

The economic impact of moderate stage Alzheimer's disease in Italy: evidence from the UP-TECH randomized trial

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ABSTRACT

Background: There is consensus that dementia is the most burdensome disease for modern societies. Few cost-of-illness studies examined the complexity of Alzheimer's disease (AD) burden, considering at the same time health and social care, cash allowances, informal care, and out-of-pocket expenditure by families.

Methods: This is a comprehensive cost-of-illness study based on the baseline data from a randomized controlled trial (UP-TECH) enrolling 438 patients with moderate AD and their primary caregiver living in the community.

Results: The societal burden of AD, composed of public, patient, and informal care costs, was about €20,000/yr. Out of this, the cost borne by the public sector was €4,534/yr. The main driver of public cost was the national cash-for-care allowance (€2,324/yr), followed by drug prescriptions (€1,402/yr). Out-of-pocket expenditure predominantly concerned the cost of private care workers. The value of informal care peaked at €13,590/yr. Socioeconomic factors do not influence AD public cost, but do affect the level of out-of-pocket expenditure.

Conclusion: The burden of AD reflects the structure of Italian welfare. The families predominantly manage AD patients. The public expenditure is mostly for drugs and cash-for-care benefits. From a State perspective in the short term, the advantage of these care arrangements is clear, compared to the cost of residential care. However, if caregivers are not adequately supported, savings may be soon offset by higher risk of caregiver morbidity and mortality produced by high burden and stress. The study has been registered on the website www.clinicaltrials.org (Trial Registration number: NCT01700556).

Key words: cost analysis, Alzheimer's disease, UP-TECH, RCT, caregiver, community-living

Introduction

Dementia is becoming one of the main causes of disability in developed countries (WHO and ADI, 2012). In 2010, it has been estimated that worldwide, about 35.6 million people 65 years and older had dementia. This number is expected

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to nearly triple in the next 40 years (Thies and Bleiler, 2011), as the prevalence and incidence of dementia increase exponentially with age in older subjects (Jorm and Jolley, 1998; Ferri *et al.*, 2005). There is wide consensus that dementia is one of the most burdensome diseases for welfare systems, but establishing the costs incurred by this illness is a complex process (Costa *et al.*, 2012).

Previous cost-of-illness studies have used a wide array of methods in an attempt to encompass cost elements, but this has led to heterogeneous findings (Schneider *et al.*, 1999; Prince, 2004; Jonsson and Wimo, 2009; Hurd *et al.*, 2013; Leicht *et al.*, 2013). In Europe, healthcare cost estimates of Alzheimer's disease (AD) patients ranged from €6,435 (in France) to €64,426 per patient per year (in the United Kingdom), with a clear trend of increased costs with AD severity (Jonsson and Wimo, 2009). Informal care may account for up to 81% of the total cost for care (Boada *et al.*, 1999). The unpaid time of caregivers ranged from \$5,655 (mild AD) to \$3,506 (severe AD) for supervising their family members and from \$9,451 (mild AD) to \$36,794 (severe AD) for direct care provision (Hux *et al.*, 1998).

It is known that AD cost is highly dependent on the setting of care (community vs. residential vs. hospital). Moreover, it has been estimated that delaying a patient's institutionalization can save US\$1,863 per month (Leon *et al.*, 1998). These findings reinforce the importance of studies to inform cost-effective strategies aimed at avoiding institutionalization of AD patients.

Two previous cost-of-illness studies have been carried out in Italy (Cavallo and Fattore, 1997; Trabucchi, 1999), however, neither study comprehensively evaluated all cost categories (e.g., costs of medical care, cash-for-care allowances, and families' out-of-pocket expenditure), nor included data on AD severity. Furthermore, these studies did not investigate patient and caregiver correlates of cost.

The UP-TECH study is a multicenter, randomized controlled clinical trial in Italy, that enrolled 438 AD patient-caregiver dyads into three arms. This clinical trial is investigating whether innovative interventions, such as case management and new technologies can improve the cost-effectiveness of care processes for older people with AD (Chiatti *et al.*, 2015). The baseline assessment performed on the enrolled patients included an in-depth evaluation of the use of care resources, which allowed a detailed cost-of-illness study. The results can address important gaps in the economic analysis of AD in Italy and represents a valuable opportunity to inform policy.

