ScienceDirect

Contents lists available at sciencedirect.com
Journal homepage: www.elsevier.com/locate/jval

Themed Section: The Health Economics of Alzheimer's Disease and Related Dementias

Cost-Effectiveness of a Digitally Supported Care Management Program for Caregivers of People With Dementia

Michelle Pfaff, MSc, Wolfgang Hoffmann, MD, MPH, Melanie Boekholt, MA, Olga Biernetzky, PhD, Iris Blotenberg, PhD, Dilshad Afrin, MSc, Moritz Platen, PhD, Stefan Teipel, MD, Jochen René Thyrian, PhD, Ingo Kilimann, MD,* Bernhard Michalowsky, PhD*

ABSTRACT

Objectives: To examine the cost-effectiveness of a digitally supported care management system (CMS) for caregivers of people with dementia (PwD) compared with usual care.

Methods: The analysis was based on 192 caregivers (n = 96 CMS, n = 96 usual care) of PwD in a cluster-randomized controlled trial testing a digitally supported CMS, aiming to identify and address caregivers' unmet needs and develop and implement an individualized support and care plan over 6 months. Incremental costs from the public-payer and societal perspectives, quality-adjusted life years (QALY), and the incremental cost-effectiveness ratio 6 months after baseline were calculated using multivariate regression models. We assessed the probability of cost-effectiveness using a range of willingness-to-pay thresholds.

Results: Caregivers in the intervention group gained QALYs (+0.004 [95% CI −0.003 to 0.012], P value = .225) and had lower costs from the public payer (−378€ [1926-1168], P value = .630), but higher costs from the societal perspective (+1324 [−3634 to 6284], P value = .599). The intervention dominated usual care from the payer perspective, whereas the incremental cost-effectiveness ratio was €331 000/QALY from a societal perspective. The probability of cost-effectiveness was 72% and 79% from the public payer and 33% and 35% from a societal perspective at the willingness-to-pay thresholds threshold of €40 000 and €80 000/QALY gained.

Conclusions: CMS was likely cost-effective from the payer but not from a societal perspective, underlining the importance of informal care. The gain in QALY was marginal and could be due to the short observation period. Focusing on both the caregiver and the PwD, rather than assessing the PwD needs through the caregiver, could improve the cost-effectiveness results.

Keywords: caregiver support, collaborative care, cost-effectiveness, dementia, informal care.

VALUE HEALTH. 2025; 28(4):527–535

Highlights

- Caregivers of people with dementia (PwD) face significant health risks. Although care management systems (CMS) improve PwD outcomes, caregiver-focused CMS remain underexplored.
- This study evaluates a tablet-based, digitally supported CMS for caregivers, creating personalized care plans. CMS was cost-effective for public payers but not from a societal perspective, revealing challenges in caregiver-centered interventions.
- Findings stress the need for dyadic approaches addressing both caregiver and PwD.

Introduction

Currently, about 1.8 million people in Germany live with a form of dementia.[1] Most people with dementia (PwD) receive informal care from informal caregivers, who support them with their daily tasks and provide supervision.[2] As the disease progresses, the demands for caregiver support increase to a level that can become unbearable for many caregivers. Research has shown that informal caregivers of PwD experience significant physical and emotional burdens and related morbidity, including mental health disorders, such as depression, anxiety disorders, or substance abuse.[3] High caregiver burden can destabilize the care arrangement, leading to hospitalizations or adverse health outcomes,[4] such as reduced health-related quality of life (HRQoL). This may affect the caregiver's ability to provide further informal care to the PwD. Additionally, studies have shown that the informal care costs, derived from the caregiver dedicating time to assist the PwD with daily tasks, constitute the majority of the total costs in caregiver-centered interventions.[5,6] This time commitment often leads to a reduction in working hours, which, in turn, leads to decreased labor productivity, reduced tax revenue for the state, and diminished pension benefits for the caregivers at an individual level.

The Gesund AngehörIge pflegeN - Healthy care for family caregivers (GAIN) intervention, evaluated in this study, aims to reduce the challenges faced by caregivers of PwD by implementing a digitally supported care management program designed to optimize care and support. Previous research revealed that older adults showed lower digital health literacy than other age groups.[7] Additionally, participation in digital health is associated with higher education, social participation, and increased familiarity with digital tools, suggesting that older adults may be an underrepresented group needing special attention.[7,8] By utilizing a target group-specific tablet-based self-assessment and a rule-based expert system, the intervention generates personalized

*Shared last authorship.

care plans to identify and address unmet needs, which, in turn, aims to improve HRQoL.[9] The unmet needs and HRQoL assessment will be published elsewhere, whereas this article evaluates the cost-effectiveness of the intervention.

Cost-effectiveness analyses are crucial because they allow policymakers and healthcare providers to allocate limited resources more efficiently by identifying interventions that provide the greatest health benefits relative to their costs. Previous studies have mainly focused on assessing the effectiveness and cost-effectiveness of the care management system from the perspective of the PwD, for whom it is shown to effectively reduce unmet needs and improve the HRQoL while being cost-effective.[10,11] Therefore, we believe that there is potential in adapting these PwD-focused interventions and expanding them to the caregiver. Previous studies have shown that caregiver-centered studies can be cost-effective.[12–15] In line with these studies, we performed a cost-effectiveness analysis from the public-payer and societal perspectives (including informal care costs).

Methods

Study Design

The analysis was based on data from the cluster-randomized controlled intervention trial GAIN (clinicalTrials.gov NCT04037501), which investigated the clinical use and cost-effectiveness of a digitally supported care management program for caregivers of PwD. The trial design has been described elsewhere[9] and was funded by the Federal Joint Committee (G-BA, 01VSF18030).

