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Featured Article

Cost-effectiveness of a collaborative dementia care management—Results of a cluster-randomized controlled trial

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Abstract

Introduction: The purpose of this study was to determine the cost-effectiveness of collaborative dementia care management (DCM).

Methods: The cost-effectiveness analysis was based on the data of 444 patients of a cluster-randomized, controlled trial, conceptualized to evaluate a collaborative DCM that aimed to optimize treatment and care in dementia. Health-care resource use, costs, quality-adjusted life years (QALYs), and incremental cost per QALY gained were measured over a 24-month time horizon.

Results: DCM increased QALYs (+0.05) and decreased costs (−569€) due to a lower hospitalization and a delayed institutionalization (7 months) compared with usual care. The probability of DCM being cost-effective was 88% at willingness-to-pay thresholds of 40,000€ per QALY gained and higher in patients living alone compared to those not living alone (96% vs. 26%).

Discussion: DCM is likely to be a cost-effective strategy in treating dementia and thus beneficial for public health-care payers and patients, especially for those living alone.

Keywords: Dementia; Alzheimer's disease; Dementia care management; Collaborative care; Cost-effectiveness; Economic impact; Costs; Economics; Medical treatment; Nonmedical treatment; Formal care; Informal care

1. Background

The aging of the population is expected to cause a rapid increase in the number of people affected by dementia [1,2]. Worldwide, there are more than 47 million persons living with dementia (PwD). This number is projected to reach 75 million in 2030 [3]. The worldwide cost of dementia is estimated to be US$ 818 billion [4]. Especially over the last five years of life, health-care expenditures among PwD were considerably higher than those for patients who died from heart disease or cancer, and many of the expenses were uncovered, representing a financial burden [5].

In the absence of a cure, PwD need a timely diagnosis and evidence-based treatment and care to delay the progression of the disease and to improve health-related quality of life

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(HRQoL). Attenuating functional decline could improve or at least maintain HRQoL and provides the chance that PwD will need less care, saving already scarce health-care resources [6–8]. However, guideline-based diagnosis is rarely employed, missing the opportunity for early intervention for the majority of PwD. In addition, health-care systems have become more complex so that PwD and families lack access to recommended guideline-based diagnosis, treatment, and care [9]. Both challenges are linked since access to health care services depends on a diagnosis. Studies confirmed that the adherence to dementia guidelines is currently poor despite existing evidence that recommended treatments can improve symptoms and delay the progression of dementia [10].

Several countries introduced strategies to overcome the challenges of a timely diagnosis with guideline-related postdiagnostic support within the complex health-care system [11]. Next to implemented disease management or managed care programs for chronic conditions, such as diabetes or coronary heart diseases, collaborative dementia care management (DCM) programs emerged as a potential solution to improve treatment and care in PwD [12]. These programs are defined as interventions delivered in the community aiming to coordinate the treatment and care for PwD with respect to their needs and the recommendations of evidence-based guidelines [13]. A meta-analysis across 13 randomized controlled trials revealed that DCM could delay patients' institutionalization, reduce patients' behavioral disturbances and depression, and reduce the caregivers' burden [14]. The DelpHi trial (Dementia: Life- and Person-Centered Help) confirmed the findings of previous trials [14], demonstrating significant improvements in patients' pharmaceutical treatment, neuropsychiatric symptoms, and the caregivers' burden [15].

Given the increasing number of PwD, it is necessary to understand the economic impact of these DCM programs. Only a few trials evaluated the effect of DCM on cost, revealing inconclusive evidence [10,16–19]. Previously published cost-effectiveness analyses of case management and postdiagnostic support programs revealed a nonsignificant reduction in cost and, contrary to the expectations, a reduction in HRQoL and quality-adjusted life years (QALYs) [20,21]. Studies were conducted over one decade ago and limited due to small sample size and a short observational period, or they evaluated an intervention that solely provided information and education and did not include a comprehensive assessment of patients' needs and the implementation of a care plan [10,16–19]. Vroomen et al. [22] evaluated the cost-effectiveness of an intensive care management, revealing no significant differences in clinical or total cost outcomes but significant lower informal and day care cost which led to a probability of cost-effectiveness of 97% at the threshold of 0€ per QALY gained. However, the authors indicated that these findings should be interpreted with caution as this study was not a randomized controlled trial.

The World Alzheimer Report, therefore, highlighted the lack of evidence concerning the cost-effectiveness of comprehensive DCM approaches, focusing on costs and HRQoL [11]. The National Institute for Health and Care Excellence also highlights that there is a significant need for research in innovative approaches to improve treatment and care for PwD living alone [23]. Thus, this study aimed to assess the cost-effectiveness of the community-based collaborative and comprehensive DCM of the DelpHi trial as well as the differences in the cost-effectiveness of the DCM between PwD living alone compared to those not living alone, based on 24 months of follow-up data.

2. Methods

2.1. The DelpHi trial

2.1.1. Design

This analysis was conducted alongside the cluster-randomized, controlled interventional DelpHi trial [24], which was designed to test the efficacy of a collaborative DCM compared to usual care. Initially, all general practitioners (GPs) who provide primary care in a residential practice in Mecklenburg-Western Pomerania (state of Germany) were informed about the trial. One hundred thirty-six GPs provided their written informed consent (IC) to participate in this study and thus were randomized with a ratio of 1:1 to the intervention (DCM) or to the control group (usual care). GPs checked patients' eligibility for the trial ($\geq$70 years, living at home) and screened for dementia using the DemTect procedure [25]. If the screening procedure indicated a hint for dementia, the GP provided written and oral information about the study and asked for IC. The study protocol and documents for written IC were approved by the Ethical Committee of the Chamber of Physicians of Mecklenburg-Western Pomerania (registry number BB 20/11). Comprehensive data assessments were conducted at baseline and after 12 and 24 months. The design of the trial is described in the study protocol [24].