Methods

The UP-TECH study was extensively described elsewhere (Chiatti *et al.*, 2013b). Briefly, lists of AD patients were obtained from the Alzheimer's Evaluation Units (AEUs) from five health districts of the Marche Region (Pesaro, Ancona, Macerata, Fermo, San Benedetto del Tronto). Eligible subjects were patients with a diagnosis of AD according to the NIA-AA 2011 criteria (Albert *et al.*, 2011; McKhann *et al.*, 2011), with a Mini-Mental State Examination (MMSE) (Folstein *et al.*, 1975) score between 10 and 20, corresponding to moderate stage AD, and assisted at home by at least one family caregiver (although not necessarily living with the caregiver herself/himself). We included only patients with moderate AD as we hypothesized that the impact of the interventions tested could be more evident and cost-effective in this subpopulation (e.g. caregiver burden was not too high at enrollment). An invitation letter was sent to 653 patient-family caregiver dyads retrieved from the AEU lists who met the eligibility criteria, asking them to participate in the research study: at the end of the recruitment, 438 dyads were enrolled in the project, resulting in a response rate of approximately 67% (more methodological details are described in the protocol and the recruitment papers (Chiatti *et al.*, 2013b; 2015)). Data have been collected between January 2013 and July 2013. All 438 dyads completed baseline assessment and were included in the present analysis.

The UP-TECH database was integrated through record linkage with the data on hospitalizations from the Regional administrative register of hospital discharges. The study was submitted to the Regional Ethics Committee, which consented to the study being carried out.

Study variables

After obtaining a written informed consent, a trained nurse administered a structured questionnaire, which was a modified version of the InterRAI Contact Assessment (interRAI CA, Ann Arbor, MI, USA) (Hirdes *et al.*, 2010). Instrumental activities of daily living (IADL)-performance (Barberger-Gateau *et al.*, 1992) and activities of daily living (ADL)-hierarchy scales (Morris *et al.*, 1999) were assessed to estimate the level of cognitive and physical performance of the patients. The IADL Involvement Scale, which is based on a sum of seven IADL-related items, produces a scale that ranges from 0 to 48, with higher scores indicating greater difficulty. ADL dependency was summarized using the ADL Hierarchy Scale which ranges from 0 (no impairment) to 6 (total dependence). The caregiver's burden was evaluated

by administering the Caregiver Burden Inventory (CBI) scale, developed by Novak and Guest (1989) and validated in Italy (Marvardi *et al.*, 2005). The CBI is a multidimensional questionnaire composed of five subscales: time-dependence burden, developmental burden, physical burden, social burden, and emotional burden. Overall, it includes a set of 24 items evaluated using a five-point Likert scale ranging from 0 (not at all) to 4 (very much), which are summed. (Scores can vary from 0 to 96, with higher scores indicating greater caregiver distress). Behavioral disturbances of patients were appraised by asking caregivers if the patient displayed, in the last three days, one or more of the following symptoms: verbal or physical aggression, socially inappropriate behavior, socially inappropriate sexual behavior, and/or wandering.

We used caregivers' educational attainment and occupation as proxies of dyad socioeconomic status (SES) (Huisman *et al.*, 2003). Educational level was categorized according to the years of formal education completed: no title—primary school (up to 5 years); intermediate (6–8 years); high (9–14 years); university degree or higher (>15 years). Caregivers were grouped into social classes using present occupation, or their last job before retirement (De Lillo and Schizzerotto, 1985; Cardano *et al.*, 2004).

Cost items

Data regarding the use of resources in the six months prior to the first interview (July 2012–December 2012) were gathered by the trained nurses, using an ad hoc developed Resource Use Questionnaire. The following categories of resources were collected: (1) AD-related drugs; (2) other drugs; (3) hospitalizations; (3) visits to the Emergency Department (ED); (4) outpatient visits/exams; (5) social and health interventions provided in the community; (6) care provided by private care workers; (7) hours of informal care provided by the primary and other informal caregivers. In addition, we assessed whether the patient was granted the so-called “*indennità di accompagnamento*,” the care allowance, provided by the Italian Institute for Pensions (INPS) to the people who have ADL and IADL limitations, and need 24-hour assistance. The explicit aim of the “*indennità*,” is to provide the patients with supplementary money, in order to fund the purchase of additional care services.

