Improving the Cost-Effectiveness of a Healthcare System for Depressive Disorders by Implementing Telemedicine: A Health Economic Modeling Study

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Objectives: *Depressive disorders are significant causes of disease burden and are associated with substantial economic costs. It is therefore important to design a healthcare system that can effectively manage depression at sustainable costs. This article computes the benefit-to-cost ratio of the current Dutch healthcare system for depression, and investigates whether offering more online preventive interventions improves the cost-effectiveness overall.* **Methods:** *A health economic (Markov) model was used to synthesize clinical and economic evidence and to compute population-level costs and effects of interventions. The model compared a base case scenario without preventive telemedicine and alternative scenarios with preventive telemedicine. The central outcome was the benefit-to-cost ratio, also known as return-on-investment (ROI).* **Results:** *In terms of ROI, a healthcare system with preventive telemedicine for depressive disorders offers better value for money than a healthcare system without Internet-based prevention. Overall, the ROI increases from €1.45 ($1.72) in the base case scenario to €1.76 ($2.09) in the alternative scenario in which preventive telemedicine is offered. In a scenario in which the costs of offering preventive telemedicine are balanced by reducing the expenditures for curative interventions, ROI increases to €1.77 ($2.10), while keeping the healthcare budget constant.* **Conclusions:** *For a healthcare system for depressive disorders to remain economically sustainable, its cost-benefit ratio needs to be improved. Offering preventive telemedicine at a large scale is likely to introduce such an improvement.* (Am J Geriatr Psychiatry 2013; ■:■−■)

Key Words: Cost-benefit analysis, depressive disorder, e-health, prevention, health economic modeling

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Depression is the single leading cause of nonfatal disease burden[1–3] and has substantial economic consequences.[4–7] Reducing the disease burden due to depressive disorders at affordable costs is therefore of great significance to public health.

Cushioning the adverse effects of depression requires a healthcare system well equipped to manage the disorder. To that end, the interventions for depression that are offered need to be acceptable to both healthcare users and healthcare providers. In addition, the interventions must be effective in generating the required health gains and be economically sustainable over time. It is difficult to identify which particular combination of interventions will meet all these criteria within the extensive range of available options that are offered in multiple formats to different target groups.

The task of identifying an "optimal" healthcare system becomes even more daunting when the acceptability and cost-effectiveness of a newly designed healthcare system have to be compared with the cost-effectiveness of the current healthcare system. In particular, we need to know how a (hypothetical) healthcare system based on widespread implementation of preventive telemedicine would compare with the current healthcare regimen without preventive telemedicine. Would such a healthcare system produce larger health gains? In addition, how would the new system compare with the current healthcare regimen in terms of its benefit-to-cost ratio?

To facilitate decision making, we developed a health economic simulation model for depression called DEPMOD. This model assesses the population-level cost-benefit ratio of an alternative healthcare system relative to the current one. Although availability of data prompted us to apply DEPMOD to the population aged 18–65 years, we expect that DEPMOD is also relevant to older populations. This is especially true because the older population has an elevated risk for depression,[8] and the evidence suggests an increased risk of additional adverse outcomes for older people with depression.[9] The older population might be under pressure to be economically productive, even beyond the current age of retirement, due to the present-day economic downturn in "graying" societies. At the same time, increased life expectancy, common in high-income countries, is associated with an increase in the number of depressed older people. In sum, graying societies, increased demand for mental healthcare, rising healthcare expenditure, and dwindling labor forces for mental health underscore the importance of the healthcare system being reassessed and geared toward offering more cost-effective interventions. Implementing interventions that can be offered over the Internet seems to be a promising approach because these interventions are likely to be scalable, effective, and cost-effective. DEPMOD simulates the possible consequences of offering Internet interventions for major depression.

Experience with the Australian Assessing Cost-Effectiveness models for heart disease, mental disorders, and prevention[10–12] and the WHO-CHOICE models (Choosing Interventions That Are Cost-Effective)[13,14] indicates that health economic models may have value for policy making. DEPMOD was specifically designed for the Dutch healthcare system, using Dutch population-based cohort data on depressive disorder[15] and standard cost prices pertinent to the Dutch healthcare system.[16] It also models the impact of several preventive e-health interventions that were recently developed, evaluated, and disseminated in The Netherlands. However, DEPMOD can be used for other countries and populations, provided that data requirements are met.