2.1.2. Sample, participant flow, and drop out

Study enrollment started on January 1, 2012, and ended on December 31, 2014. A total of 6838 people were screened by 128 GPs, 1166 (17%) patients fulfilled the eligibility criteria, 634 (54%) agreed to participate, and 516 started the baseline assessment. After baseline assessment, 85 participants withdrew their IC, 73 died, and six suspended the assessments, resulting in a sample of 407 and 352 participants who completed the 12- and 24-month follow-up, respectively. The second follow-up period ended on March 31, 2017. A drop out was significantly associated with a lower comorbidity (odds ratio [OR] 0.94, confidence interval [CI] 0.91 to 0.98) and a higher functional impairment of the PwD, with a nonparticipation of the caregiver (OR 0.31, CI 0.18 to 0.53) and with being in the control group (2.02, CI 1.21 to 3.37). GPs were not informed about their

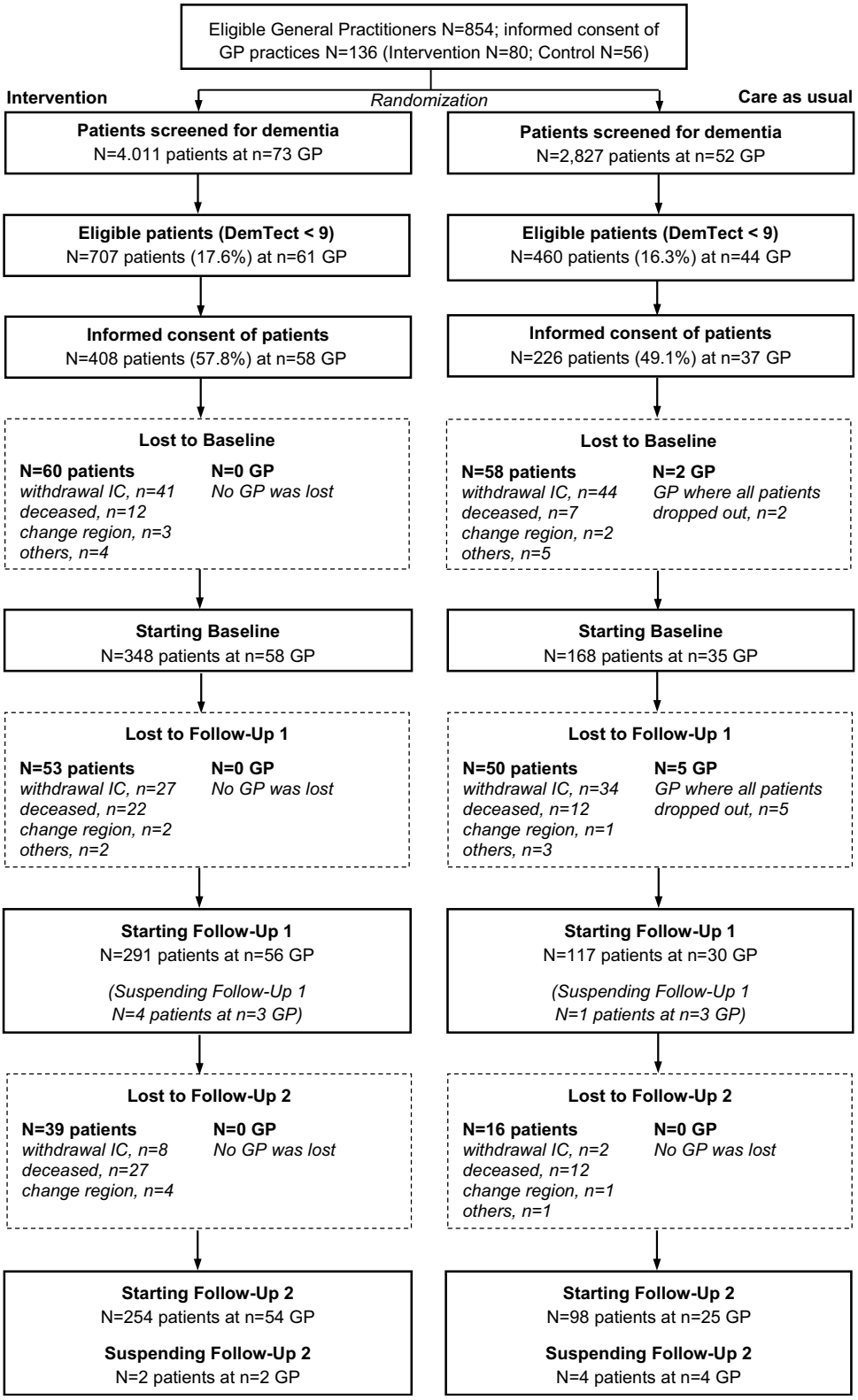

Fig. 1. DelpHi trial flowchart.

randomization status but become aware of their status during the course of the study due to the nature of the intervention. This could have led to a decreased motivation for the recruitment in the control group and thus to the imbalanced groups (drop-out analysis presented in Supplementary Tables 1 and 2). The trial flowchart is displayed in Fig. 1.

2.2. Community-based, collaborative DCM versus usual care

DCM is a model of collaborative care, aiming to support PwD and their caregivers through coordination and management of optimal treatment and care [26]. The intervention was developed according to current guidelines [27–30], targeted at the individual participant level, delivered in participants' homes by nurses with dementia-specific qualifications and based on the following pillars: (1) management of treatment and care, (2) medication management, and (3) caregiver support and education. Based on a comprehensive standardized assessment of the treatment, care, and the living situation using several questionnaires, the nurses identified patients' and caregivers' unmet needs, supported by an IT-based intervention management system [31]. Based on different dementia guidelines [29,32], 95 intervention modules were defined. Each module consists of predefined trigger conditions that were directly related to the used questionnaires, a subsequent intervention task, as well as at least one criterion for its completion. Subsequently, the nurse developed and implemented an individual intervention plan, discussed this plan face to face with the treating GP, and carried out those tasks in close cooperation with the GP and various health-care and social service professionals within the 6-month intervention period. The intervention is described in more detail by Eichler et al. [26].