Participants were recruited in the practices of general practitioners (GP) and Neurologists, as well as 5 memory clinics in Mecklenburg-Western Pomerania, Germany. Additionally, direct recruitment by the study center using local newspapers and flyer distribution was conducted. The participants were eligible to participate in the study if they were above 18, actively caring for a PwD living at home, able to speak German sufficiently to complete questionnaires, and gave written informed consent.

Ethical approval was obtained from the Ethical Committee of Universitätsmedizin Greifswald (Registry number BB 120/2019) and the Ethical Committee of Universitätsmedizin Rostock (Registry number A2020/0013).

Intervention

The frame of this intervention was the evidence-based dementia care management of the Dementia: life- and person-centered help in Mecklenburg-Western Pomerania (DelpHi-MV) study, which was proven effective[11] and cost-effective.[10] However, DelPhi-MV was a collaborative care model, focusing predominately on identifying and addressing the patient's unmet needs, whereas caregivers received some support and education (eg, for support groups) only. Thus, the gain intervention is an adaptation that entirely focuses on the caregiver, aiming to identify and address all existing unmet needs of caregivers using an IT-based assessment of unmet needs implemented in routine physician practices and memory clinics.

The GAIN intervention consists of (1) an IT-based self-assessment of the health and social status at the GP practice, (2) a comprehensive nurse-led needs assessment at home at the time of recruitment, (3) a systematic, written feedback for the participant's treating GP or memory clinic, (4) a study nurse-led completion of the needs assessment at the participant's home, (5) a collaborative consultation between the participant's GP or memory clinic and the study nurse in which recommendations for treatment and care for the participant are coordinated, and (6) continuing support in reducing the participant's unmet needs identified in the needs assessment within 6 months after recruitment.

The GAIN intervention was supported by an IT- and algorithm-based intervention management system. This rule-based expert system matches participants' characteristics with predefined modular care and treatment interventions to generate an individual care and support plan. The intervention management system helps to identify unmet needs (eg, insufficient care level of the PwD, need for support with medical aids, or need for advice) and create personalized care plans subsidiary to any preexisting services of healthcare providers that the participants are already utilizing.

The care manager contacted the participants every 4 weeks via phone for 6 months to support the implementation of the treatment and care plan, update the plan if necessary, monitor the implementation progress, and offer further active support.

The control group received care as usual during the study, which does not include specific or individualized measures for family caregivers. Family caregivers only access healthcare or social support if they become patients or actively seek information or support groups offered by patient organizations such as the Alzheimer's Society.

Participant Flow

Figure 1 shows the study enrollment from October 2020 to March 2022. Memory clinics and GPs did not record how many people they screened before enrollment. In total, 192 patients (96 intervention vs 96 control) started the baseline assessment, and 170 caregivers (87 vs 83) completed the follow-up assessment. The follow-up assessment was initially scheduled for 6 months. However, because of COVID-19 restrictions, some participants were assessed later. This variation was accounted for in the calculation of QALY by linearly interpolating utility values to day 183 for participants assessed later than planned. The analysis was conducted based on the intention-to-treat principle, meaning that all 192 patients were included in the cost-effectiveness analysis, resulting in $n = 22$ imputed cases.

We used intraclass correlation coefficients to assess whether the clustering of the treating GPs affected the outcome variables. In total, 8 clusters treat, on average, 24 patients, ranging from 1 to 61. We used nonparametric bootstrapping with 1000 replications, revealing an intraclass correlation coefficient close to 0 for the outcome variables. We, therefore, decided to disregard the clustering in further analyses.