The aim of the current article was to briefly describe DEPMOD and then apply DEPMOD by modeling the current package of healthcare interventions and an extended package in which preventive telemedicine is added. The goal was to address the question of whether preventive telemedicine offers good value for money.

We define telemedicine (e-health) as psychological self-help interventions that are delivered over the Internet, either with or without minimal therapist support. Meta-analyses of randomized trials have demonstrated the effectiveness of both prevention of depressive disorder[17,18] and (preventive) e-health interventions.[19,20] In addition, telemedicine is very scalable because of the widespread usage of the Internet. It should be noted that older people are the fastest growing group of new Internet users, and one of the main reasons older individuals use the Internet is because they are seeking answers to health questions. By implication, there is a good match between older people's Internet usage and e-mental health. Although not explicitly modeled here, evidence suggests that depression prevention is also effective in

the older population.[21] The goal of the current article was to synthesize the relevant clinical and economic evidence in a health economic modeling study.

METHODS

Comparing Scenarios: Usual Care Versus More Preventive Telemedicine

DEPMOD is used to compute the cost-benefit ratio by comparing "usual care" with an alternative scenario in which usual care is augmented with preventive telemedicine (Scenario A). In addition, Scenario B is analyzed in which the costs of offering additional preventive telemedicine are compensated for by reducing the healthcare budget for curative interventions, thereby keeping the overall costs of the new scenario under the current budgetary ceiling.

The usual care scenario which forms the basis for the comparisons is an evidence-based healthcare system that is fully in agreement with the Dutch clinical guidelines for the treatment of depression. Because it is likely to be better than the current Dutch healthcare system, we refer to it as "enhanced usual care" (Table 1). This long list of evidence-based interventions was then used to select only those interventions that were acceptable from a patient's point of view and were appropriate from a healthcare professional's point of view. To that end, focus groups were used; a panel of 17 healthcare users judged to what extent they would be willing to accept and actively engage in each of the interventions, whereas a panel of 10 healthcare professionals judged to what extent the interventions were appropriate to offer for the various manifestations of depressive disorder. Both panels showed a relatively high degree of consensus with regard to their preferences (Cronbach alpha = 0.79 for care users and 0.70 for care providers). Taking these preferences into account, the extensive evidence-based interventions was reduced to a shorter list of interventions that are not only evidence based but also preference based (Table 1).[17,19,22–33]

The list of evidence-based and preference-based interventions forms the basis for performing scenario analysis and is likely to be more cost-effective than usual care. In usual care, not every intervention is evidence based or meets with approval by both care users and healthcare providers.

Table 2 describes the scenarios that were analyzed by using DEPMOD. First, the base case scenario of evidence-based and preference-based care without prevention was assessed, in which coverage rates and adherence rates were elicited from the focus groups. The alternative scenario (Scenario A) is essentially the same as the base case scenario, except prevention and (preventive) telemedicine is now offered. To be more specific, prevention consists of face-to-face interventions with an arbitrarily low coverage rate set at 2%. Preventive e-health interventions are offered at a coverage rate of 15%, which is likely to be attainable in practice.[34] E-health interventions for prevention of relapse and recurrence are assumed to be somewhat lower, with coverage set at 10%. Finally, Scenario B offers telemedicine as in Scenario A, while cutting back on other treatment costs, thus keeping the overall costs balanced. Coverage rates in both alternative scenarios are hypothetical and can be used to conduct "what-if" analyses around potentially interesting healthcare systems.

The remainder of the Methods section describes DEPMOD, which is based on methods as described by Briggs et al.[35] and Drummond et al.[36]

DEPMOD

Conceptually, DEPMOD combines the epidemiology of major depression and simulates how a healthcare system affects the incidence (via prevention), prevalence (via treatment), and recurrence (via relapse prevention) of the disorder. Generating health impacts by offering interventions entails costs. Both the costs and the health gains are evaluated by using DEPMOD.

The epidemiology of depression is modeled as a series of transitions between different health states (healthy, depressed, and death), taking into account both severity of depression (subclinical, mild, moderate, and severe depression) and the number of depressive episodes (recurrences). The simulated healthcare system consists of a mix of preventive interventions, curative interventions (for mild, moderate, and severe depression), and interventions to prevent recurrences, as outlined in Tables 1 and 2.