Annual costs for implementing the DCM valued 780€ per patient and were related to the first year. PwD were solely followed up in the second year but did not receive the DCM. A description of the costs for implementing DCM is presented in Supplementary Table 3.

PwD of the control group received routine care provided by different professions of the primary care system as usual without access to the specific DCM intervention. Thus, GPs of these PwD did not know the unmet medical, social, and care needs that could be identified by the DCM in PwD homes.

2.3. Sociodemographic and clinical data

Sociodemographic data (age, sex, living situation) and the following clinical variables were assessed: cognitive impairment according to the Mini-Mental State Examination (MMSE) [33], comorbidity according to the Charlson Comorbidity Index [34], depression according to the Geriatric Depression Scale [35], and deficits in daily living activities according to the Bayer Activities of Daily Living Scale [36].

2.4. Health-related quality of life

HRQoL was assessed as self-rating using the 12-item Short Form Health Survey (SF-12), a generic, multidimensional instrument that measures the physical dimension of HRQoL with respect to the perception of general health, physical functioning, bodily pain, and role limitations due to the physical health state, as well as mental dimensions including social functioning, mental health, and vitality and role limitations due to emotional state [37]. The SF-12 is acceptable and valid as health status instrument and suitable for mildly to moderately cognitive impaired PwD [38,39]. The responses to the SF-12 were converted to health utilities using the scoring algorithm for the SF-6D, a preference-based single index measure for HRQoL anchored at 0 for death and 1 for full health [37,40]. We assumed a linear change of HRQoL between baseline, 12 months, and 24 months, which is consistent with the nature of dementia diseases, represented by growing cognitive and functional deficits, in turn, increasingly affecting HRQoL. In case of death (the exact date was recorded), the utility value was assumed to equal zero. We used the health utilities and the time duration to calculate QALYs for each patient using the area under the curve technique. The QALYs were discounted at 5% per year [41]. Calculations of utility values and QALYs are demonstrated in Supplementary Table 4 and Formula 1, respectively.

2.5. Health-care resource uses and costs

Health-care resource utilization was retrospectively collected through interviews at 12 and 24 months. To improve the validity of the data, PwD, caregivers, and (if possible) the staff of the care services were interviewed using a list of common resources and services. The utilization review records several medical and formal care services (see Table 1). Informal care time was evaluated using the Resource Utilization in Dementia questionnaire [42]. Average costs per patient were calculated using published unit costs in 2018 Euros (€) [43,44]. Methods for the calculation of costs are demonstrated in Table 1. Costs were discounted at 5% per year [45].

2.6. Cost-effectiveness analysis

2.6.1. Base-case analysis

The analysis was conducted from the public payer perspective (excluding informal care and caregivers QALYs) and based on 444 participants (intervention n = 315, control n = 129) who completed the baseline and at least one follow-up assessment or who died [46,47]. PwD who deceased were not excluded from this analysis and handled as patients having zero QALYs and causing zero costs since the date of death. Missing values were imputed on item level using multiple imputations by chained equations separately by randomization treatment allocation, adding 50 additional data sets for each missing

Table 1
Methods and unit costs used for monetary valuation of medical and formal health-care resources and services

Cost categories	Services	Units	Unit costs*	Unit cost and source for monetary valuation
Medical care				
Outpatient physician treatment	GP or specialists	Visits	20.95€ - 81.56€, depending on specialization	Cost per visit [44]
Inpatient treatment	In-hospital treatment and rehabilitation	Days	593.04€ and 121.85, respectively	Average per diem cost for in-hospital treatment in Mecklenburg-Western Pomerania and for specialization of rehabilitation [44]
Medications	Regularly prescribed drugs (Rx-drugs)	Quantity	Market prices, 253.58€†	Pharmaceutical Index of the Scientific Institute of the AOK [70]
Medical aids	Aids such as tub-lifts, tub-seats, walking sticks, walkers, and others	Quantity	Market prices, 168.92€†	Market prices
Other outpatient treatment	Occupational therapy, speech therapy, physiotherapy, and others	Visits	20.46€	Cost per contact and reimbursement schedules of statutory health insurance [71]
Formal care				
Ambulatory care	Home care provided by professionals	Quantity/ contacts	Market prices, 11.48€†	Market prices for Mecklenburg Western-Pomerania
Day care	Partial in-patient day- and night-time nursing care and short-term care	Days	43.31€, 50.74€ and 57.94€, depending on care level‡	Insurance rates of compulsory long-term policies in relation to patient level of care, including costs for board and lodging [72]
Nursing home care	Long-term care (institutionalization)	Days	61.17€, 76.36€ and 92.39€, depending on care level‡	Insurance rates of compulsory long-term policies in relation to patient level of care, including costs for board and lodging [72]
Informal care	Caregivers' time spent regarding ADL, IADL, and supervision.	Hours	11.30€ (opportunity cost); 18.00€ (proxy good); 4.62€ (two-standard deviation lower opportunity cost for supervision)	Average opportunity cost for lost production or leisure time and average gross wage plus nonwage labor cost (proxy good method) for Central Europe [73]. Hours spent for informal care were limited to a maximum of 18 hours per day.

Abbreviations: GP, general practitioner; AOK, allgemeine Ortskrankenkasse; ADL, activities of daily living; IADL, instrumental activities of daily living.
*Inflation included.
†When drugs, aids, or services were unknown or market prices were not available.
‡Care level one: mild functional impairment, care level two: moderate functional impairment, care level three: severe functional impairment.

variable. Poisson (resource utilization as count data) and linear (health utilities) regression were used and furthermore adjusted for age, sex, living situation, and comorbidity. A description of the imputation methods is presented in Supplementary Table 5 and Formula 2 [47–50].

