

The Economic Costs of Progressive Supranuclear Palsy and Multiple System Atrophy in France, Germany and the United Kingdom

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Abstract

Progressive supranuclear palsy (PSP) and multiple system atrophy (MSA) are progressive disabling neurological conditions usually fatal within 10 years of onset. Little is known about the economic costs of these conditions. This paper reports service use and costs from France, Germany and the UK and identifies patient characteristics that are associated with cost. 767 patients were recruited, and 760 included in the study, from 44 centres as part of the NNIPPS trial. Service use during the previous six months was measured at entry to the study and costs calculated. Mean six-month costs were calculated for 742 patients. Data on patient sociodemographic and clinical characteristics were recorded and used in regression models to identify predictors of service costs and unpaid care costs (i.e., care from family and friends). The mean six-month service costs of PSP were €24,491 in France, €30,643 in Germany and €25,655 in the UK. The costs for MSA were €28,924, €25,645 and €19,103 respectively. Unpaid care accounted for 68–76%. Formal and unpaid costs were significantly higher the more severe the illness, as indicated by the Parkinson's Plus Symptom scale. There was a significant inverse relationship between service and unpaid care costs.

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Introduction

Progressive supranuclear palsy (PSP) and multiple system atrophy (MSA) are rare progressive neurodegenerative disorders, usually presenting as akinetic-rigid syndromes ('parkinson plus syndromes'). Age at onset is typically between 55 and 65, and the average life expectancy from onset is 5–10 years for both diseases [1–8]. The prevalence of each of these disorders has been estimated at 2–7 per 100,000 [4,5,9–15], although this is likely to be an underestimate because of diagnostic confusion with idiopathic Parkinson's disease. The number of people aged 55 or above with PSP has been estimated at 14–25 per 100,000, with a figure of 17–29 per 100,000 for MSA [5,10]. Given that there are

approximately 177 million people aged 55 or over in the 27 countries of the EU [16] this translates to 25,000–44,000 with PSP and 30,000–51,000 with MSA.

Patients with MSA and PSP require care from a range of services, and it is likely that such inputs will need to increase as the disease progresses. However, to date there have been no attempts to comprehensively measure and cost service use for patients. Measures of costs for a representative sample of patients allow us to determine relationships between care inputs and patient needs, assess the cost-effectiveness of specific treatments and highlight the impact that these conditions have on society as a whole.

As part of the NNIPPS study [17] we adapted a health service use questionnaire [18] to estimate the resource use associated with

PSP and MSA in three European countries (France, Germany and the UK). This paper reports the service use and cost for patients at entry to the study and identifies predictors of the costs.

Methods

Ethics approval

Patients gave written consent prior to participating in the study. The protocol and amendments were reviewed and approved by the Comité de Protection des Personnes of Pitié-Salpêtrière Hospital (France), the UK Multicentre Research Ethics Committee (MREC), (UK), Ethikkommission of the University of Ulm, (Germany), and by local Institutional Review Boards (Ethics Committees) where appropriate (UK, Germany). These include, UK: Ethics committees of Belfast, Birmingham - City Hospital, Birmingham - Queen Elizabeth Hospital, Cambridge, Liverpool, King's College London, NHNN & Queen Square Hospital, Newcastle upon Tyne, Stafford, Aberdeen, Guernsey, Swansea. Germany: Aachen, Berlin, Bochum, Dresden, Freiburg, Halle, Hannover, Magdeburg, München, Regensburg, Rostock, Tübingen, Ulm.

The broad aims of the NNIPPS project were to evaluate the use of riluzole, a potential neuroprotector and to assess the natural history of PSP and MSA. Details of the inclusion criteria and study design are published elsewhere [17]. Briefly, patients with an akinetic-rigid syndrome diagnosed as PSP or MSA according to the NNIPPS diagnostic criteria were eligible. The intention to treat (ITT) population comprised of 760 patients (362 PSP and 398 MSA) recruited in 44 centres in the UK, France and Germany. Patients were stratified according to diagnosis and randomised double-blind to riluzole or placebo. The primary efficacy measure was survival, and secondary endpoints included rate of change in functional scores.

