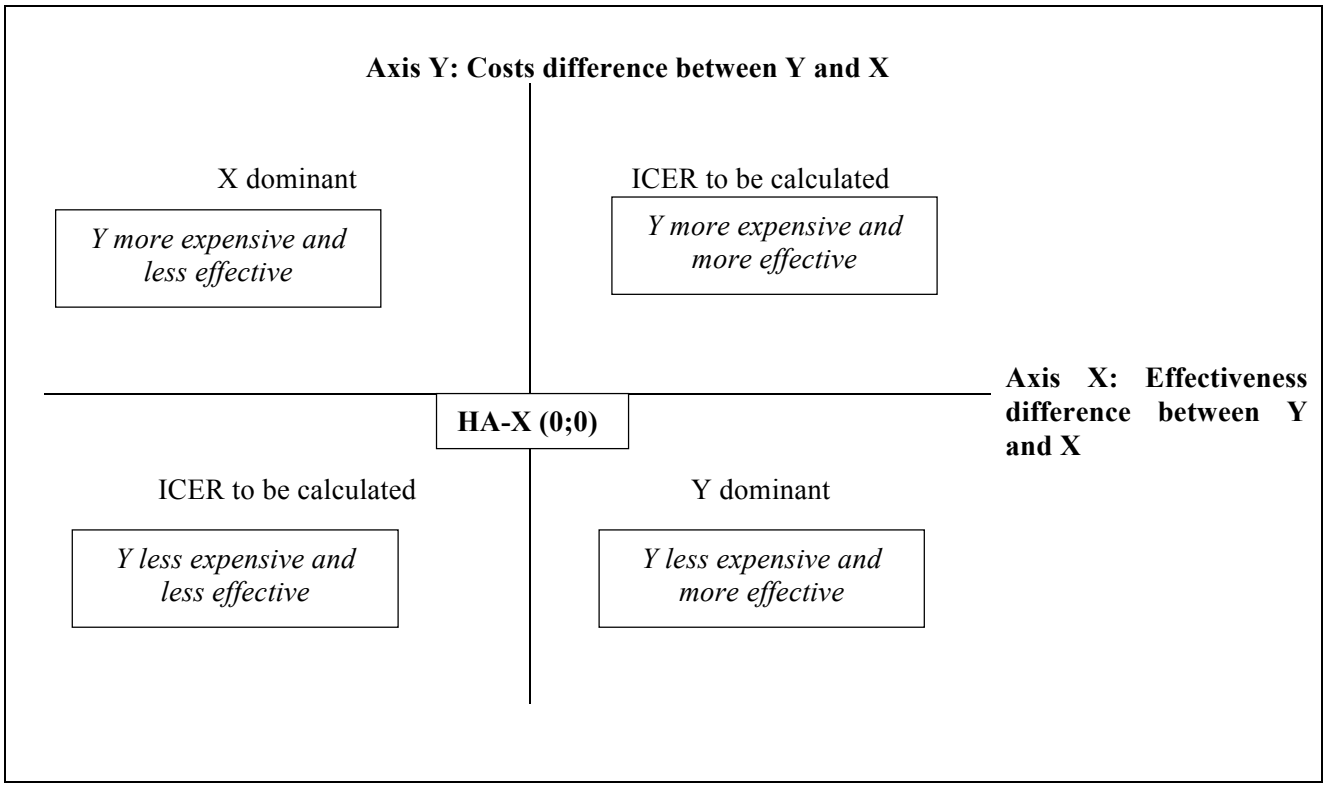

Table 1. The identification and measurement of outcome.

Type of outcome	Example of variables/instruments[1]
Natural units	
• Survival	• Survival time
• Independence in ADL and IADL	• ADL Staircase (Hulter-Åsberg & Sonn, 1988)
• Accessibility, usability	• Housing Enabler (Iwarsson & Slaug, 2010) • Usability in My Home (Fänge & Iwarsson, 1999)
• Service use	• Institutionalization • Use of home help and care services • Repeated HAs
QoL & HRQoL	
• Generic	• EQ-5D (EuroQol Group, 1990) • Quality of Well-Being scale (QWB) (Kaplan and Anderson, 1996)
• Condition-specific	• MSQOL-54 (for Multiple Sclerosis) (Rothwell, 1998)
• Situation-specific	• Trial-specific modules and checklists

[1] To be selected in accordance with the therapeutic goals, i.e. preventive, rehabilitative, long-term care.

Table 2. The identification and measurement of HA costs. A prototype of a Resource Use Table for HA.