Descriptive statistics were used to demonstrate unadjusted incremental cost and QALY over 24 months. The incremental cost-effectiveness ratio (ICER) was calculated using the incremental cost per QALY gained by the DCM program compared with usual care [51]. Owing to slight differences in sample characteristic and dependency of observation to cluster (GPs), incremental costs and QALYs were estimated using linear regression models with random effects for the GP and adjusted for sociodemographic and clinical variables [41,52,53]. Because of a highly skewed distribution of cost, standard errors and confidence intervals were estimated by bootstrapping (2000 replications) [54]. To handle sampling uncertainty in the ICER, we used nonparametric bootstrapping, creating 1000 resamples that were stratified for the cluster and group distribution [55]. The probability of the DCM being cost-effective was calculated using these resamples and different willingness-to-pay (WTP) margins [56,57]. The methods used for this analysis were consistent with those of published methodological guidelines for undertaking economic evaluations [58].

2.7. Sensitivity analyses

To reflect the degree of uncertainty in the ICER estimates due to sampling variation and generalizability issues [51], different sensitivity analyses were conducted. First, a complete case analysis (n = 425) was conducted. In addition, a few patients incurred extremely high costs (intervention: n = 4, mean cost 131,448€; control: n = 2, mean cost 189,706€), due to extended hospitalization. Those patients significantly boosted the total cost. Therefore, costs were truncated at the 99th percentile value (95,000€) to minimize the impact of high-cost patients on estimated incremental costs (scenario in favor of the control group). Third, the

intervention cost included protocol-driven costs that were related to efforts made to conduct data assessments, which did not represent routine care practice. Therefore, the intervention cost was reduced (560€/patient), assuming that the DCM can be carried out for 90 patients per year. Finally, informal care and caregivers QALYs were included to assess the cost-effectiveness from a societal perspective. The number of participating dyads of PwD and caregivers (n = 183) was low because some PwD were living alone or do not have a participating caregiver. Informal care time was monetarily valuated using the opportunity cost approach. To handle the uncertainty in the calculation of informal care cost, the proxy good and the opportunity cost approach with a two standard deviation lower unit cost for the supervision were used (see Table 1).

2.8. Subgroup cost-effectiveness analysis

The sample was separated concerning PwD living situation into those living alone and those not living alone to identify who benefits most from the DCM and for which subgroup the highest cost-effectiveness could be achieved. For both groups, the ICER and the probability of cost-effectiveness were calculated using a cost-effectiveness plane and cost-effectiveness acceptability curves.

3. Results

Patients were on average 80 years, mostly female, and mildly cognitively and functionally impaired. There were no significant differences in sociodemographic and clinical variables between the intervention and control groups. PwD in the intervention group were more likely to be formally diagnosed with dementia (77% vs. 67%, $P = .057$). This might be due to the smaller sample size of GPs in the control group, and/or the mentioned lower motivation of control GPs to recruit PwD, especially those being more severely cognitively impaired and thus those being more likely to be formally diagnosed. The sample characteristic is presented in Table 2.

3.1. Base-case analysis

Compared with usual care, the DCM was associated with higher QALY (1.35 vs. 1.30, $P = .130$) and lower cost (24,046€ vs. 24,615€, $P = .590$) after 24 months. Looking at costs in detail and compared to usual care, the DCM led to a higher cost per patient for medication (804€; 95% CI 235–1372) due to a higher prescription of antidementia drugs (27% vs. 39%), and higher cost for medical aids (263€; 95% CI 29–498) but caused lower cost in all other cost categories, especially for in-hospital treatments (−1231€; 95% CI -4665–2202) and nursing home care (−1074€; 95% CI -2855–706). The time to the institutionalization was on average seven months delayed in patients who received the DCM (+7.0 months; 95% CI 1.71–12.35). Table 3 summarizes the differences in costs and QALYs at 24 months.

Incremental QALYs (0.049; 95% CI -0.04–0.135) and costs (−569€; 95% CI -5466€–4328€) favored the DCM, indicating that the DCM was likely to be more effective and less costly. The probability of the DCM being cost-effective was 56% at 0€ WTP. The probability increased to 88%, 95%, and 98% at a WTP of 40,000€, 80,000€, and 160,000€ per QALY gained, respectively. The cost-effectiveness plane and acceptability curve are represented in Fig. 2.

3.2. Sensitivity analyses

In the complete case analysis, incremental costs decreased (−81€; 95% CI -5137–4973) but more QALYs were gained (0.053; 95% CI -0.04–0.14). The DCM still dominated the usual care. The probability of the DCM being cost-effective was slightly lower compared to the base case at the WTP of 0€ and 40,000€ per QALY gained (46% vs. 58% and 85% vs. 88%, respectively).

A truncation of cost resulted in higher incremental costs (453€; 95% CI -3469€–4328€), an ICER of 9244€ per QALY gained, and a lower probability of cost-effectiveness at a WTP of 0€ and 40,000€ per QALY gained (36% vs. 58% and 84% vs. 88%, respectively).

After removing protocol-driven costs, incremental cost decreased to −837€ (95% CI -5778–4102), and the probability of cost-effectiveness increased at the WTP margin of 0€ and 40,000€ per QALY gained (58% vs. 56%, 90% vs. 85%, respectively).

Considering a societal perspective that includes informal care and QALYs of the caregivers, incremental QALYs (0.060; 95% CI -0.06–0.18) and costs (−351€; 95% CI -8700€–7996€) were still in favor of the DCM, indicating that the DCM dominated usual care. The probability of the DCM being cost-effective was higher at 0€ WTP (64% vs. 56%) but lower at all other WTP margins (see Supplementary Fig. 3). Using the proxy good method to valuate informal care led to lower incremental cost (−2691 €; 95% CI -24,216€–18,833€), whereas a lower valuation of the supervision resulted in higher incremental cost (1084 €; 95% CI -15,528€–17,697€) and an ICER of 18,066€ per QALY, demonstrating that caregivers receiving the DCM spend more time for caring but less for supervising the PwD over 24 months compared to usual care (see Supplementary Table 6 and Supplementary Fig. 1).