Cost perspectives and costing activity

A detailed description of cost categories by perspective is reported in Table 1. The analysis uses three different cost perspectives, and distinguishes

among the costs attributable to the public sector (the National Health Service, the Municipalities, and the State), to private families (i.e. out-of-pocket expenditures) and to society as a whole. Each cost item was assigned to the appropriate perspective, and classified either as “public” or “private.” The societal perspective includes both public and private costs and additionally considers the cost of informal care. Cost data were retrieved from official sources when available. In lieu of official sources, the best available data from national and local surveys were used.

Informal caregiving was valued using a “replacement cost approach” (McDaid, 2001), i.e. estimating the cost of replacing informal caregivers' input with professional assistance. In order to be more conservative in the final estimates (especially as we were not able to distinguish between the hours of supervision and direct care provision, since many families reported 24-hour a day care patterns), we valued the cost of informal caregivers as half of the cost of private care workers, following the approach used by Björkgren *et al.* (2000) and Poss *et al.* (2008).

We used a specific assumption to deal with the risk of double-counting the resource consumption when the dyad declared, at the same time, that they received the care allowance and declared out-of-pocket expenditure. As the legal rationale of the “*indennità*” is to fund out-of-pocket care-related expenditure of families, we subtracted its value from the total out-of-pocket expenditure for all those patients receiving the allowance. When the value of the “*indennità*” was higher than out-of-pocket expenditure (thus hinting that the family uses part of it for other purposes), we replaced negative values with null quantities.

Statistical analyses

Analyses of socio-demographic characteristics of the sample, level of patients' disease severity, social/educational status, resource consumption, family relationship between patient and caregiver, and caregiving burden were purely descriptive. Regarding the cost analyses, two different approaches were adopted. First, univariate (non-parametric) analyses were performed to compare annual costs, by perspective and patients' age. In this case, a bootstrap method was used to estimate the confidence intervals of each cost item. Second, a Generalized Linear Model (GLM) was used to study the relation between costs and independent variables (Schwarzkopf *et al.*, 2012; Lindholm *et al.*, 2013). Model validation was carried out using the following tests: χ^2 for the family chosen; Pearson correlation, Pregibon link, modified Hosmer, and

Table 1. Cost categories, by perspective, included in the study

TYPE OF COST	SOURCE	COST PER UNIT
Public cost		
Drugs	National Formulary of Drugs (v.2013/06/24)	n.a.
Out-patient care	National tariffs list	n.a.
Emergency Department	Mean cost retrieved from a national survey	€242/ED visit
Hospitalization	DRG tariff in the Marche Region	n.a.
Community care		
GP home visits	GP regional contract	€18.9/visit
Home healthcare	Labor cost from national contract – NHS	€24/h
Home help	Labor cost from national contract – cooperatives	€18/h
AD daycare centers	Mean cost retrieved from a regional survey	€30/d
Care allowance	Value set by national laws	€499.27/mo
Out-of-pocket expenditure		
Drugs not reimbursed	National Formulary of Drugs (v.2013/06/24)	n.a.
Out-patient care	National tariffs list	n.a.
AD day care center copayment	Regional survey	€30/d
Private care workers	Estimation of care staff cost	€7.5/h
Informal care		
Informal caregivers	Valued as half of the cost of private care workers	€3.75/h

n.a. = not applicable; AD = Alzheimer's disease; DRG = diagnosis related group; ED = Emergency Department; GP = general practitioner; NHS = National Health Service.

Lemeshow for link function utilized. These tests suggested not to use the out-of-pocket expenditure as a dependent variable, given its excessively skewed distribution. Therefore, we chose to use the sum of public and private costs as a proxy variable to investigate the patterns of out-of-pocket expenditure in the sample.

Results

General characteristics of AD patient–caregiver dyads included in the analysis are reported in Table 2. Patients were more frequently women, with a mean age of 81.5 years. Their ADL-hierarchy scale score was 1.5 out of 6, while their IADL performance indicated greater impairment, reaching 35.1 out of 48 on the IADL scale. Caregivers too, were mostly women (66.2%), usually children of the patients (55.7%) or a spouse/partner (30.8%). Only 8.2% of the caregivers had a university or higher degree, 36.7% completed high school, whereas the majority only finished intermediate school (24.9%) or primary school/no title (30.1%). The level of caregiving burden, measured using the CBI, reached an average of 27.6 points (± 16.8).