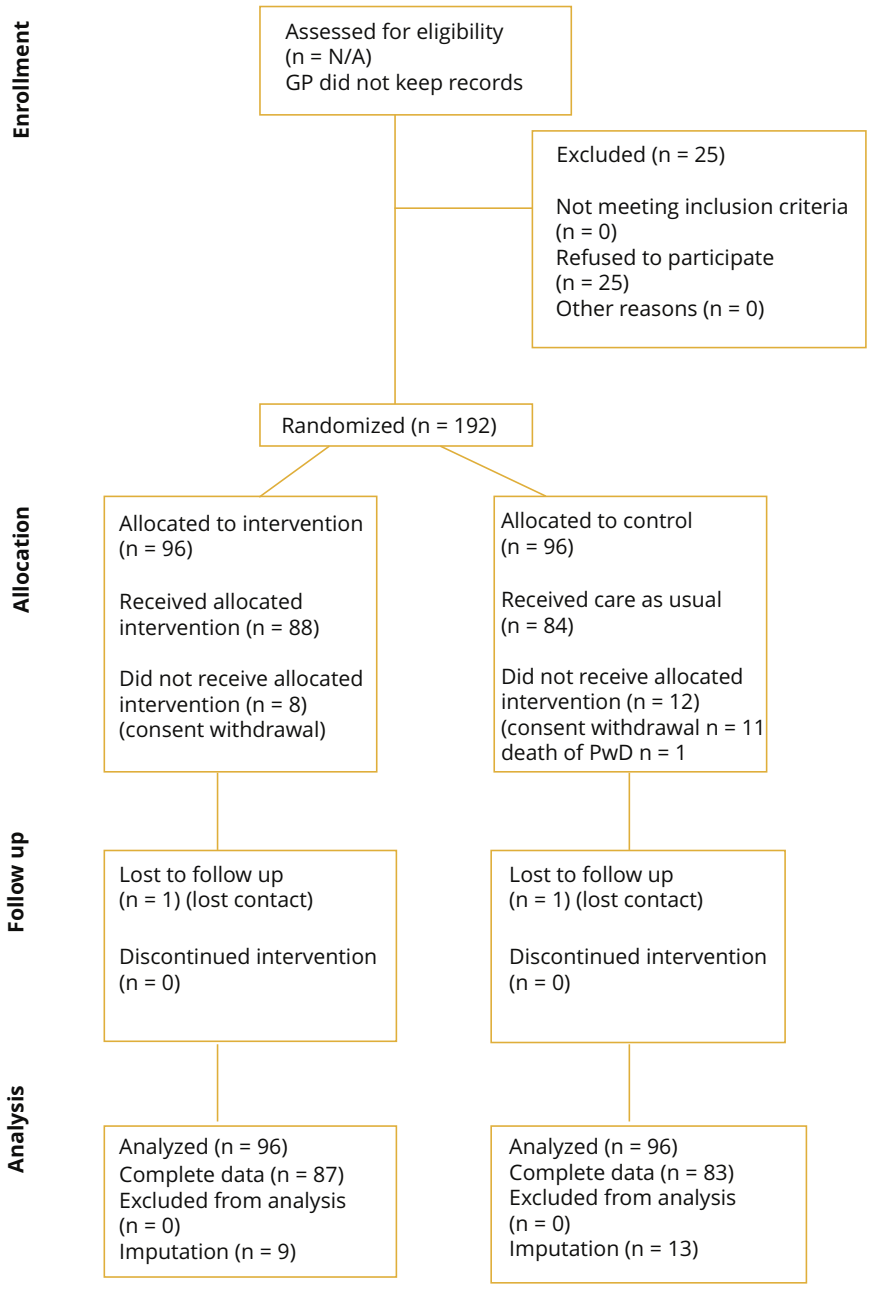
A drop-out analysis was conducted for patients who completed the baseline assessment only ($n = 22$) (see Appendix Table 1 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2025.01.011). Caregivers with a longer history of informal care (3-4 years) were significantly less likely to drop out ($\beta = -2.49$, OR 0.08, CI 0.01-0.59, P value = .038) than caregivers with a short informal care duration (up to 2 years). Furthermore, drop-out was more likely in caregivers with lower HRQoL, measured with the EQ-5D-5L ($\beta = -5.16$, OR 0.01, CI 0-0.59, P value = .008), and higher caregiver burden, measured with the Zarit Burden Interview ($\beta = -0.12$, OR 0.9, CI 0.82-0.98, P value = .052). Lastly, a caregiver was more likely to drop out when the PwD had a care grade, representing a more advanced degree of functional impairment ($\beta = 1.43$, OR = 4.19, CI 1.38-12.67, P value = .034).

Data Assessment of Cost-Effectiveness Outcomes

Data assessments were carried out at baseline and 6-month follow-up by the caregivers at their GP's practice or memory clinic.

HRQoL was assessed using the EQ-5D-5L, comprising the dimensions mobility, self-care, usual activities, pain/discomfort, and

Figure 1. GAIN trial flowchart.



N/A indicates not applicable; PwD, people with dementia.

anxiety/depression with 5 levels, ranging from no problems to extreme problems.[16] The levels can be translated into 5-digit numbers, describing a specific health state and a utility index based on the German preference-based value set. The utility index ranges from −0.661 to 1, in which 1 represents full health in all dimensions.[17] The utility index was used to generate QALY, using the average of the EQ-5D-5L indices at baseline and follow follow-up, multiplied by the observation time (0.5 years).

Caregiver burden was assessed using the 7-question short (Zarit-7) form of the Zarit Burden Interview.[18] This shortened validated version includes functional/behavioral impairments in the home care situation's social, psychological, and physiological domains. All items are rated on a 5-point Likert scale with response options ranging from 0 to 4, yielding scores between 0, indicating no burden, and 28, indicating severe burden.

Because the follow-up assessment time differed for each caregiver, we used mixed-effect models to analyze the change in HRQoL and caregiver burden, using the difference between the baseline and follow-up assessment as a time variable in interaction with the study group (intervention vs control). Our fixed effects were the baseline score, age, sex, whether the caregiver lives together with the PwD, the interaction of the time of the follow-up assessment and the study group (intervention/control). Our random effect was the unique identifier of each caregiver.

Resource utilization was collected retrospectively only at the follow-up assessment using the questionnaire for health-related

resource use in an elderly population (FIMA),[19] covering the utilization of physicians (GP and various specialists), in-hospital stays, therapies (physical, occupational, and speech), medication, aids, professional home care, and daycare. Healthcare resource use was monetarized using standardized unit costs (see Appendix Table 2 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2025.01.011).

Informal care time provision was assessed only at the follow-up assessment using the Resource Utilization in Dementia Questionnaire,[20] which assesses the caregiver time spent supporting the PwD in their activities of daily living (ADL) and instrumental activities of daily living (IADL), and supervision. ADL include tasks such as feeding oneself, bathing, dressing, and homemaking, whereas IADL consists of tasks such as managing money, shopping, taking prescribed medication, and moving within the community. Caregivers' productivity losses (if employed) were also assessed.

Informal care time, including productivity losses, was monetarized using the opportunity costs approach. Therefore, informal care time was multiplied by the average unit costs (€) for the opportunity costs for one hour of informal care provision in central Europe and inflated to the price year 2023 (€19.72/h).[21] Costs were adjusted for inflation to the year 2023. No discounting was needed.

The calculations and estimation of the intervention costs (€520 per caregiver) can be found in Appendix Table 3 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2025.01.011.

Cost-effectiveness Analysis

Missing data were handled using multiple imputation by chained equations on the item level, considering the drop-out analysis results for building the predictor matrix.[22] Zero-inflated count data, such as GP visits, were imputed with a Poisson regression. Binomial data, such as the purchase of a nursing aid and health utility scores, were imputed using predictive mean matching. About 15% of the data were missing. m = 15 imputed data sets were pooled using Rubin's rule.[23]

Sample characteristics were investigated using descriptive statistics. We analyzed the resource utilization and costs only at follow-up using the bottom-up method based on assessed healthcare utilization and published unit costs from the public-payer and societal perspectives. The public-payer perspective consists of all healthcare sector-related costs (medical treatments and ambulatory care), whereas the societal perspective also includes informal care costs and productivity losses.