3.3. Subgroup cost-effectiveness analysis

Although the gain in incremental QALY was slightly lower in PwD living alone (+0.034) compared to PwD not living alone (+0.067), the DCM was more likely to be cost-effective in PwD living alone, represented by lower incremental cost (−3642€ vs. +1799) and a higher probability of cost-effectiveness (82% vs. 13% at WTP 0€/QALY; 96% vs. 26% at WTP 40.000€/QALY). While DCM still dominated the usual care in PwD living alone, the ICER of the DCM for those living with a caregiver valued 26,851€

Table 2
Sociodemographic and clinical characteristics of the total sample (n = 444)

Characteristics	Intervention (n = 315)	Control (n = 129)	*P* value
Age			
Mean (SD)	80.7 (5.7)	79.7 (4.9)	.095*
Sex, n (%)			
Female	190 (60.3)	77 (59.7)	.915†
MMSE			
Mean (SD)	22.2 (5.1)	21.8 (5.8)	.463*
Severity of cognitive impairment‡, n (%)			
No indication of	71 (22.5)	28 (21.7)	.933†
Mild	159 (50.5)	68 (52.7)	
Moderate to severe	85 (27.0)	33 (25.6)	
Living situation, n (%)			
Alone	163 (51.8)	61 (47.3)	.405†
Formally diagnosed with dementia§			
Yes, n (%)	241 (76.5)	87 (67.4)	.057†
B-ADL			
Mean (SD)	3.9 (2.6)	3.5 (2.5)	.138*
Number of ICD-10 diagnoses			
Mean (SD)	13.3 (7.9)	13.8 (6.9)	.496*
Charlson Comorbidity Index			
Mean (SD)	3.4 (2.3)	3.0 (2.1)	.120*
Severity of comorbidity¶, n (%)			
Low	64 (20.3)	38 (29.5)	.104†
High	123 (39.1)	48 (37.2)	
Very high	128 (40.6)	43 (33.3)	
GDS			
Mean (SD)	3.4 (2.4)	3.1 (2.5)	.237*

Abbreviations: B-ADL, Bayer-Activities of Daily Living Scale, range 0–10, lower score indicates better performance; GDS, Geriatric Depression Scale, sum score 0–15, score ≥ 6 indicates depression; ICD, International Statistical Classification of Diseases and Related Health Problems; MMSE, Mini-Mental State Examination, range 0–30, higher score indicates better cognitive function; SD, standard deviation.

*t-test.

†Fisher's exact test.

‡According to MMSE.

§After screening (the before-screening rate was approximately 29%).

¶According to Charlson Comorbidity Index.

per QALY. Results of the subgroup analysis are presented in Table 3 and Fig. 3.

4. Discussion

This analysis adds important evidence to the current paucity of knowledge about the cost-effectiveness of a community-based, comprehensive DCM program, demonstrating that DCM was likely to be cost-effective by improving QALYs at lower costs compared with usual care. The results from the base-case analysis were consistent with those from the sensitivity analyses, demonstrating the robustness of our findings. Subgroup analysis revealed a strong advantage of the DCM in PwD living alone, especially due to substantial higher savings in costs.

Several studies evaluated the cost-effectiveness of pharmacological and nonpharmacological treatments in dementia, reporting higher incremental cost per QALY between 32,000£ and 53,000£ for antidementia drug treatments [59] and 6695£ and 207,942£ per QALY gained for nonpharmacological and noninvasive intervention [60,61]. The DCM took a collaborative approach and integrated both medical and nonmedical treatments, perhaps bringing synergies among these treatments. However, previous studies provided inconclusive evidence regarding the cost-effectiveness of DCM [20–22]. There is some evidence suggesting that admission to care homes and health-care costs are reduced in the medium term. However, the long-term results were uncertain. Although solely 9% of PwD in this sample were institutionalized within the 24 months' time frame, our findings also showed that PwD receiving DCM were less likely to be institutionalized, causing tremendously lower nursing care cost, especially for those PwD living alone [16–19,62]. In contrast to previous studies revealing that PwD receiving DCM had more in-hospital treatments, in our cohort, the number of days stayed in the hospital were higher in the control group, especially for those living alone [14]. Our data showed that hospital admissions were mostly nonelective, independent of having dementia, and strongly dependent on individuals' comorbidity and unpredictable complications that could only partly be prevented by a DCM. A few hospitalized PwD could tremendously affect the incremental cost, which was confirmed by one of the sensitivity analyses. However, our results revealed that supporting PwD living alone could lead to reduced hospitalization.

In addition, the results of our trial were different from previously published studies reporting that DCM led to significantly higher utilization of home care, day care, and respite care [63]. It might be possible that some DCMs aimed to increase the utilization of such services to meet PwD caring needs. On the other hand, patients included in previous trials were significantly more cognitively impaired compared to our mildly cognitively impaired sample (mean MMSE score 13 to 18 vs. 22) [16–18,62], which means that previous DCM were likely initiated after the progression of dementia diseases. The inclusion of patients into the DelpHi trial was based on a screening procedure. Only 40% of DelpHi patients had a formal dementia diagnosis before the screening procedure but 77% did after the initial screening [64,65]. Timely diagnosis and early initiation of DCM might be more effective in delaying the institutionalization and maintaining HRQoL, resulting in a more cost-effective outcome as compared to previously published studies [66]. Further research is needed to assess whether the DCM is more cost-effective than usual care throughout the entire course or only in the onset or the first years of dementia diseases.