Prevalence of service use by AD patients is reported in Figure 1. As a consequence of the inclusion criteria, all patients relied on family caregiving. Ninety-one percent of the patients used AD-related drugs, composed of

antidementia compounds, prescribed by the AEU, antidepressants, antipsychotics, anxiolytics, and hypnotics/sedatives, and 81% of them used other drugs. Fifty-five percent of the patients reported outpatient visits and exams in the six months prior to the interview, and 29% were assisted by a private care worker. Hospitalizations were somewhat frequent in the sample (7%), as were visits to the Emergency Department (12%).

The estimated societal burden of AD patients was about €20,000/yr (Table 3). Out of this, the cost borne by the public sector was €4,534/yr. This value included the cost for direct care services – provided by the NHS and the Municipalities – plus the value of the cash allowances granted by the Italian National Institute of Pensions (INPS). The latter was indeed the largest driver of public cost: 39% of patients received the grant for a total yearly mean cost of €2,324. The other significant driver of public expenditure was prescription drugs for AD and co-morbid diseases, which amounted to €1,402/yr, or almost 1/3 of total public spend. Antidementia drugs were used by approximately 51% of patients, which accounted for the majority of AD drug costs (84%) (see Table S1, available as supplementary material attached to the electronic version of this paper at www.journals.cambridge.org/jid_IPG). The most frequently used drugs for co-morbid diseases were cardiovascular drugs (40.1%; 31.1% cost composition), drugs for the alimentary tract and metabolism (19.7%; 18.2% cost composition),

Table 2. Characteristics of the dyads patient/caregiver in the final sample ($n = 438$)

	N OR MEAN	(% OR \pm SE)
Patients	438	
Gender (female)	272	(62.1%)
Age (years)	81.5	(\pm 5.7)
MMSE	16	(\pm 3.0)
IADL	35.1	(\pm 13.4)
ADL	1.5	(\pm 1.6)
Behavioral disturbance	116	(26.5%)
Caregivers	438	
Gender	290	(66.2%)
Age	61.4	(\pm 13.0)
Relationship		
Spouse/partner	135	(30.8%)
Son/daughter	244	(55.7%)
Other relative	59	(13.5%)
Educational level		
No title/primary school	132	(30.1%)
Intermediate school	109	(24.9%)
High school	161	(36.7%)
University degree or higher	36	(8.2%)
Social class		
Not attributed	35	(8.1%)
Lower	117	(26.8%)
Middle	79	(18.0%)
Middle-upper	145	(33.1%)
Upper	54	(12.3%)
Caregiver burden inventory	27.6	(\pm 16.8)
Hours of informal care provided (per week)		
Primary caregiver	50.2	(\pm 50.3)
Other caregivers	20.2	(\pm 31.3)

ADL = activities of daily living; IADL = instrumental activities of daily living; MMSE = Mini-Mental State Examination; SE = standard error of the mean.

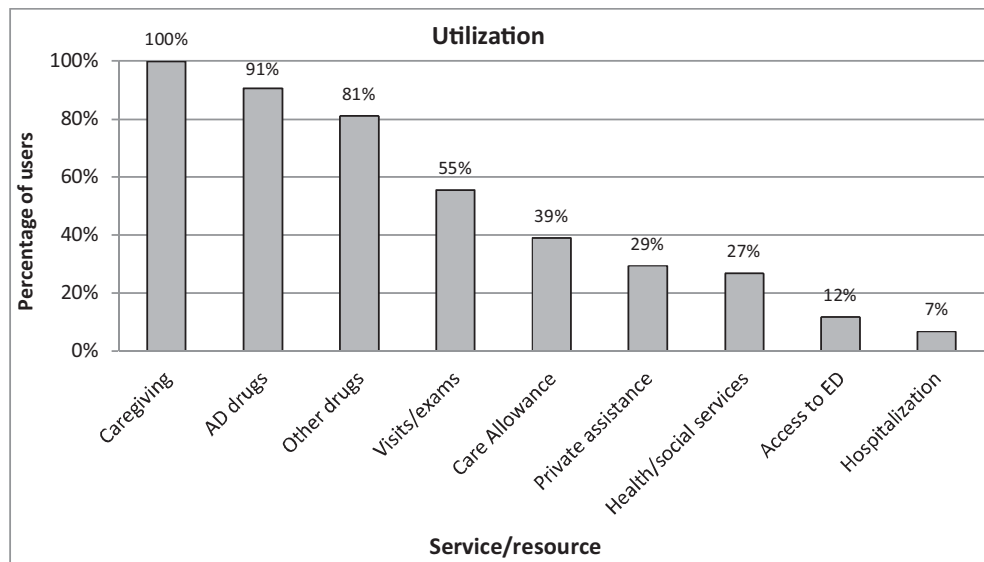


Figure 1. Frequency of resource use ($n = 438$)
AD (Alzheimer's Disease), ED (Emergency Department).