The purpose of DEPMOD is to calculate the total healthcare expenditure and health gains under the current healthcare system, and to compare the current scenario with the alternative scenarios. The

TABLE 1. Selected Evidence-Based and Preference-Based Interventions According to Depression Severity Level

	Costs	Compliance Rate	Effect
	€ ($)	%	OR
Subclinical depression			
Self-help book[a]	348 (413)	52	0.66
Group course: 8–10 sessions[b]	506 (601)	64	0.57
E-health intervention (unsupported)[c]	178 (211)	56	0.55
	€ ($)	%	d
Mild depression			
E-health intervention (supported)[c]	313 (372)	43	0.32
Interapy: online psychotherapy, 10 sessions of CBT[d]	2,154 (2,558)	44	0.70
Individual psychotherapy, primary care, 8 sessions[e]	1,296 (1,539)	56	0.69
Moderate depression			
E-health intervention (supported)[c]	313 (372)	43	0.32
Interapy: online psychotherapy, 14 sessions of CBT[f]	2,154 (2,558)	44	0.70
Individual psychotherapy, primary care, 8 sessions[e]	1,296 (1,539)	56	0.69
Severe depression			
Individual psychotherapy, outpatient care, 8–24 sessions[g]	1,447 (1,719)	68	0.70
Antidepressants, 3–6 months via GP[h]	235 (279)	44	0.72
Antidepressants, 3–6 months, with additional psychological support[i]	289 (343)	56	0.72
Combination therapy (medication and psychotherapy)[j]	1,215 (1,443)	65	1.05
	€ ($)	%	OR
Recurrent depression			
Clinical management with maintenance medication, 12 months[k]	537 (638)	42	0.75
Preventive cognitive therapy: 8 group sessions[k]	406 (482)	63	0.73
Supported self-help PCT: via the Internet[l]	403 (479)	46	0.73

Notes: Data are given as costs (in 2009 euros and dollars), compliance with therapy (%), and effect, as odds ratio (OR) or as standardized effect size, d, all representing average values. GP: general practitioner; PCT: preventive cognitive therapy.

[a]Taken from Willemse et al.[22]

[b]Taken from Cuijpers et al.[17,23]

[c]Taken from Spek et al.[19] and Cuijpers et al.[24]

[d]Taken from Ruwaard et al.[25]

[e]Taken from Cuijpers et al.[26,27]

[f]Taken from Ruwaard et al.[25]

[g]Taken from Ekers et al.[28]

[h]Taken from Arroll et al.,[29] Fournier et al.,[30] and Kirsch et al.[31]

[i]Taken from Fournier et al.[30] and Kirsch et al.[31]

[j]Taken from Cuijpers et al.[32]

[k]Our reanalysis of the meta-analysis by Vittengl et al.[33]

[l]See k. Hypothetical effect size on the assumption that supported e-health is as effective as face-to-face delivered prevention of recurrence, albeit associated with a lower adherence rate.

following sections describe the model, the data, and the underlying assumptions in more detail.

Epidemiology. DEPMOD is restricted to depressive disorder, as defined according to the *Diagnostic and Statistical Manual of Mental Disorders, Third Edition*.[37] DEPMOD assumes a population of 10 million people, aged 18–65 years. Estimates of incidence (238,350 new cases per year), episode duration (6 months on average), prevalence (588,600 acute cases annually), and recurrence rates of depressive disorder (45% of the currently depressed people have a history of previous episodes) were obtained from The Netherlands Mental Health Survey and Incidence Study, a population-based psychiatric epidemiologic cohort study.[15] Depression-specific mortality rates were assessed by using a meta-analytic approach.[38] DEPMOD takes into account that the risk of yet another depressive episode increases with the number of previous episodes.