The incremental cost-effectiveness ratio (ICER) was calculated using the incremental cost per QALY gained by the intervention compared with usual care. For statistical comparison between groups, *t* tests (unadjusted means) and multivariate regression models adjusted for age and sex of the caregiver, caregiver living with the PwD or not, and EQ-5D-5L score at baseline (adjusted means) were calculated to account for baseline imbalance. Baseline costs were not assessed; hence, we were unable to adjust for them.

Nonparametric bootstrapping (1000 bootstraps) was used to generate the cost-effectiveness plane and acceptability curve using different willingness-to-pay (WTP) thresholds to handle sample uncertainty.

The cost-effectiveness results were reported following the Consolidated Health Economic Evaluation Reporting Standards guidelines.

Sensitivity Analyses

The following sensitivity analyses were carried out using multivariate regression models as described above to test the robustness of the cost-effectiveness conclusion: complete case analysis and subgroup analyses for caregivers living together with the PwD or living alone, for gender, for age (median split), and care grade (no vs any care grade).

Table 1. Baseline characteristics of caregivers and PwD.

Characteristic	Intervention (*N* = 96)	Control (*N* = 96)	*P* value
Age			
Mean (SD)	67.3 (11.6)	63.6 (12.3)	.035*
Sex, *n* (%)			
Female	68 (70.8)	76 (79.2)	.243
Relation to PwD, *n* (%)			
Partner	60 (62.5)	52 (54.2)	.306
Other family member	36 (37.5)	44 (45.8)	
Living with PwD, *n* (%)			
Yes	64 (66.7)	58 (60.4)	.453
Employment, *n* (%)			
No	66 (68.8)	57 (59.4)	.229
Years of care provided, *n* (%)			
≤2	44 (45.8)	49 (51)	.717
3-4	18 (18.8)	18 (18.8)	
>4	34 (35.4)	29 (30.2)	
Age of PwD			
Mean (SD)	79.1 (8.28)	77.3 (9.81)	.175
Sex of PwD, *n* (%)			
Male	49 (51.0)	46 (47.9)	.773
PwD Caregrade			
Yes	69 (71.9)	54 (56.3)	.035*

PwD indicates person with dementia; SD, standard deviation.
*A statistically significant difference between groups; we used *t* test for all metric variables and chi-square test for categorical variables.

Results

Sample Characteristics

Table 1 shows the sample description. Caregivers were, on average, 65 years old (67 years [intervention] vs 64 years [control], *P* value = .035), the majority was female (70.8% vs 79.2%, *P* = .243) and unemployed (68.8% vs 59.4%, *P* = .229). The majority were spouses or partners of the PwD and were living together (66.7% vs 60.4%, *P* = .306). Significantly more PwD in the intervention group had a care grade than in the control group (69% vs 54%, *P* value = .035).

Health-related Quality Of Life and Caregiver Burden

Unadjusted scores (Table 2) demonstrated that caregiver burden significantly decreased (intervention −1.3 vs controls +0.1, *P* value = .041) in the intervention group, whereas HRQoL nonsignificantly increased (intervention +0.003 vs controls −0.007, *P* value = .565). Adjusted results of our mixed-effect models showed that the change in caregiver burden (b = 3.735, [−0.292 to 7.763], *P* value =.069) and HRQoL (b = 0.086, [−0.014 to 0.179], *P* value = .0095) over time between the intervention and control group was statistically half-sided significant (Table 2).

Incremental Costs and Quality-Adjusted Life Years

Costs at follow-up and QALY for both groups are summarized in Table 3. Unadjusted mean resource utilization and unadjusted

Table 2. Unadjusted and adjusted (mixed-effect model) results of health-related quality of life (EQ-5D-5L) and caregiver burden (Zarit Burden).

Unadjusted results	Baseline mean (SD)	Follow-up mean (SD)	Difference mean (SD)	*P* value
HRQoL (EQ-5D-5L)				.565*
Intervention	0.872 (0.01)	0.875 (0.01)	+0.003 (0.01)	
Control	0.883 (0.02)	0.875 (0.02)	−0.008 (0.01)	
Caregiver burden (Zarit Burden)				.041*,‡
Intervention	11.0 (0.6)	9.8 (0.6)	−1.3 (0.4)	
Control	9.9 (0.6)	10.1 (0.6)	+0.1 (0.4)	
Adjusted mixed-effect model	EQ-5D-5L Score 6 months after baseline			
Predictors	Estimates	Standard Error	95% CI	*P* value
Intervention group (ref: control)	0.083	0.049	−0.014 to 0.179	.095‡
Age	−0.002	0.001	−0.003 to 0.001	.004‡
Sex (ref: female)	−0.035	0.017	−0.068 to −0.002	.037‡
Living with PwD (ref: yes)	−0.001	0.017	−0.036 to 0.032	.935
Time†	0.044	0.041	−0.037 to 0.125	.285
Baseline score	0.565	0.049	0.468-0.662	.001‡
Interaction time† × study group	−0.128	0.084	−0.291 to 0.036	.036‡
Marginal R^2/conditional R^2	0.098/0.667			
Adjusted mixed-effect model	Zarit burden score 6 months after baseline			
Predictors	Estimates	Standard Error	95% CI	*P* value
Intervention group (ref: control)	3.735	2.055	−0.292 to 7.763	.069‡
Age	−0.044	0.029	−0.101 to 0.012	.126
Sex (ref: female)	0.591	0.721	−0.822 to 2.001	.412
Living with PwD (ref: yes)	−0.071	0.731	−1.504 to 1.362	.922
Time†	3.030	1.731	−0.362 to 6.424	.080‡
Baseline Score	0.629	0.054	0.522-0.737	.001‡
Interaction time† × Study group	−7.927	3.463	−14.71 to 1.138	.022‡
Marginal R^2/Conditional R^2	0.098/0.667			

CI indicates confidence interval.
*Difference over time estimated via *t* test; mixed-effects regression model: standard errors were estimated with nonparametric bootstrapping (2000 replications).
†Time = difference between baseline and follow-up assessments.
‡Statistically significant differences ($P \leq .1$).

costs and effects are found in Appendix Tables 4 and 5 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2025.01.011.