Cost category	"Routine HA" (older client in Vignette 1)		"Complex HA" (woman with MS in Vignette 1)	
	Units	**Cost in SEK**	**Units**	**Cost in SEK**
DIRECT COSTS				
Staff costs				
• OT time for contact and assessment of client (including home visit)	1.5	*508.62*	3	*1,017.23*
• OT time for grant preparation*	1	*339.08*	2	*678.15*
• OT time for training of the client	0	-	1	*339.08*
• OT time for follow up	0.5	*169.54*	0.5	*169.54*
Other staff				
• Architect time	0	-	1	*700.00*
Travels				
• Lump reimbursement	2	*100.00*	3	*150.00*
HA grant	--	*35,000.00*	--	*88,000.00*
Other direct cost				
• Consumables		*200.00*		*300.00*
INDIRECT COSTS	n.a.**	n.a.	n.a.	n.a.
Total case cost in SEK	**--**	**36,317.23**	**--**	**391,354.00**
in Euro		*4,235.46*		*45,641.27*

Data used in the case study are fictional; * The time for grant preparation refers to the time invested in supporting the client in compiling all the forms and documents required for the final HA grant; **n.a.: Not applied;.

Table 3. Results of a naive "complete economic analysis" of 36 HA interventions.

Housing Adaptation	N	Days free of institutionalization in the last 3 years	Mean value of outcome per client	Total cost	Mean cost per client
No HA	6	5,520	920	0 kr	0 kr
Routine HA	10	9,750	975	254,221 kr	25,422 kr
Complex HA	5	5,175	1035	1,174,062 kr	234,812 kr

Housing Adaptation	n	Difference in mean outcomes Vs. no HA	Difference in mean costs Vs. no HA	Difference in mean outcomes Vs. routine HA	Difference in mean costs Vs. routine HA
No HA	6	-	-		
Routine HA	10	55	25,422 kr		
Complex HA	5	115	234,812 kr	60	209,390 kr

Type of ICER (for an additional day free of institutionalization of the client)	**ICER in SEK**	**ICER in €**
· ICER Routine HA vs. no HA	462 kr	€ 53.91
· ICER Complex HA vs. no HA	2,042 kr	€ 238.13
· ICER Complex HA vs. Routine HA	3,490 kr	€ 407.00

Type of ICER (for an additional year free of institutionalization of the client)	**ICER in SEK**	**ICER in €**
· ICER Routine HA vs. no HA	168.710 kr	€ 19.,675.64
· ICER Complex HA vs. on HA	745.274 kr	€ 86.,916.85
· ICER Complex HA vs. Routine HA	1.,273.791 kr	€ 148.,554.63

Data used in the case study are fictional.

Vignette 1. The three overarching questions and the daily routine of the occupational therapist.

During the same week Kristina (K.), an OT working in a Swedish municipality, made first-time home visits to two clients that had been referred to her by their home care staff.

The first client was a man aged 82, living alone in a private house where he had lived for >40 years. Some years ago, he was diagnosed with type II diabetes, and neuropathy that affects his balance. Recently discharged after a hip replacement caused by a severe hip fracture, he was now dependent on a rollator (wheeled walker) for mobility, and he had been granted home service for some assistance in self-maintenance (showering), cleaning and cooking. Actually, after the death of his wife a couple of years ago, he had hardly engaged in any cooking of his own. Instead, he had gone to a day centre nearby to have his daily main meal. His only son and his son's wife lived 30 min away by car, but since they both worked full-time, they did not have much time to support him daily. The house had a hygiene room furnished in the 1960s, with a bathtub and a washbasin with a cupboard underneath. In addition, the kitchen dated back to the early 1960s, with old-fashioned hardware but was well maintained. At the entrance, there was a flight of stairs with six steps, with no handrails and without any weather protection.

The second client was a woman aged 52, diagnosed with Multiple Sclerosis (MS) three years ago. She was married and lived with her husband and a daughter in her late teens. Until now this client had been working full time, but due to increasing tiredness, she considered reducing her work time to 75%. Her husband worked full-time in a job that required much travelling, and he spent at least five nights per month away from home. The client enjoyed cooking and baking, and was very proud of her nice home. However, now and then she had started to feel that her balance and endurance were not sufficient to allow for longer periods of heavier cleaning or cooking while standing, and she felt frustrated when her activity performance became compromised. Increasingly, the client sometimes felt unsure when walking, in particular in the entrance staircase and during the short walk required to reach her car, usually parked in front of her house. Recently, she had received two hours of home care services, mainly for cleaning. The family lived in an old private house that had undergone some renovation, but would not be considered high standard. Actually, besides a more modern kitchen, this house was essentially similar to that described for the first client.