As we step into an aging society, the number of PwD is projected to increase, which will be associated with the increasing utilization of health-care resources [49]. Geriatricians, neurologists, and psychiatrists are unlikely to be able to scale up for the growing number of PwD [11]. Therefore, DCM approaches that include different aspects of task sharing among specialists, GPs, and nurses will provide a promising strategy, unlocking existing capacity within the

Table 3
Unadjusted health-care resource utilization, cost, and quality-adjusted life for year one, year two, and cumulated (n = 444)

Health-care resource use, mean (SD)	Total sample (n = 444)		PwD living alone (n = 224)		PwD not living alone (n = 220)	
	DCM	Care as usual	DCM	Care as usual	DCM	Care as usual
Medical treatments						
Physician, visits	22.5 (11.2)	23.6 (13.1)	20.9 (10.3)†	23.7 (13.3)†	24.3 (11.9)	23.5 (12.9)
In hospital, days	9.3 (19.1)	11.5 (41.1)	9.9 (18.4)	16.4 (58.6)	8.6 (19.9)	7.0 (10.2)
Medications, number	14.0 (5.9)‡	12.8 (5.6)‡	13.8 (5.8)†	12.7 (5.8)†	14.1 (6.2)†	12.9 (11.5)†
Medical aids, number	13.1 (5,7)‡	11.9 (5.3)‡	13.5 (5.4)†	12.0 (5.4)†	12.7 (6.1)	11.7 (5.2)
Therapies, visits	14.5 (34.3)	16.7 (50.1)	12.8 (28.2)	15.1 (46.2)	16.2 (39.6)	18.1 (53.7)
Formal care						
Day/night care, days	36.7 (73.2)	40.1 (108.4)	44.5 (75.5)	54.7 (119.7)	28.5 (69.7)	27.0 (97.0)
Ambulatory care, visits	403.9 (612.9)	404.8 (781.1)	565.5 (659.6)	548.1 (917.7)	230.7 (501.7)	276.1 (606.2)
Nursing home, days	31.2 (114.7)	42.8 (150.0)	31.2 (105.6)†	57.1 (168.7)†	31.2 (123.3)	29.9 (129.8)
Time to institutionalization, days	373.3 (227.9)‡	159.0 (125.8)‡	412.5 (204.5)§	151.6 (115.3)§	317.8 (256.3)	173.6 (171.9)
Costs* in Euros, mean (SD)						
Health-care cost	**23,266 (19,977)**	**24,615 (31,360)**	**25,482 (18,592)**	**29,905 (40,181)**	**20,889 (21,166)**	**19,870 (19,611)**
Medical treatments	**12,931 (13,467)**	**13,055 (25,324)**	**13,505 (13,254)**	**15,811 (35,842)**	**12,315 (13,710)**	**10,583 (7849)**
Physicians	707 (426)	751 (385)	641 (383)†	748 (376)†	776.6 (453)	754.3 (391)
In-hospital	5805 (11,854)	7037 (24,901)	6199 (11,432)	10,030 (35,515)	5383 (12,315)	4352 (6289)
Medications	3656 (2985)§	2851 (2141)§	3716 (3299)‡	2728 (1886)‡	3591 (2615)†	2962 (2355)†
Medical aids	2475 (2238)†	2083 (1769)†	2693 (2237)‡	2002 (1584)‡	2241 (2223)	2156 (1929)
Therapies	288 (681)	332 (998)	255 (563)	303 (926)	322 (786)	357 (1058)
Formal care	**10,335 (11,854)**	**11,560 (17,500)**	**11,978 (10,964)**	**14,094 (17,941)**	**8575 (12,539)**	**9287 (16,904)**
Day/night care	1673 (3429)	1869 (5063)	2005 (3488)	2534 (5595)	1317 (3340)	1272 (4492)
Ambulatory care	6667 (6891)	6621 (9314)	8084 (7270)	7767 (10,132)	5149 (6129)	5594 (8457)
Nursing home	1995 (7373)	3069 (11,237)	1889 (6269)†	3793 (11,242)†	2108 (8417)	2421 (11,276)
Cost for intervention	780 (0)	0 (0)	780 (0)	0 (0)	780 (0)	0 (0)
Total cost*	**24,046 (19,977)**	**24,615 (31,360)**	**26,263 (18,592)**	**29,905 (40,181)**	**21,670 (21,167)**	**19,870 (19,611)**
QALYs*	**1.349 (0.41)**	**1.300 (0.44)**	**1.328 (0.41)**	**1.294 (0.45)**	**1.373 (0.41)**	**1.306 (0.43)**
Costs in Euros, mean (SE) [95% CI]						
Incremental costs	**−569 €** (2491) [–5466, 4328]		**–3642 (3938)**		**+1799 (3020)**	
Incremental QALY	**+0.049 QALY** (0.04) [–0.04, 0.135]		**+0.034 (0.06)**		**+0.067 (0.06)**	
Incremental cost per QALY	**Intervention dominates**		**Intervention dominates**		**26,851€/QALY**	

Abbreviations: CI, confidence interval; DCM, dementia care management; QALY, quality-adjusted life years.
NOTE. Values in bold indicate summarized values.
*Discounted at 5%.
†$P = <.1$.
‡$P = <.05$.
§$P = <.01$.

health-care system by a simultaneous improvement of HRQoL and a reduction of cost [49,57]. In the absence of a cure, improving treatment and care according to evidence-based guidelines and HRQoL represents currently the best solution that can satisfy PwD and caregivers' needs. This analysis revealed that DCM could increase HRQoL by modestly reducing health-care costs compared with usual care. An implementation of DCM into routine care could, therefore, be beneficial for public health care payers and patients, especially for those living alone and perhaps those living in rural areas lacking a well-developed infrastructure and good accessibility of GPs and specialists. Thus, DCM could be used as an efficient way to handle the growing number of PwD and thus, to relief, at least in parts, the growing economic burden of dementia diseases. However, implementation into routine care will require health-care reforms, which are not easy to achieve due to the associated high implementation cost and the existing shortage of health professionals, particularly nurses. Therefore, further translational research is needed to evaluate how cost-effective treatments could be implemented in routine care efficiently.