From the public-payer perspective, the mean costs were lower in the intervention group than in the control group (€1540 vs €1911, *P* value = .630). When accounting for informal care costs, the intervention group had higher costs resulting from caregiver ADL/IADL (€17 319 vs €14 358) but significantly lower costs in informal care provided by other family members or friends (€212 vs €11 469 (*P* value = .006)). Therefore, from the societal perspective, the intervention group had slightly higher total costs than the control group (€19 072 vs €17 748, *P* value = .599).

In addition, caregivers receiving the intervention gained QALYs (+0.004 [−0.003 to 0.012]).

Incremental Quality-adjusted Life Years and Cost-Effectiveness Ratio and Acceptability

From a payer perspective, the gain in QALYs at lower costs resulted in an ICER of € −94 500 /QALY, demonstrating that the intervention dominates usual care. Therefore, the probability of cost-effectiveness was 72% and 79% at a WTP threshold of €40 000 and €80 000 from a public-payer perspective, respectively (Fig. 2A,B).

The societal perspective showed that the intervention group gained more QALYs at nonsignificantly higher costs (+1324€ [−3634 to 6284]), resulting in an ICER of €331 000 /QALY gained. The probability of cost-effectiveness was 33% and 35% at a WTP threshold of €40 000 and €80 000 from a societal perspective, respectively (Fig. 2A,B).

Sensitivity Analyses

The complete case analysis confirmed that the intervention was cost-effective from the public-payer perspective but not from a societal standpoint (see Appendix Figs. 1 and 2 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2025.01.011). The subgroup analysis (see Appendix Figs. 3-10 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2025.01.011) demonstrated that the intervention was more likely to be cost-effective from a public-payer perspective for caregivers living together with the PwD (probability of cost-effectiveness 82% at WTP of €40 000/QALY gained), female caregivers (69% at WTP of €40 000/QALY gained), older caregivers over 66 years of age (78%

Table 3. Adjusted mean cost and effects and ICER from the public-payer and societal perspectives at follow-up.

Category	Intervention (*N* = 96) Mean (SD) [CI]	Control (*N* = 96) Mean (SD) [CI]	Difference Mean (SD) [CI]	*P* value
Medical treatments	943 (183) [582-1304]	1199 (183) [838-1561]	−256 (260) [−771 to 258]	.327
GP	91 (8) [74-108]	84 (8) [67-101]	6 (12) [−17 to 30]	.575
Neurologists	6 (2) [1-12]	11 (2) [5-17]	−4 (4) [−13 to 3]	.236
Other specialized doctors	116 (10) [94-137]	123 (10) [101-144]	−7 (15) [−37 to 23]	.646
Therapies	244 (48) [148-340]	253 (48) [157-349]	−8 (69) [−145 to 128]	.900
In-hospital treatments	239 (156) [−69 to 548]	556 (156) [247-865]	−316 (223) [−757 to 123]	.158
Medication	93 (10) [73-113]	98 (10) [78-118]	−4 (14) [−33 to 23]	.748
Medical aids	151 (26) [98-204]	72 (26) [20-125]	78 (38) [3-153]	.040[§]
Formal care[†]	77 (442) [−796 to 950]	719 (442) [−153 to 1592]	−642 (630) [−1886 to 602]	.310
Cost for intervention	520	0	520	
Public-payer perspective*	1540 (550) [454-2626]	1919 (550) [833-3005]	−378 (784) [−1926 to 1168]	.630
Informal care[‡]	17 532 (1721) [14 136-20 927]	15 828 (1721) [12 433-19 224]	1703 (2452) [−3134 to 6542]	.488
ADL/IADL by caregiver	17 319 (1715) [13 935-20 704]	14 358 (1715) [10 974-17 743]	2960 (2444) [−1862 to 7783]	.227
ADL/IADL by others	212 (316) [−411 to 836]	1469 (316) [845-2093]	−1257 (450) [−2145 to −368]	.006[§]
Societal perspective*	19 072 (1764) [15 592-22 553]	17 748 (1764) [14 267-21 228]	1324 (2514) [−3634 to 6284]	.599
QALYs	0.440 (0.003) [0.435-0.445]	0.436 (0.003) [0.431-0.441]	0.004 (0.004) [−0.003 to 0.012]	.225
Incremental cost/QALY gained				
Public-payer perspective		Intervention dominates		
Societal perspective		+331 000 €/QALY		

Note. All monetary values are given in Euros (€).
ADL indicates activities of daily living; GP, general practitioner; IADL, instrumental activities of daily living; QALY, quality-adjusted life years; SD, standard deviation.
*Includes intervention costs.
[†]Ambulatory care.
[‡]Includes supervision.
[§]A statistically significant difference between groups, for statistical comparison between groups multivariate regression model adjusted for age, sex, and living with person with dementia at baseline (adjusted mean) were calculated.

at WTP of €40 000 /QALY gained), and caregivers of patients with a care grade (91% at WTP of €40 000/QALY gained).