Making an assessment of the functional status of the two clients, despite the quite different diagnoses K. concluded that they displayed similar profiles of functional limitations. Regarding environmental barriers in the home and its close surroundings, the two houses were also equal. That is, both clients faced accessibility problems mainly at the entrance to the house and in the hygiene room. Also, there were accessibility problems in the kitchen, since they would both benefit from cupboards with expandable interiors and the possibility to arrange a work-place suitable for sitting. The major differences between the two clients were in their life situations and activity repertoires. Also, their diagnoses had quite different implications in a long-term perspective, not the least considering that MS is a chronic, progressive disease.

Subsequently, based on the different life situations and diagnoses of the two clients, K. decided to go for quite different approaches to the two HA cases. For the first client (man, aged 82) she planned to suggest a HA somewhat limited in scope, in order to support his safety, activity and participation in walking and moving in and out of the house, and in hygiene. For the second client (woman, aged 52), given the fact that she was in an early phase of a chronic, progressive disease, K. would suggest a more comprehensive HA. This case would include not only measures to make transfer in and out of the house and personal hygiene safe and independent, it would also entail a large-scale refurbishment of the kitchen.

Vignette 2. Identifying and measuring the outcomes.

After completing the two home visits, K.'s task was to design the most suitable intervention to address the two clients' needs.
In both cases, an important outcome is reducing the client's dependence on assistance from others in daily life activities. Monitoring the achievement of this outcome can be done by operationally translating the same outcome into several variables of interest that can be measured prospectively after the intervention. Examples are the ability to perform daily life activities (self-reported or, preferably, assessed by an observer), the use of home help services (in hours or cost), the use of informal care (in hours).

Avoiding institutionalization of the two clients can also be considered an outcome, even if in the short-term, the older client is exposed to a higher risk compared to the 52-year woman. This outcome can be measured using "days to institutionalization" as an outcome variable, as "days free of institutionalization" (no. of days of the year – no. of days spent in an assisted living facility), or even using a dichotomous variable such as "institutionalized / not institutionalized".

Last, but not least, improving the client's quality of life can also be seen as an important outcome of a HA intervention. However, the measurement of this outcome has to be made differently. In the first case, K. can use a generic instrument such as the EQ-5D, while in the second case she needs to use a condition-specific tool, e.g. the MSQOL-54. That is, a generic instrument would not be useful in this second case, as it would lack responsiveness to clinically significant changes in HRQoL among people with MS.

After the identification of these outcomes, K. decided to follow the two clients over the next four years. She will systematically review data from official records to retrieve information on their use of other social and health services, the number of Emergency Department admission and hospitalizations. With the help of an OT student, every 12 months she will assess the conditions of the two clients using a questionnaire that includes validated instruments to measure ADL dependence and HRQoL. In addition, she will retrieve data on the amount of informal help received by the clients.

Vignette 3. Identifying and measuring the costs of the HA intervention.

The two cases and HA interventions described in Vignette 1 have major differences, not only from practical and ethical perspectives but also in terms of costs. In both cases, K. followed alternative approaches to the intervention. She had the option to consider a more restricted HA ("routine HA") or a more comprehensive one ("complex HA"). K. tried to identify the major costs associated with the alternative HA under consideration. She decided to use the point of view of the municipality as the perspective of the evaluation, and to limit the analysis of cost to the first year (see table 2). In terms of *indirect costs*, they did not differ much based on the comprehensiveness of the suggested HAs. The organizational structure for HA case management is well established in the municipality, and the costs for staff (salaries, education and training, etc.), office space and equipment, administration, grant management, etc. are not affected by the comprehensiveness of a single HA case. In contrast, the *direct costs* differed depending on the characteristics of the individual intervention and on the final choice regarding the complexity of the HA implemented.