Patients were to be followed-up 3-monthly for three years for safety assessment. For efficacy and natural history assessment, the following measures were completed at entry to the study (between 2000 and 2002) and used in the subsequent economic analyses: (i) demographic characteristics (including age, gender, ethnicity, education), (ii) vital signs (including weight and height), (iii) Hoehn and Yahr disease staging scale (HYS) [19], (iv) a Short Motor Disability Scale (SMDS) [21], (v) Clinical Global Impression of Disease Severity (CGI-ds) [20], (vi) Parkinson Plus Symptoms scale (NNIPPS-PPS) [21], (vii) Short-Form 36 [22], (viii) Client Service Receipt Inventory (CSRI) [18]. SMDS was completed at follow-up 3-monthly, HYS, CGI-ds, PPS, 6-monthly, and SF36 and CSRI 6-monthly the first year then 12-monthly.

Service use and costs

It is important in any economic study to include information on all services that may be used because of the specific condition under investigation. Service use during the six-month period prior to interview was measured using the Client Service Receipt Inventory (CSRI) adapted for these disorders (Appendix S1). Participants were asked for information on their use of hospital and community services, i.e. whether they used them, how many times and (where relevant) for the average duration of contacts. They were also asked to provide details of any scans or tests they had received in the six-month period, whether they had been provided with any prostheses (wheelchairs, walking frames, etc), and whether any adaptations had been made to their home because of their illness. Further information was sought on care provided because of the illness by family members or friends and any impact that the illness had on employment of the patients themselves or members of their families.

Unit costs were attached to the service use measures in order to generate service costs and were obtained from a number of sources. UK unit costs were taken from a recognised national source [23]. Figures for most services in France and Germany were obtained from Medtap International [24]. A small number of costs were not available and therefore they were based on the costs from other countries and adjusted using ratios between the countries for costs that were available. Most figures from the UK represented actual costs whilst those provided by Medtap International represented a mixture of costs and charges. Care is thus required in making comparisons between countries.

The study recorded personal care input from family members and friends. Whilst care from friends or family members is rarely paid for, it still represents an important economic cost as the time spent caring could have been used in alternative activities. We made the assumption that if the family member or friend was not providing care then this would have to be provided by services and consequently we valued unpaid care at the cost of a home care worker. (Similarly, we could have argued that if the family member or friend was not caring for the patient then they could in theory use their skills to provide care in a paid capacity for someone else.)

Data on medications received were recorded for each patient in the study. Medication names were entered as free-text variables and approximately 1000 different names were recorded (some being the same medications with slightly different spellings or brand names). A pragmatic approach was taken whereby only medication taken by at least 1.5% of the sample was costed. The costs of drugs were obtained where possible from the British National Formulary (the most common source for such data in the UK) and combined with medication levels and period of receipt. Medication costs were subsequently converted to Euros by dividing by 0.663 (the exchange rate at the time of the study) [25]. All costs were inflated to 2007/8 prices and UK costs converted to Euros. The unit costs of specific services used in the study are shown in Appendix S2.

Analysis

Costs were reported for each country and strata (PSP/MSA) separately. Tests for significant differences between MSA and PSP were not conducted at this stage, as there could be differences between the samples in terms of patient characteristics that might also influence costs. The existence of significant differences in costs was, rather, explored using multivariate analyses. Two regression models were produced. In the first model the dependent variable was the total service costs excluding unpaid care costs. The second model used unpaid care costs as the dependent variable. Variables for inclusion in these two models were chosen because they described features that pre-disposed clients to use services (age, gender), features that enabled them to access services (educational attainment) and features that described their illness (PSP or MSA, disease duration, cognition, symptom severity) [26]. Cognition was measured with the MMSE (dichotomised into two groups with scores 0–27 and 28–30 due to the data distribution) whilst the NNIPPS-PPS total score was used as a global index of disease severity. Given the different service systems in each country and the fact that the unit costs (for reasons described above) may not be directly comparable, we have conducted separate regression analyses for each country and controlled for clustering in study sites.