Table 3. AD-related costs, by type of cost and perspective (*n* = 438)

PERSPECTIVE/TYPE OF COST	6-MONTH MEAN COST (€)	[95% CI]	ESTIMATED YEARLY COST (€)	% OF SOCIETAL BURDEN
Public cost	2,267	[2,041.2–2,492.8]	4,534	22.5
Alzheimer's drugs	446	[412.7–478.9]	892	4.4
Other drugs	255	[160.5–349.4]	510	2.5
Exams/visits	20	[15.8–23.8]	40	0.2
Health and social interventions	30	[19.3–39.8]	60	0.3
Emergency Department	31	[22.6–40.4]	62	0.3
Hospitalizations	323	[167.6–477.9]	646	3.2
State care allowances	1,162	[1,030.0–1,295.3]	2,324	11.5
Patient cost	1,487	[1,486.6–1,742.3]	2,974	n.a.
Alzheimer's drugs	12	[7.1–17.1]	24	n.a.
Other drugs	24	[12.6–34.5]	48	n.a.
Exams/visits	1	[0.4–1.1]	2	n.a.
Health and social interventions	7	[4.0–9.2]	14	n.a.
Private assistance	1,444	[1,185.6–1,701.6]	2,888	n.a.
Patient cost subtracting the allowance ^a	1,001	[795.7–1,207.2]	2,002	14.3
Informal care	6,795	[6,241.5–7,348.7]	13,590	67.5
(Main) caregiver	4,843	[4,379.8–5,306.2]	9,686	48.1
Other caregivers	1,952	[1,674.4–2,229.9]	3,904	19.4
Societal cost ^b	10,064	[9,437.4–10,689.7]	20,128	100.0

AD = Alzheimer's disease; CI = confidence interval; € = Euro.

^aSee the methodological section for details on how the value is computed.

^bSocietal cost includes: public cost, patient cost without allowance, and informal care cost.

and blood and blood-forming organ medications (17.2%; 25.3% cost composition) (see Table S2, available as supplementary material attached to the electronic version of this paper at www.journals.cambridge.org/jid_IPG).

Out-of-pocket expenditure predominantly concerned the cost of hiring private care workers, while the cost for privately purchased drugs was rather limited (€24 and €48 for Alzheimer and other drugs, respectively).

The largest share of societal burden, however, comprised informal care. Even by valuing the hours of care, provided by family caregivers, at half the rate of the lowest skilled labor (private care workers), the value of the societal burden peaked at €13,590/yr (67.5% of total costs). Forty-seven percent of caregivers (primary + secondary) expended 41–168 h/wk assisting the patient (see Figure S1, available as supplementary material attached to the electronic version of this paper at www.journals.cambridge.org/jid_IPG). Ten percent of households spent >168 h/wk caring for the AD patient, while 33% and 10% of family members spent, respectively, 15–40 and 0–14 h/wk looking after the Alzheimer's patient. The family members who spent the majority of time on

caregiving were spouses/partners (70 h/wk) followed by grandchildren (44 h/wk) and children-in-law (30 h/wk) (see Figure S2, available as supplementary material attached to the electronic version of this paper at www.journals.cambridge.org/jid_IPG).

Predictors of total costs are shown in Table 4. IADL dependency was the only significant predictor of public cost. IADL impairment also influenced the consumption of resources when considering the total public and private expenditure. In addition, the sum of public and private expenditure correlated with higher level of education. Again, impaired IADL status was associated with increased societal cost, whereas cognitive impairment was negatively correlated. Among the characteristics of caregivers, only CBI score was associated with increased societal expenditure.