Considering the first situation (man, aged 82), such cases are routine in many municipalities in Sweden, and common in the OT case load. That is, many older clients prefer to stay in their homes where they have lived for many years, and do not desire to be offered any expensive or fancy solutions. Many of them prefer simple arrangements that do not require much change in their daily routines and in their home. Thus, the first case could be solved without much consultation time. Actually, if the older man would not have had neuropathy problems, with a documented anamnesis of increasing difficulty, and perceived risk, when walking up the stairs at the entrance and when using the bathtub, it might even have been possible to solve his problems by means of assistive devices, at least during a limited period to monitor functional recovery after the hip fracture. However, in the current situation, K. decided to suggest a routine HA. After her first home visit, another short visit together with a craftsman was sufficient to come up with the technical solutions for installation of a ramp at the entrance, removal of a few thresholds, and the arrangement of a shower stall instead of the bathtub. In addition to writing the certificate of needs required for the HA grant application, K. needed to spend some time supporting the client in the application procedure. In order to identify the cost of her time, using a special form that she had developed, K. systematically recorded the number of hours that she actually spent working on the case. She then asked the Personnel Office to get a specification of the cost of a single working hour, and she was able to value her working time by simple multiplication. She also considered the cost of traveling to and from the client's home, both in terms of travel time, as well as the use of transportation, e.g. bus or taxi, in the analysis. The other remaining direct cost that she considered was the actual HA grant given to the client. The grant value could be considered as a satisfactory measure of cost from the municipality perspective.

The second case (woman, aged 52) was considerably more resource intensive. This client’s life was more complex, involving a family and the jobs of two adults, and a future characterized by the challenges of living with a chronic, progressive disease. Consequently, in order to get an accurate picture of the situation, K. needed to visit the client and her family more than once. She also had to consult with other health care professionals, concerning the prognosis of the disease and the disablement process over the years to come. After this intensive period of consultations with different people, K. decided that she would suggest a complex HA to the client. Since the house was quite old, the family wanted to take advantage of making some additional renovations, not primarily induced by the need for HA. In this case, the kitchen as well as the hygiene room and the entrance, including space for transfer between a wheelchair and the chair, needed to be considered. For a complex case like this, the HA grant would cover the costs directly related to the client’s specific needs, while costs defined as general renovation must be financed by other means (e.g. a bank loan). The planning as such required a building permit, therefore an architect was engaged. The planning process was complex and demanding, and the client and her family were prepared to invest time and effort in putting the HA grant application together. K followed the planning and participated actively in order to see that the solutions suggested met the needs of the client – not only in the short term but also in a long-term perspective, taking the progressive character of the disease into account. Also in this case, the measurement of direct costs followed the standard procedure, as described above. That is, K. recorded the amount of time working on the case, the travel costs and, at the end, the amount of the HA grant given.

Vignette 4. Cost-Effectiveness and Cost-Utility Ratios and ICER. Naive examples and calculations.

Tanja (T.) is the director of the City Planning Office of a Swedish municipality. The management of the HA interventions in the town was strongly criticized by the politicians of the opposition. This suggested to her to create a new evaluation system of the work of the office, in order to ensure more transparency and accountability on how municipal resources were actually spent.

She issued new guidelines for the OTs working in the municipality, including new forms for collecting data regarding client characteristics (level of dependence in daily activities, socioeconomic status, health, etc.), intervention outcomes, and costs. She succeeded in ensuring regular yearly follow-ups of new (incident) HA clients of the City Planning Office.

After three years, the City Planning Office collected a set of data useful for a comprehensive report to the Board of Urban Planning and other stakeholders (political parties, group of citizens, etc.) (see table 3). To get better insight into the effectiveness of HAs, T identified a subgroup of 21 OT clients in the Municipality. They were comparable regarding baseline physical and cognitive functioning, age, health status and environmental barriers in the housing environment. Based on their different situations and personal preferences, such as diagnoses, structure of the house, involvement of other family members, preference of the landlords, 6 of the clients received no HA intervention, 10 had a routine HA, and 5 of them received a complex HA intervention.

Obviously, the HA costs for the three groups were different, but what T. was interested in understanding was the value of the money spent. This is why she realized what she considered a "complete economic evaluation" of the 21 cases. Using the number of days free of institutionalization in the last 3 years as a main outcome, her analysis suggested that those receiving a more complex intervention had the possibility to live in the community longer (on average 975 and 1,035 days for those with a routine and a complex intervention respectively). The ICER for a day of life spent in the community was SEK 462 per day (about € 53) for the routine intervention and much higher (SEK 2,042) for the complex one (about € 238), when using the "no intervention" group for comparison.

When T. compared the ICER of a complex to a routine HA intervention, she realized that the difference in outcome between the two groups was not sufficiently large to justify the use of public resources. The cost of an extra year lived in the community for individuals receiving a complex intervention was SEK 1.2 million (around € 148,500) when using those individuals receiving routine interventions as a reference category. At this cost, the OTs perhaps should start considering providing alternative services such as home visits, home help services or meals-on-wheels, to their clients in order to ensure a better cost-outcomes ratio..