Cost data are typically positively skewed and this can lead to similarly skewed residuals representing a violation of one of the assumptions on which ordinary least squares models are based. One option for addressing this is to use bootstrapping methods

which make no assumption about the underlying data distribution. However, the need for modelling the actual data distribution has been advocated [27]. We have here used a general linear model and specified that the data follow a gamma distribution (which cost data frequently do) and also specified a log link function. This allowed the proportional impact of a unit change in the independent variables on cost to be assessed which was more appropriate than assessing the direct impact given that we were analysing data from quite different service systems.

Results

Of the 760 patients in the ITT cohort usable data on service use was available at baseline for 742 participants (PSP n = 352, MSA n = 390). Population characteristics are shown in Table 1. The mean age was similar for all countries, and in each the PSP patients tended to be slightly older. In the UK there were relatively fewer women in the sample compared to France and Germany. Clinical characteristics (disease duration and severity) were very similar for PSP and MSA patients and in each country.

There were some similarities across the three countries in the use of services by patients with PSP (Table 2). The majority of patients had contacts with neurologists and around one-third with other specialists during the six-month period, and most had contacts with general practitioners. Most patients had also had adaptations to their homes, had prostheses such as wheelchairs or walking frames and received unpaid care from family or friends. Almost all received medication. Around one-quarter of patients spent some time in a residential or nursing home. There were some country differences to note. Physiotherapists were seen by around two-thirds of patients in France but by under half in the UK. Neurology inpatient care was used by relatively more patients in Germany (although other inpatient care was used by similar proportions). Social worker and speech therapist contacts were more likely in the UK. Nurses were seen by around two-thirds of all patients in France and the UK and fewer in Germany. Patients in Germany were more likely than those elsewhere to have received blood tests, EEGs and MRIs. Patients in France were the least likely to have received unpaid care from family/friends

(although two-thirds still did so). For those receiving specific services there were also large differences in the number of contacts. Residential care days were greater in number in Germany and least in the UK. Contacts with physiotherapists, social workers, nurses and speech therapists were far greater in both France and Germany compared to the UK. Of those patients using day care and home helps, the number of contacts was greatest in the UK. Patients who were admitted to hospital in France had shorter lengths of stay than in Germany or the UK. The final row of Table 2 shows that the mean six-month service costs were similar in France and the UK and around one-fifth higher in Germany.

There were very similar patterns of service use for patients with MSA (Table 3). Again, most patients had contacts with neurologists and general practitioners, and many had contacts with other specialists. Residential care was used less in Germany. Most patients received medication and had help from family and friends. Once again, there were fewer contacts with physiotherapists, nurses and speech therapists in the UK compared to France and Germany. The UK patients again had a higher number of day care contacts than the other countries. Mean six-month costs were highest in France, followed closely by Germany. Total costs in the UK were one-third lower in the UK compared to France.

The distribution of service costs (excluding unpaid care from family/friends) shows that in France, social care accounts for around one-third of PSP costs whilst in Germany and the UK the main contributor to PSP costs is inpatient care (Table 4). For MSA patients, inpatient care is the main contributor to cost in each country. Medication accounts for a very small amount of cost. Unpaid care from family/friends accounts for most of the costs. For PSP the contribution is 68% in France, 73% in Germany and 76% in the UK. For MSA the figures are 76%, 75% and 75% respectively.

Figures 1 and 2 show the relationship between total mean cost and symptom severity as measured with the NNIPPS-PPS scale. It can be seen that costs increase with severity in each country for PSP patients. This is also generally the case for MSA patients, although in the UK the patients with the highest severity do not have the highest costs.