Discussion

This study evaluated the cost-effectiveness of a digitally supported care management program for caregivers of PwD implemented in GP practices and memory clinics using an IT-based and nurse-led in-depth unmet needs assessment and an individualized care plan to optimize treatment, care, and support for caregivers. Our results suggested that the intervention was likely cost-effective by gaining QALYs at lower costs from a payer perspective, resulting in a cost-effectiveness probability of 72% to 86% at WTP threshold between €40 000 and €160 000 per QALY gained. However, the intervention caused higher costs from a societal perspective, resulting in an ICER of €331 000 per QALY gained, which is likely not cost-effective. In addition, from both perspectives, the gain in QALYs after 6 months was marginal. Sensitivity analyses confirmed the results, revealing that the intervention was primarily cost-effective for female and older caregivers living together with the PwD having a caregrade.

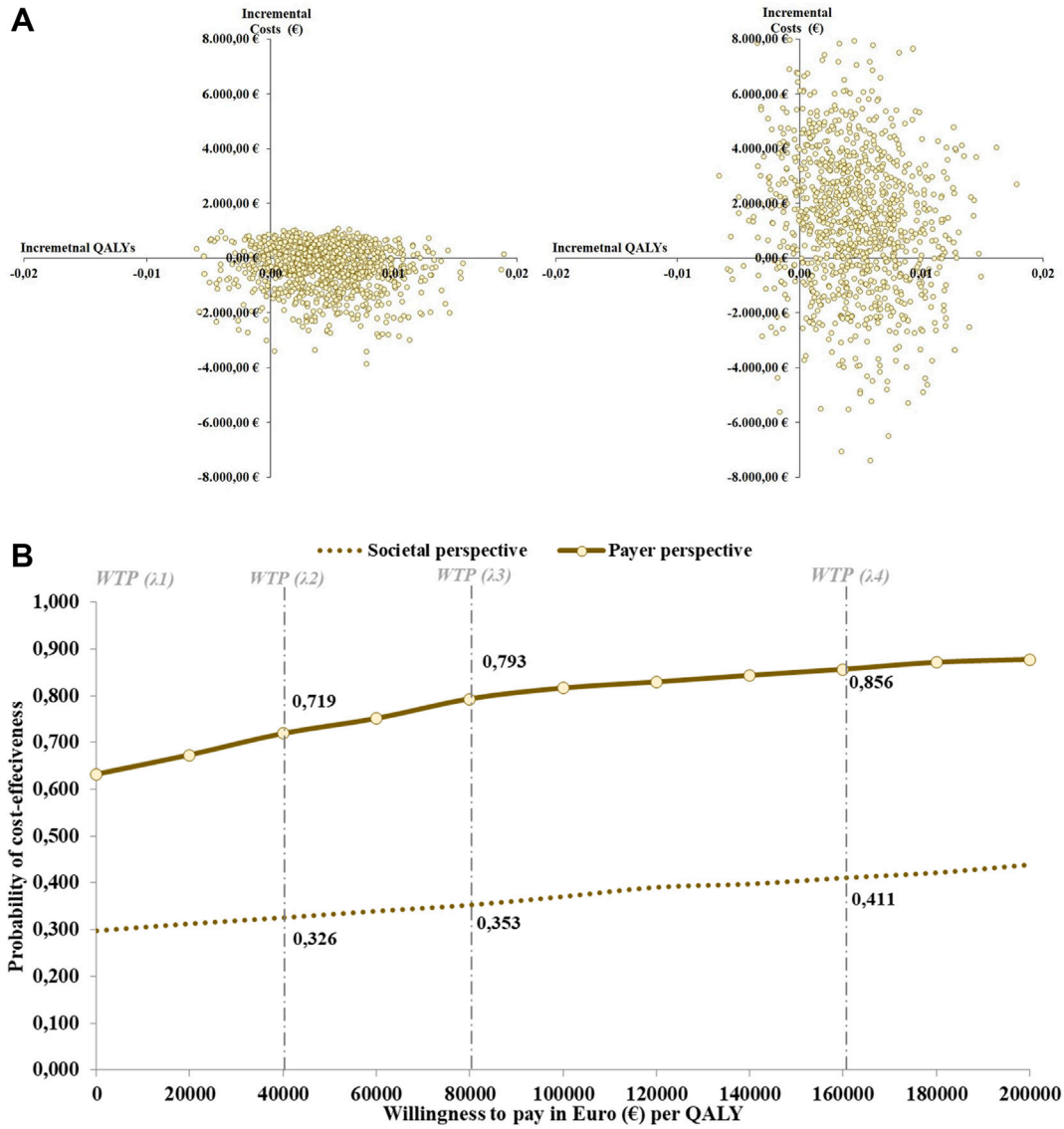
Previous studies have focused on support programs for caregivers of PwD and showed positive HRQoL outcomes, observing a gain in QALY of 0.03 after 8 months[13] that remained unchanged after 12 months and 24 months.[14] Two studies exploring the effects of an App-based eHealth intervention[15] and a digital support, monitoring and reminder platform[12] observed a gain in QALY of 0.003 after 3 and 6 months, respectively. Our analysis showed a gain in QALY of 0.004 after a 6-month intervention period, which aligns with the previously published results of other digital support programs for caregivers.[12,15] The small gain in QALY could be caused by the fact that the intervention period was not long enough to cause significant changes in caregiver HRQoL.[24] Therefore, further studies with extended or repeated follow-up periods after the intervention are required.

The evaluation of the incremental cost is of further importance. Previous studies noted that caregiver intervention led to a nonsignificant cost increase from the societal perspective after 8,[13] 12, and 24 months.[14] Another app-based eHealth intervention and a digital support platform study reported a nonsignificant cost decrease from a societal perspective.[12,15] Our intervention showed nonsignificantly decreased costs from the public payer perspective and nonsignificantly increased costs from the societal perspective, which is also in line with previous studies.