Healthcare system. A healthcare system consists of preventive interventions to reduce incidence; treatment of mild, moderate, and severe depression to reduce disease burden; and relapse prevention in recovered patients to reduce risk of relapse and recurrence. These

TABLE 2. Modeled Scenarios: Coverage Rates (%) for Each of the Interventions According to Depression Severity Level

	Base Case	Alternative A	Alternative B
Subclinical depression			
Self-help book	0	2	2
Group course: 8–10 sessions	0	2	2
E-health intervention (unsupported)	0	15	15
Mild depression			
E-health intervention (supported)	2	2	1.5
Interapy: online psychotherapy, 10 sessions of CBT	2	2	1.5
Individual psychotherapy, primary care, 8 sessions	17	17	12.4
Moderate depression			
E-health intervention (supported)	2	2	1.5
Interapy: online psychotherapy, 14 sessions of CBT	2	2	1.5
Individual psychotherapy, primary care, 8 sessions	16	16	12
Severe depression			
Individual psychotherapy, outpatient care, 8–24 sessions	18	18	13.5
Antidepressants, 3–6 months via GP	20	20	15
Antidepressants, 3–6 months, with additional psychological support	20	20	15
Combination therapy (medication and psychotherapy)	16	16	12
Recurrent depression			
Clinical management with maintenance medication, 12 months	0	2	2
Mindfulness-based PCT: 8 group sessions	0	2	2
Supported self-help PCT: via the Internet	0	10	10

Notes: CBT: cognitive behavioral therapy; GP: general practitioner; PCT: preventive cognitive therapy.

factors of primary prevention, cure, and relapse prevention can be considered a system of healthcare "echelons" along the disease continuum. Each echelon consists of a mix of interventions.

Each intervention is described by its impact on health (Cohen's d), coverage rate (percentage of population receiving the intervention), adherence rate (extent to which patients comply with the intervention), and cost (per intervention per patient). Effects were based on meta-analyses where possible, and randomized controlled trials or estimates otherwise (Table 1). Costs were estimated by mapping the amount of time of healthcare professionals per intervention multiplied by hourly rates.

The sum of all cost and total health gains were calculated at the level of the population. Costs were restricted to direct medical cost (in euro [€] for the reference year 2009, converted to US$ by using purchasing power parities).[39] Unit cost prices were obtained from the Dutch Guideline for Health Economic Evaluations.[16] Health gains are expressed as a reduction in the disease burden due to depression (i.e., fewer disability-adjusted life-years [DALYs]).

Assessing health gains. Healthcare interventions aim to reduce the number of DALYs in the population. DALY is a measure of disease burden in a population, taking into account two components of disease burden: morbidity and mortality. Morbidity is related to time spent in a health state characterized by a lowered quality of life due to disability. Mortality comes into the equation when illness is associated with premature death. Drummond et al.[36] presents a description of the use of DALYs in economic modeling. In DEPMOD, DALY reductions are achieved in two ways: by preventing people from becoming depressed through primary prevention and by treating people who have depression and thereby lowering their disease burden.

Cost-Effectiveness Analysis

To allow for parameter uncertainty in costs and effects, the model randomly draws a value from the distributions assigned to the parameters and computes the outcome for that configuration of parameter values. This procedure is repeated 1,000 times over all parameters simultaneously. In each run, the outcomes (costs and health gains for each scenarios) are computed and stored in DEPMOD's memory. Then, following the methods of Briggs et al.,[35] all 1,000 simulated outcomes are evaluated simultaneously, thus explicitly accounting for uncertainty in the input parameters.

After generating 1,000 values of costs and DALYs for the current and alternative healthcare systems, costs and effects are discounted when the time horizon exceeds 1 year. Discounting rates (1.5% for the effects and 4.0% for the costs, per the pertinent