Discussion

Our study sheds light on the overall burden of AD in a population of patients at a moderate stage of the disease. By examining the costs using three different perspectives, the expenditure of the public sector (the State, the Municipalities and the NHS)

Table 4. Predictors of total costs (all perspectives; $n = 438$)

MODEL	COEFF.	STANDARD ERROR	p
Model 1. Predictors of public cost			
• IADL	0.0291	0.001	0.001
Model 2. Predictors of public + private cost			
• IADL	0.0375	0.006	0.001
• Educational level: high school versus no title/primary level	0.6188	0.261	0.018
Model 3. Predictors of societal cost			
• MMSE	-0.0302	0.010	0.002
• IADL	0.0247	0.003	0.001
• CBI	0.006	0.002	0.005

All models are adjusted for characteristics of patients (age, gender, ADL, IADL, and MMSE) and caregivers (age, gender, CBI, statuses, and education level).

ADL = activities of daily living; CBI = Caregiver Burden Inventory; IADL = instrumental activities of daily living; MMSE = Mini-Mental State Examination; Coeff. = correlation coefficient; p = probability; Standard Error = standard error of the mean.

was relatively low compared to the overall societal burden. The preference of the Italian Welfare State for cash-for-care allowances, instead of direct care services, was clearly reflected by our results (Shutes and Chiatti, 2012). The cost for care allowances overwhelmed the cost for direct care provision. In many cases the total cost of the care subsidy exceeded that of out-of-pocket expenditure by recipients, suggesting that a substantial part of the allowance was spent in other ways. This reinforces the widespread idea, that in Italy, this care subsidy is a form of compensation for carers' work and complements the income of Italian families. The implications for social policy are indeed relevant and suggest the need for new regulations to increase the accountability of how the care allowance is used.

Prescription drug expenditure accounted for the largest share of the remaining public cost, while the amount of public spending for care services in the community was negligible. Another emerging characteristic was the relevance of the support provided by private care workers (Chiatti *et al.*, 2013a), which represented the major driver of out-of-pocket expenditure.

Two previous cost-of-illness studies have been carried out in Italy (Cavallo and Fattore, 1997; Trabucchi, 1999), however, neither study assessed the costs of medical care. This reflected the structure of dementia care in the country, which traditionally falls outside of the NHS. Moreover, neither study included information on disease severity, nor were they based on a large sample of AD patients assessed by specifically trained research nurses. Cavallo and Fattore's study was based on a postal survey (Cavallo and Fattore, 1997), while the CoDem study (Trabucchi, 1999) included only 103 AD patients. In these two investigations, the level of informal care ranged from 61.6 h/wk (for personal support only) to 124.6 h/wk for patients with severe

dementia (a Clinical Dementia Rating score of 3). In our study, the number of hours of informal care provided by the primary caregiver (supervision + direct care) peaked to a mean of 50.2 h/wk, to which must be added an extra 20 h/wk from other informal caregivers.

The importance of informal assistance provided by Italian families, outside of the market, was evident in two ways. First, the value of the social cost peaked at €13,590/yr or 67.5% of total costs. Second, the public expenditure was significantly less than those same patients would incur in residential care. In the Marche Region, where our study is being carried out, the cost for a year spent in institutional care, for a patient with moderate AD, could vary from €12,045 to €14,600, in contrast to €4,534 for public expenditure of patients living at home, observed in our sample (Marche, 2010). The crucial role of informal caregiving is not limited to Italy. In a recent study carried out in Germany, total costs for community-based caring, after adjusting for age, gender, functional status (ADL and IADL), and co-morbidity, were higher than total costs for nursing home-based caring, mainly due to the higher costs of informal care (Konig *et al.*, 2014). From a State perspective in the short term, the "convenience" of these care arrangements in the community is apparent, since the alternative, residential care settings, is clearly more burdensome. However, if caregivers are not adequately supported, these savings may be soon offset, given the high burden, stress, and often advanced age of caregivers, which expose them to a higher risk of morbidity and mortality (Vitaliano *et al.*, 2003). Already the caregivers in our sample population were close to the threshold for anxiety and depression (McDowell, 2006; Chiatti *et al.*, 2015). Studies have determined that these mood disorders were associated with much higher public

costs for older people living at home (Vasiliadis *et al.*, 2013), as well as healthcare costs for older patients (Luppa *et al.*, 2008).