4.1. Limitation

The DelpHi trial was conducted with a small sample of mildly cognitively impaired patients in a mostly rural setting in Germany, which limits the generalizability of the presented results. The validity of the retrospectively assessed health resource data over the long period of 12 months might be limited with regard to completeness and accuracy, due to

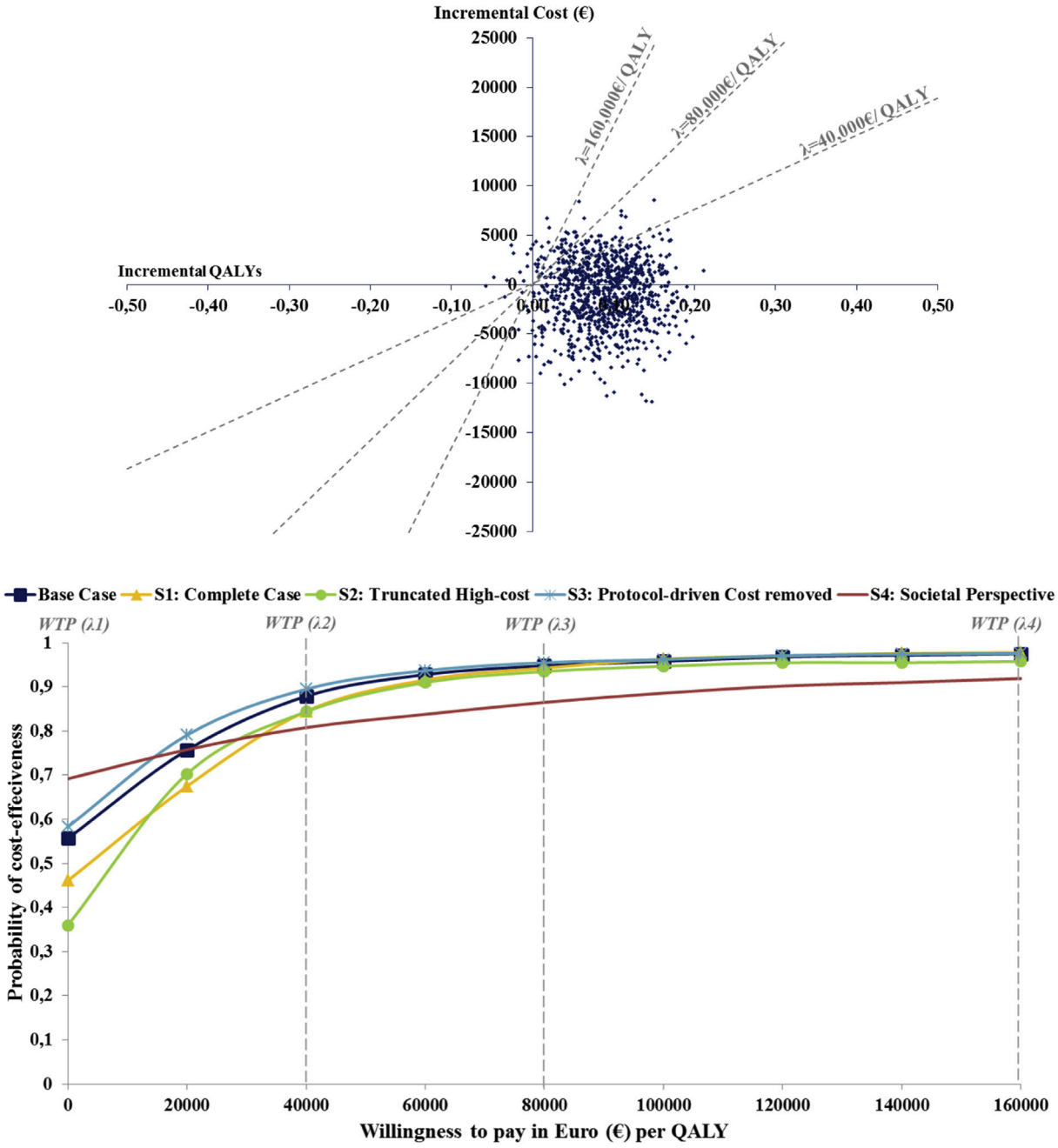

Fig. 2. Cost-effectiveness plane (base-case analysis) and cost-effectiveness acceptability curves (base-case and sensitivity analyses) of the dementia care management; S1: analysis based on complete cases of 425 patients who completed baseline and both follow-up assessments or died; S2: total costs were truncated at the 99th percentile value of 95,000€ (99% of the population had total health-care costs less than 95,000€); S3: reduced cost for intervention due to an exclusion of protocol cost (780€ replaced by 560€); S4: the societal perspective including informal care cost and caregivers' productivity losses; QALYs, quality-adjusted life years; WTP (λ), willingness-to-pay threshold; S, sensitivity analysis.

recall bias among caregivers. In addition, the SF-12 is solely suitable for PwD with an MMSE score greater than 16 [38]. Even though this sample under analysis was predominately mildly cognitively impaired, 13% of PwD had a MMSE score of less than 16. For these patients, the validity of the health utilities was limited. The preference weights used to calculate health utilities were obtained from a sample of the general population in the United Kingdom, which could furthermore bias health utilities due to different country-specific preferences.