TEXT BOX 1. DEPMOD's Assumptions and Their Consequences

Assumption	Justification	Implication
The 1-year incidence is constant at 238,350 cases per year. Prevalence is 588,600 annually in the adult Dutch population of 10 million people.	Data obtained from The Netherlands Mental Health Survey and Incidence Study, a population-based, psychiatric epidemiologic cohort study.[15]	Prevalence determines the cost and effects. The ratio incidence/prevalence determines the relative importance of prevention.
Episode duration is 6 months on average.	After Spijker et al.[40]	Taking episode duration into account affects health benefits. A shorter duration means less potential to generate health benefits.
It is possible to have up to five recurring episodes of depression. After the fifth recurrence, a patient is assumed to be chronically depressed. Recurrence rates of depressive disorder are 50%, 70%, 80%, 85%, and 90% for the first to the fifth episode.	Relapse rates are higher after a previous depressive episode	Increasing risk of recurrence results in patients making heavier demands on the healthcare system, which emphasizes the importance of preventing recurrence from a cost-effectiveness point of view.
Effects are normally distributed.	After Briggs et al.[35]	Uncertainty around the effect parameters is symmetrical.
Costs are gamma distributed.	After Briggs et al.[35]	Uncertainty around the cost parameters is skewed to the right.
Costs include only direct medical costs (in this article).	Production losses are not relevant for retired people. Direct nonmedical costs are only a fraction of direct medical costs.	The model's output is from the perspective of healthcare providers, not the patient, and not from parties such as employers.
WTP for averting one DALY is €20,000 ($23,755).	WTP for averting one DALY can be as much as €80,000 ($95,020). A relative low number of €20,000 ($23,755) was chosen to be more conservative.	A healthcare system is deemed cost-effective when the price per one DALY averted is less than the WTP ceiling of €20,000 ($23,755).
Effects of CBT are maintained over at least 1 year after treatment, but effects of pharmaceutical interventions decline almost instantly after discontinuation.	Based on analysis after[22]	Longer lasting prophylactic effects for CBT than for pharmaceutical interventions amounts to in increased cost-effectiveness of CBT relative to antidepressant medication.
CBT offered during the acute stage of depression introduces a prophylactic effect.	After Willemse et al.[22]	The presence of a prophylactic effect makes it more desirable to treat acute cases of depression with CBT because it may help to avoid new onsets of the disorder in the future.

CBT: cognitive behavioral therapy; DALY: disability-adjusted life-year; WTP: willingness to pay.

economic guideline) are automatically subjected to further sensitivity analyses. In the next step, differences in the costs (incremental costs) and differences in DALYs (incremental effects) across both scenarios are obtained, and an estimate of the incremental cost-effectiveness ratio (ICER) is computed: ICER = $(C_1 - C_0)/(E_1 - E_0)$, were *C* are costs, *E* are effects, and subscripts *1* and *0* refer to the alternative and base case scenarios, respectively. The ICER is one of the key outcomes of an economic evaluation.[35] Our time horizon was 5 years, but this could be changed to a minimum of 1 year. Finally, the return on investment (ROI) of each scenario is calculated by dividing DALY health gains, conservatively valued at €20,000 ($23,750) per DALY, by total cost.

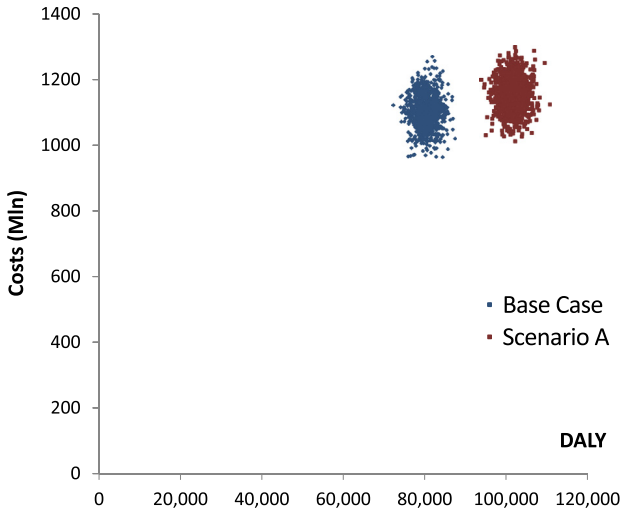
In health economic modeling, making assumptions is inevitable. Whenever assumptions were made, we used conservative amounts to decrease the risk of outcomes being overly optimistic. It is important to understand how the assumptions affect the outcome of the model. Text Box 1 presents DEPMOD's main assumptions, their justifications, and their possible impact on the findings.

RESULTS

Alternative A

The first comparison (the base case scenario versus the alternative Scenario A) evaluates the added value of

FIGURE 1. Simulation output costs and disability-adjusted life-year (DALY) averted in the base case scenario versus Scenario A.