In this study, we distinguished the share of cost directly attributable to AD from that which might be associated with other diseases and/or physical dependency. In this regard, previous evidence pointed out that potentially sizeable savings could be achieved by the management of co-morbidities in people with dementia (Knapp *et al.*, 2013). We found that a large share of the public costs was related to disease co-morbidities (e.g. drugs and hospitalizations), suggesting the need to specifically target this population, for instance, by improving prescription appropriateness through medication reviews and/or improving the compliance to therapy.

In the regression analysis of cost predictors, functional impairment, rather than cognitive impairment, more consistently predicted the use of resources. (The only exception was the correlation between a higher MMSE score and overall societal burden.) This is in line with previous evidence (Lindhölm *et al.*, 2013), suggesting that IADL dependency is the main driver of care cost among AD patients. We found no socioeconomic correlates of public spending, which is consistent with the mission of the Italian welfare system to universally provide assistance (although the overall level dispensed is relatively small). Conversely, the role of caregiver education suggested the probable association between a higher SES and a higher expenditure for the care of the AD patients. These findings raise the issue of equity of care, since it reveals the additional risk of caregiving burden, for those families with lower financial means. The disadvantages of dyads with a lower educational status will increase as the public support for dementia continues to retrench as a result of the financial crisis in the Mediterranean countries.

Caregiver social class was not significantly correlated with AD burden in the multivariate analysis, once educational attainment was inserted into the models. This suggests that caregiver educational level has a stronger impact in determining the care arrangements of the patients, which may also be connected to the fact that, due to a limitation of the study questionnaire, we could not measure family social class, but only individuals' social class (Erikson, 1984)

The study has other limitations, which must be considered when appraising its results. First of all, regarding the representativeness of the sample, it has to be mentioned, that at the present time, no data are available regarding the prevalence of AD in the Marche Region and the characteristics of the population of caregivers. This

is a major issue for the Regional Government, which the UP-TECH project is actually trying to address. However, the 67% recruitment response rate achieved on the lists of the AEU patients (which include all patients of the Region with a diagnosis of AD) and the large size of the sample ($n = 438$ patient-caregiver dyads), make us optimistic regarding the latter's representativeness of Marche's population of patients with moderate AD, living in the community, with at least one family caregiver. The characteristics of the UP-TECH sample are indeed consistent with those of the samples enrolled by other studies (both RCTs and cross-sectional studies) targeting patients with dementia (Coon *et al.*, 2003; Sink *et al.*, 2006; Black *et al.*, 2013) and those with moderate AD (Wisniewski *et al.*, 2003; Belle *et al.*, 2006). In these studies, the caregivers had a very similar age and gender composition, while the dementia patients had a comparable profile in terms of age, gender, MMSE score, and ADL and IADL dependency. A second potential limitation of the paper refers to the inclusion criteria of our study population, i.e., patients with moderate AD, with at least one family caregiver. This implies that those patients without a family caregiver – although their number should be relatively small in the Italian population – were not included in the analysis. A third limitation relates to the lack of conventional measures of AD symptom gravity, such as the NPI (Cummings, 1997) and the Behave-AD (Reisberg *et al.*, 1996), in the UP-TECH study. However, we tried to address this by using the caregivers' reports of behavioral disturbances, which is a very common proxy in the health economic analysis of AD cost (Jonsson and Wimo, 2009). Last but not least, for some cost items, we could not use the actual price, but had to rely on an estimate from either surveys or the cost of labor set by the national employment contracts. Even with these limitations, our up-to-date study is one of the most realistic carried out in Italy, as it is based on a comprehensive and reliable collection of data, following an intensive training of nurse assessors and a continuous monitoring of a large number of patients.

Conflict of interest

None.

Description of authors' roles

CC contributed to the statistical analysis and interpretation; the conception, development and writing of the paper. GF contributed to the

statistical analysis and interpretation; the development and writing of the paper. JMR contributed to the conception, development, and writing of the paper. FD contributed to the statistical analysis and interpretation; the development and writing of the paper. FB contributed to the execution of the study; data preparation; critical comments on paper drafts. LC provided critical comments on paper drafts; critical review of paper drafts. FM contributed to the execution of the study; management of participant recruitment; supervision of data collection; data preparation; critical review of paper drafts. AC provided critical comments on paper drafts; critical review of paper drafts. FL supervised the data collection and provided critical comments on paper drafts.

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Supplementary Material

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