PwD were selected through a systematic screening procedure at different GP practices. Although the selection was systematic, the number of participant's was not adequately balanced between the intervention and control groups due to the mentioned possible reduction of the recruitment motivation of control GP, representing a

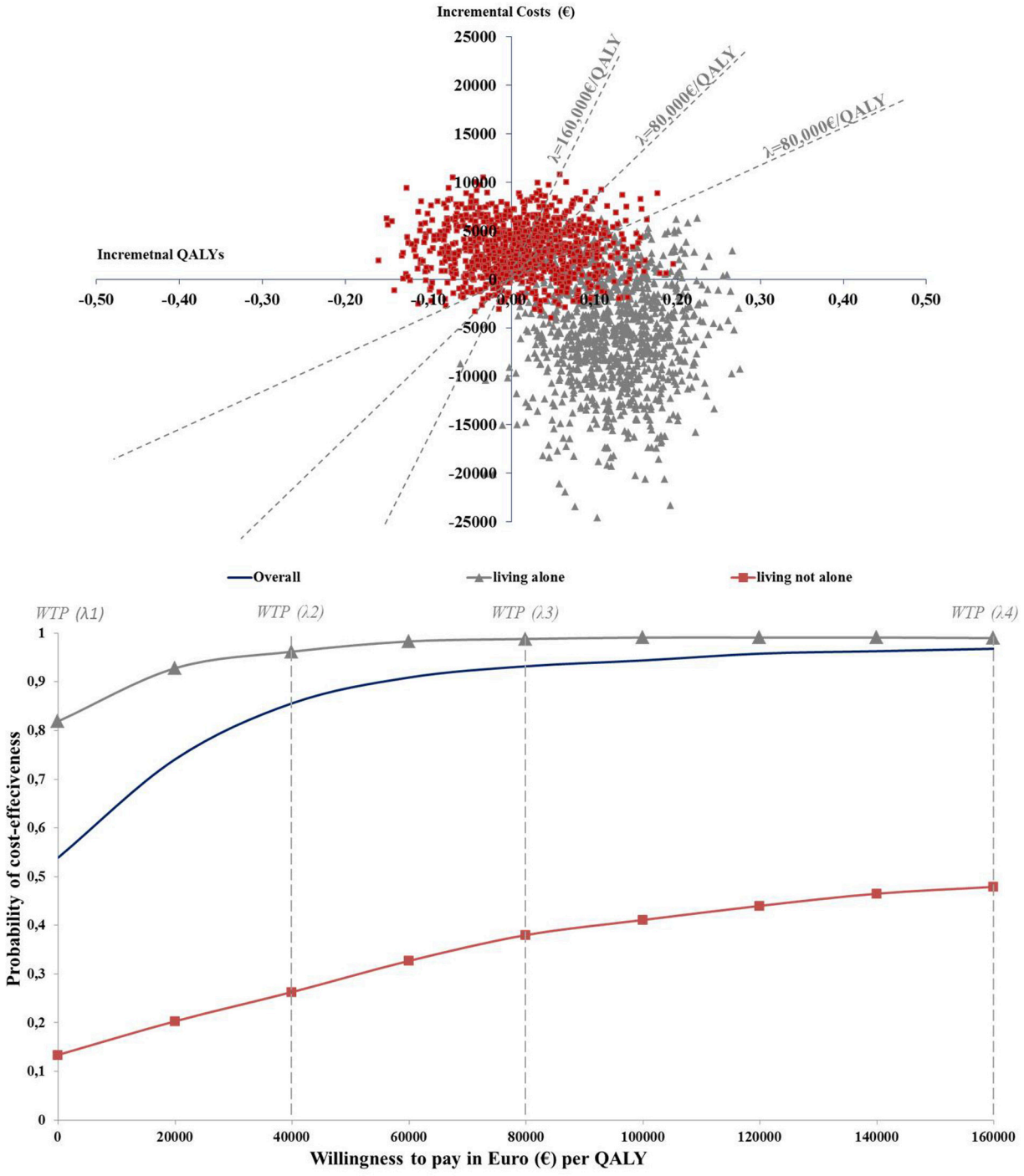

Fig. 3. Cost-effectiveness plane and cost-effectiveness acceptability curves of the DCM shown separately for patients living alone and those not living alone; QALY, quality-adjusted life years; WTP (λ), willingness-to-pay threshold; S, sensitivity analysis.

potential selection bias that could affect demonstrated results. Nevertheless, there were no significant group differences according to the sociodemographic and clinical variables at baseline. Finally, the inclusion criterion for the study was a positive screening for dementia, regardless of the specific dementia subtype. Therefore, demonstrated results could differ between specific subtypes. Furthermore, only 40% of our sample had a formal dementia diagnosis before the screening. This rate is well within the range of international data (20% and 50%) [6,67]. However, 23% of the patients who were screened positive for dementia were not identified as being cognitively impaired according to the MMSE, which could imply false-positive cases. However, the sensitivity for detecting milder forms of cognitive impairment is very high for the DemTect (80–100%) [68] but poor for the MMSE (43–46%) [69]. Therefore, the proportion of false-positive cases should be much lower than 23%.

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Supplementary Data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jalz.2019.05.008.

RESEARCH IN CONTEXT

1. Systematic review: The authors reviewed the literature using PubMed, Science Direct, and the Cochrane Library databases. Although the benefit of dementia care management approaches on patient- and caregiver-related outcomes is widely studied, only a few trials evaluated the cost-effectiveness of such programs, revealing inconclusive evidence. Therefore, the World Alzheimer Report 2016 highlighted the lack of knowledge about the cost-effectiveness of dementia care management approaches.
2. Interpretation: Findings of this study led to a hypothesis that an early initiation of postdiagnostic support using a collaborative and comprehensive dementia care management is likely to be cost-effective by improving quality-adjusted life years at lower total cost.
3. Future directions: Our conclusion highlights the issue of early diagnosis and postdiagnostic support from an economic perspective. Further research is needed to reveal (1) who benefits most from such approaches, (2) how such approaches could be modified and extended, and (3) where an implementation is most appropriate.

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