offering preventive interventions in terms of improvement in the cost-benefit ratio of the healthcare system. Cost and effects were modeled out over a period of 5 years. We present here the key findings. First, a healthcare system with indicated prevention and relapse prevention costs 5% more than a system without preventive telemedicine. Second, health gains are 27% higher in the scenario with preventive e-health. Third, in an evidence-based and preference-based system without preventive e-health, a mean (standard deviation [SD]) amount of €13,775 [€724] ($16,361 [$860]) is required for averting one DALY of disease burden. However, the costs per averted DALY drop to a more favorable €11,361 [€534] ($13,494 [$634]) when e-health is offered. This means that the costs for averting one DALY decline strongly as a result of web-based prevention, illustrating that the healthcare system in its entirety becomes more cost-effective, even though costs increase due to additional investments in preventive telemedicine. Finally, when averting one DALY is economically valued at €20,000 ($23,755), the ROI in the base scenario (without prevention) amounts to €1.45 [€0.08] per euro invested in healthcare ($1.72 [$0.09] per dollar invested). The ROI improves when prevention is added (alternative A) to the system and becomes €1.76 [€0.08] ($2.09 [$0.10]).

In sum, the data suggest that offering preventive telemedicine makes the healthcare system more cost-effective, even though offering preventive telemedicine introduces costs of its own. This finding is robust because it is hardly affected by uncertainty in the cost and effect parameters. This can be seen in Figure 1, in which alternative A is achieved by shifting the base case scenario to the right (increased DALY gain), while only slightly shifting the base case scenario upward (increased cost).

Alternative B

The next scenario introduces the same increase in preventive telemedicine but decreases the coverage of (curative) interventions offered in the base scenario by 25% to keep the total cost of the healthcare system balanced. Again, the alternative scenario is compared with the base case scenario and is modeled out over a period of 5 years. Findings are as before, yet slightly more favorable. First, because of the decreased treatment costs in the alternative scenario with 5%, total costs do not change. Second, due to the relative cost-effectiveness of preventive e-health, health gains increase by 23%. Third, as before, it costs (mean [SD]) €13,775 [€724] ($16,361 [$860]) to reduce the disease burden of depression by one DALY in an evidence-based and preference-based system without preventive e-health. Under the alternative Scenario B, this amount becomes €11,279 [€529] ($13,397 [$628]) per averted DALY. Finally, following the same line of reasoning, the ROI increases from €1.45 [€0.08] ($1.72 [$0.09]) in the base case scenario to a higher value of €1.77 [€0.08] ($2.10 [$0.10]) in alternative B.

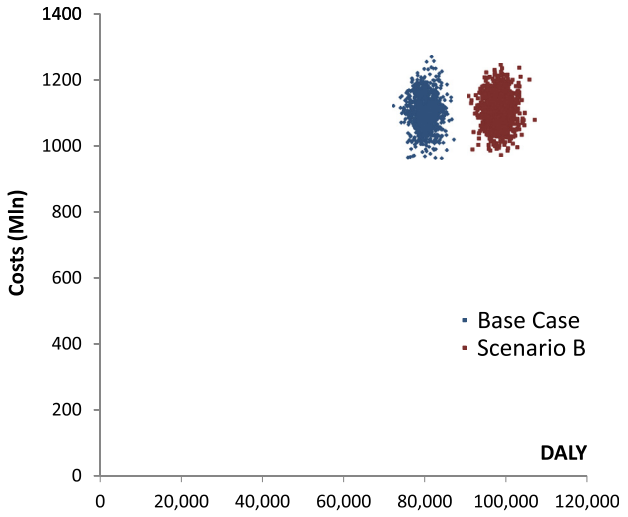
The corollary is that offering preventive e-health interventions makes the healthcare system more cost-effective because a larger health gain is achieved while keeping costs equal. Figure 2 demonstrates that the DALY gains in Scenario B are higher, while costs in both scenarios are comparable. These findings seem to be robust as they are unaffected by uncertainty in the model (as noted by the nonoverlapping uncertainty intervals in Figure 2).

CONCLUSIONS

Main Findings

The main finding of the current study was that e-health interventions which seek to prevent onset of first and later episodes of depression can help to

FIGURE 2. Simulation output costs and disability-adjusted life-year (DALY) averted in the base case scenario versus Scenario B.



make the healthcare system for depressed patients more cost-effective overall. Thus, a healthcare system for depressive disorders that is both evidence based and preference based (i.e., evidence-based interventions that are met with approval of both healthcare users and healthcare providers) represents a good ROI. Modeled out over a period of 5 years, every euro (dollar) spent would generate health gains worth €1.45 ($1.72), assuming that averting one DALY is conservatively valued at €20,000 ($23,755). However, the same healthcare system with realistic levels of preventive telemedicine implemented, and fewer curative interventions, would produce an even better payout of €1.77 ($2.10) of health-related value for every euro (dollar) invested.