Another important finding lies in the identification of the main cost driver. Two studies found that the informal care costs due to the caregiver assisting the PwD with ADL and IADL amount to between 65%[5] and 85%[6] of the total costs. In our study, the informal care costs amounted to roughly 90% of the total estimated costs from the societal perspective, which is similar to the results of Wilson et al.[6] This shows the importance of including informal care in the health economic analysis, meaning that the societal perspective should be evaluated.

Only a small number of studies have evaluated caregiver burden. For example, a digital support platform showed a

Figure 2. (A) Cost-effectiveness planes from public-payer and societal perspective. QALY indicates quality-adjusted life years. Estimates are based on regression analyses of incremental costs and effects within 1000 bootstrap sample replications of the initial sample stratified for intervention and control group. Each point represents the incremental cost and quality-adjusted life years (QALYs) of the intervention compared with usual care for several resamples, demonstrating whether the intervention was more effective and less costly (lower right quadrant), more effective and more costly (upper right quadrant), less effective and less costly (lower left quadrant), or less effective and more costly (upper left quadrant). (B) Cost-effectiveness acceptability curves from public-payer and societal perspective. Curves indicate the likelihood that the intervention is cost-effective at the given threshold if society has a willingness to pay (WTP) a certain amount per QALY. Vertical dashed lines (WTP [λ] values) indicate WTP thresholds of 40 000€, 80 000€, and 160 000€ per QALY.



QALY indicates quality-adjusted life years.

nonsignificant decrease in burden for the caregiver.[12] Our study showed no significant difference in caregiver burden between the intervention and the control group at 6 months. However, our mixed-effect model indicated a substantial increase in caregiver burden over both groups as the time between baseline assessment and follow-up assessment increased. Because dementia diseases are progressive, this could suggest that the responsibilities and challenges for caregivers tend to grow over time, suggesting that caregivers require long-term support. Additionally, a longer intervention period could clarify whether the intervention has delayed effects or whether the caregiver burden continues to increase.

Previous studies have evaluated cost-effectiveness from a dyadic perspective, including caregivers and PwD. An app-based eHealth intervention was able to show cost-effective results for both the caregiver and PwD.[15] In contrast, the digital support platform intervention was more costly and less effective for the PwD, less expensive and more effective for the caregivers, and less costly and less effective for the dyad.[12] Our intervention only analyzed cost-effectiveness from the perspective of the caregiver. A dyadic intervention and analysis, rather than assessing the PwD needs indirectly through the caregiver, could potentially improve the cost-effectiveness ratio.

Strengths and Limitations

The strength of this study was the analysis from the societal perspective, including informal care costs, which were shown to have the most considerable impact on the total costs. We found that caregivers with a lower EQ-5D-5L score or Zarit Burden score were significantly more likely to drop out. However, we used multiple imputations to minimize this impact. The GAIN trial was conducted with a rather small sample in a rural area in northeastern Germany, characterized by a scarcity of physicians, long distances, and a lack of support for caregivers, which limits the general applicability of the results. This is especially limiting for the societal perspective that includes informal care. Informal care costs represented the most significant part of total healthcare costs from a societal standpoint and could vary tremendously within the 2 groups, limiting the generalizability of the presented cost-effectiveness results from a societal perspective. Also, because the cost-effectiveness analysis was conducted as an additional evaluation, resource utilization and informal care use before starting the study were not recorded at baseline. We could, therefore, not adjust our regression models for potential baseline imbalances in costs, which may result in a potential over- or underestimation in cost savings due to the intervention. However, costs were calculated based on healthcare use, which was captured retrospectively, covering the entire study period. Given that patients in the intervention group were more likely to have a care grade, they typically had access to additional services, potentially leading to higher costs from the payers' perspective. Nevertheless, our analysis indicates that the intervention group had lower costs than the care-as-usual group despite this increased likelihood, suggesting that the true cost-saving effect of the intervention may be underestimated. Therefore, the ICER values reported are likely to be more conservative. Despite the ICER indicating cost-effectiveness from the public-payer perspective, the gain in QALYs and cost savings were not statistically significant.

Conclusions

The caregiver intervention was cost-effective from the public-payer perspective but not from the societal perspective. Despite the short observation period, a marginal gain in QALY was detected. The onset of dementia and, particularly, the initial intervention phase could overwhelm family caregivers, eg, faced with much bureaucracy required to access financial or social support. Thus, the relief could be perceived not at the time of the intervention provision but only when measures become effective. Furthermore, future research should expand the intervention to dyads beyond the single focus on family caregivers, considering spillover effects from the PwD to their caregivers and vice versa, as underlined by the subgroup analysis.

Author Disclosures

Author disclosure forms can be accessed below in the Supplemental Material section.

Supplemental Material

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.jval.2025.01.011.

Article and Author Information

Accepted for Publication: January 14, 2025

Published Online: March 7, 2025

doi: https://doi.org/10.1016/j.jval.2025.01.011

Author Affiliations: German Center for Neurodegenerative Diseases/Deutsches Zentrum für Neurodegenerative Erkrankungen (DZNE) e.V., site Rostock/ Greifswald, Germany (Pfaff, Hoffmann, Boekholt, Biernetzky, Blotenberg, Afrin, Platen, Teipel, Thyrian, Kilimann, Michalowsky); Institute for Community Medicine, Section Epidemiology of Health Care and Community Health, University Medicine Greifswald, Greifswald, Germany (Hoffmann, Thyrian); Department of Psychosomatic Medicine, University Medicine Rostock, Rostock, Germany (Teipel, Kilimann).

Correspondence: Bernhard Michalowsky, PhD, German Center for Neurodegenerative Diseases/Deutsches Zentrum für Neurodegenerative Erkrankungen (DZNE) e.V., site Rostock/ Greifswald, Ellernholzstraße 1-2, 17489 Greifswald, Germany. Email: bernhard.michalowsky@dzne.de

Authorship Confirmation: All authors certify that they meet the ICMJE criteria for authorship.

Funding/Support: The project was funded by the Federal Joint Committee (G-BA) – Innovation Fund (Gemeinsamer Bundesausschuss/ Innovationsausschuss). The funding code (FKZ) is 01VSF18030.

Role of the Funder/Sponsor: The funder had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

REFERENCES

1. Blotenberg I, Hoffmann W, Thyrian JR. Dementia in Germany: epidemiology and prevention potential. *Dtsch Ärztebl Int*. 2023;120(27-28):470–476.
2. Thyrian JR, Boekholt M, Biernetzky O, et al. Informal caregivers of people with dementia in Germany: psychosocial characteristics and unmet needs. *J Alzheimers Dis*. 2024;99(4):1235–1242.
3. Liu Z, Heffernan C, Tan J. Caregiver burden: a concept analysis. *Int J Nurs Sci*. 2020;7(4):438–445.
4. Kuzuya M, Enoki H, Hasegawa J, et al. Impact of caregiver burden on adverse health outcomes in community-dwelling dependent older care recipients. *Am J Geriatr Psychiatry*. 2011;19(4):382–391.
5. Joling KJ, Bosmans JE, van Marwijk HW, et al. The cost-effectiveness of a family meetings intervention to prevent depression and anxiety in family caregivers of patients with dementia: a randomized trial. *Trials*. 2013;14:305.
6. Wilson E, Thalanany M, Shepstone L, et al. Befriending carers of people with dementia: a cost utility analysis. *Int J Geriatr Psychiatry*. 2009;24(6):610–623.
7. König L, Kuhlmey A, Suhr R. Digital health literacy of the population in Germany and its association with physical health, mental health, life satisfaction, and health behaviors: nationally representative survey study. *JMIR Public Health Surveill*. 2024;10:e48685.
8. Poli A, Kelfve S, Motel-Klingebiel A. A research tool for measuring non-participation of older people in research on digital health. *BMC Public Health*. 2019;19(1):1487.
9. Klein OA, Boekholt M, Afrin D, et al. Correction to: effectiveness of a digitally supported care management programme to reduce unmet needs of family caregivers of people with dementia: study protocol for a cluster randomised controlled trial (GAIN). *Trials*. 2021;22(1):432.
10. Michalowsky B, Xie F, Eichler T, et al. Cost-effectiveness of a collaborative dementia care management-Results of a cluster-randomized controlled trial. *Alzheimers Dement*. 2019;15(10):1296–1308.
11. Thyrian JR, Hertel J, Wucherer D, et al. Effectiveness and safety of dementia care management in primary care: a randomized clinical trial. *JAMA Psychiatry*. 2017;74(10):996–1004.
12. Ghani Z, Saha S, Jarl J, Andersson M, Sanmartin Berglund J, Anderberg P. Erratum to: short term economic evaluation of the digital platform "support, monitoring and reminder technology for mild dementia" (SMART4MD) for people with mild cognitive impairment and their informal caregivers. *J Alzheimers Dis*. 2024;99(2):799–810.
13. Knapp M, King D, Romeo R, et al. Cost effectiveness of a manual based coping strategy programme in promoting the mental health of family carers of people with dementia (the START (STrAtegies for RelaTives) study): a pragmatic randomised controlled trial. *BMJ*. 2013;347:f6342.

14. Livingston G, Barber J, Rapaport P, et al. Long-term clinical and cost-effectiveness of psychological intervention for family carers of people with dementia: a single-blind, randomised, controlled trial. *Lancet Psychiatry*. 2014;1(7):539–548.
15. Neal DP, Kucera M, van Munster BC, et al. Cost-effectiveness of the Find-MyApps eHealth intervention vs. digital care as usual: results from a randomised controlled trial. *Aging Ment Health*. 2024:1–14.
16. Foundation ER. EQ-5D-5L user guide: basic information on how to use the EQ-5D-5L instrument. Accessed July 25, 2024. https://euroqol.org/wp-content/uploads/2023/11/EQ-5D-5LUserguide-23-07.pdf.
17. Ludwig K, Graf von der Schulenburg JM, Greiner W. German value set for the EQ-5D-5L. *Pharmacoeconomics*. 2018;36(6):663–674.
18. Kuhnel MB, Ramsenthaler C, Bausewein C, Fegg M, Hodiamont F. Validation of two short versions of the Zarit Burden Interview in the palliative care setting: a questionnaire to assess the burden of informal caregivers. *Support Care Cancer*. 2020;28(11):5185–5193.
19. Seidl H, Bowles D, Bock JO, et al. FIMA–questionnaire for health-related resource use in an elderly population: development and pilot study. Article in German. *Gesundheitswesen*. 2015;77(1):46–52.
20. Wimo A, Gustavsson A, Jonsson L, Winblad B, Hsu MA, Gannon B. Application of Resource Utilization in Dementia (RUD) instrument in a global setting. *Alzheimers Dement*. 2013;9(4):429–435:e17.
21. Oliva-Moreno J, Trapero-Bertran M, Peña-Longobardo LM, Del Pozo-Rubio R. The valuation of informal care in cost-of-illness studies: a systematic review. *Pharmacoeconomics*. 2017;35(3):331–345.
22. Buuren Sv. *Flexible Imputation of Missing Data*. 2nd ed. New York, NY: Taylor & Francis Group; 2018.
23. Barnard J, Rubin DB. Small-sample degrees of freedom with multiple imputation. *Biometrika*. 1999;86(4):948–955.
24. Balvert SCE, Del Sordo GC, Milders MV. The efficacy of dyadic interventions for community-dwelling people with dementia and their caregivers: a systematic review and meta-analysis. *Ageing Res Rev*. 2024;96:102258.