Although the model is based on a population aged 18–65 years, we believe comparable results are likely to be obtained for older populations. Evidence suggests that offering telemedicine to older people is promising. In a review on telecare for elderly people with chronic diseases, patients were generally satisfied, accepted the technology, and enjoyed self-monitoring.[41] In addition, evidence specifically on treating depression in older people with telemedicine is promising. E-health interventions proved to be effective in treating depressive symptoms in older people,[19,42] and in a sample of mainly older people, telemedicine was successfully used to adapt a collaborative care model for depression.[43] In addition, from a demographic perspective, the current generation represented by our data are the elderly of the future. We may have to substantially rely on health technologies in the future that are less labor intensive than our current healthcare models.

Strengths and Limitations

One of the benefits of a simulation model is that it helps to organize vast fields of knowledge across several disciplines. In the case of DEPMOD, these disciplines encompass psychiatric epidemiology and health economics, while the evidence that supports effect parameters is drawn from randomized clinical trials, meta-analyses, and evidence-based clinical guidelines. It also proved possible to elicit patients' preferences for certain interventions and to incorporate these preferences into the model. The model makes all information available in a dynamic form, which makes it possible to conduct "if-then" analyses. This could be of assistance when exploring options for healthcare policies.

Our study has a number of limitations that need to be acknowledged. In health economic modeling, much depends on the assumptions made in the model. Whenever we had to make an assumption, we tried to make a conservative one; that is, an assumption that is likely to portray a not overly optimistic outcome scenario. For example, we used the more conservative value of €20,000 ($23,755) for averting one DALY and not the more generous value of €50,000 ($59,388), which is frequently suggested in the literature. Although we accounted for parameter uncertainty to some extent by using extensive sensitivity analyses, we emphasize that the value of our model lies in the comparative analysis of different healthcare scenarios rather than the interpretation of absolute values.

Another limitation is that the model is based on a population aged 18–65 years. Data available on the population older than 65 years are relatively scant, although evidence seems to suggest that the older population is willing to use and is receptive to telemedicine interventions in general and depression-oriented telemedicine in particular.[19,41–43] We recommend increasing this knowledge base to assess the full impact of preventive telemedicine in this age group, as the older population segment is becoming increasingly important in terms of healthcare demand and corresponding costs. Although our model is based

on Dutch data, DEPMOD can be used in other countries as well. With the appropriate data on epidemiology, effectiveness of interventions, and costs, DEPMOD could be adapted to different contexts and population segments. Thus, diverse populations could be investigated by running DEPMOD separately for each population segment.

It should also be noted that implementing telemedicine on a large scale entails costs of its own. DEPMOD did not include the costs of making such a transition from one healthcare system to another. However, the model did compare the benefit-to-cost ratios of two healthcare systems after full implementation (i.e., when the systems were in a steady-state balance). It is worth noting that implementation, especially in the presence of a culturally diverse population, is challenging in its own right.

For these reasons, DEPMOD is best seen as an explorative decision support tool. It is able to give almost instant feedback on policy makers' attempts to select the economically more attractive scenario in the context of constrained decision making under uncertainty in a complex environment. We recommend that DEPMOD be used in an iterative consensus-building process that encompasses all pertinent stakeholders (eg, healthcare users, healthcare providers, policy makers). In any case, we would advise against using DEPMOD as an autopilot for policy making.

DEPMOD can also be used for setting research agendas because it helps to identify those parameters that have an impact on health gains and costs. If any of these parameters is surrounded by a nontrivial amount of uncertainty, it is recommended to conduct empirical research with the aim of reducing uncertainty in that parameter. Finally, we wish to emphasize that ante hoc modeling requires empirical validation later. It is thus recommended that studies be conducted to test the hypotheses suggested by the modeling study.

Implications

Our modeling work shows that preventive interventions, and especially preventive e-health interventions, have the potential to improve the cost-effectiveness of the healthcare system. This finding is consistent with other modeling studies on prevention[12,44] and e-health.[45] Given the rising demand for healthcare and the corresponding increase in healthcare expenditure, preventive telemedicine could play an important role, especially in graying societies in which access to the Internet is available to almost all citizens.

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