Table 1. Patient characteristics.

| | France | | Germany | | UK | |
|---|---------------|---------------|--------------|---------------|---------------|--------------|
| | PSP (n = 149) | MSA (n = 158) | PSP (n = 98) | MSA (n = 134) | PSP (n = 105) | MSA (n = 98) |
| Age (years), mean (SD) | 69.3 (7.3) | 63.2 (8.3) | 67.3 (5.6) | 61.3 (7.5) | 66.1 (6.7) | 62.0 (9.2) |
| Female, n (%) | 75 (48) | 79 (48) | 39 (39) | 67 (50) | 40 (38) | 34 (34) |
| Education, n (%) | | | | | | |
| Illiterate | 3 (2) | 4 (3) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Primary school | 52 (34) | 47 (29) | 37 (37) | 40 (30) | 18 (17) | 15 (15) |
| Secondary school | 66 (43) | 59 (36) | 48 (48) | 64 (47) | 63 (60) | 51 (52) |
| Higher schooling | 17 (11) | 19 (12) | 5 (5) | 9 (7) | 13 (12) | 16 (16) |
| University/College | 17 (11) | 34 (21) | 10 (10) | 22 (16) | 11 (11) | 16 (16) |
| Clinical Global Impression score, mean (SD) | 3.8 (1.0) | 3.8 (0.9) | 3.7 (1.0) | 3.5 (0.9) | 3.4 (0.9) | 3.4 (1.0) |
| Short Motor Disability Scale, mean (SD) | 6.5 (3.6) | 6.4 (3.7) | 6.5 (3.9) | 5.8(3.8) | 6.6 (3.6) | 5.9 (3.7) |
| Disease duration (years), mean (SD) | 3.9 (1.7) | 4.4 (1.9) | 3.9 (1.9) | 4.3 (1.8) | 4.4 (2.2) | 4.8 (2.0) |
| Hoehn andYahr staging scale, mean (SD) | 3.6 (0.9) | 3.5 (1.0) | 3.7 (1.0) | 3.4 (1.1) | 3.5 (0.9) | 3.4 (1.0) |
| Parkinson's Plus Symptom scale, mean (SD) | 91.9 (31.3) | 87.8 (30.8) | 90.3 (29.4) | 80.6 (31.0) | 92.4 (30.1) | 83.4 (30.8) |
| Mini Mental State Examination, mean (SD) | 24.0 (5.4) | 26.8 (2.8) | 25.7 (4.2) | 28.8 (1.9) | 25.7 (3.9) | 28.0 (2.3) |

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Table 2. Service use and costs (2007/8 €s) for patients with progressive supranuclear palsy (PSP).

| | France | | | | | | Germany | | | | | | UK | | | | | |
|------------------------------|--------|-----|-----------------------|-------|-------------------|-------|---------|-----|-----------------------|-------|-------------------|-------|-------|-----|-----------------------|-------|-------------------|-------|
| | Users | | Contacts ¹ | | Cost ² | | Users | | Contacts ¹ | | Cost ² | | Users | | Contacts ¹ | | Cost ² | |
| | N | % | Mean | SD | Mean | SD | N | % | Mean | SD | Mean | SD | N | % | Mean | SD | Mean | SD |
| Neurologist | 113 | 77 | 2.8 | 2.8 | 83 | 117 | 74 | 76 | 4.6 | 7.3 | 122 | 304 | 85 | 81 | 1.8 | 1.2 | 425 | 348 |
| Other doctor | 43 | 29 | 2.4 | 2.5 | 27 | 68 | 32 | 33 | 1.8 | 1.1 | 17 | 34 | 39 | 37 | 2.4 | 2.5 | 123 | 263 |
| Day patient | 24 | 16 | 5.7 | 4.8 | 278 | 878 | 9 | 9 | 11.8 | 13.2 | 381 | 1829 | 11 | 11 | 30.8 | 34.7 | 936 | 4157 |
| Residential care | 15 | 10 | 88.7 | 79.9 | 1278 | 5329 | 6 | 6 | 159.2 | 42.4 | 1645 | 6781 | 6 | 6 | 45.7 | 60.3 | 367 | 2386 |
| Neurology inpat ³ | 23 | 15 | 7.5 | 11.0 | 446 | 1987 | 49 | 50 | 14.9 | 10.1 | 2306 | 3267 | 14 | 13 | 13.3 | 15.8 | 827 | 3361 |
| Other inpat ³ | 23 | 15 | 8.3 | 10.5 | 785 | 3404 | 16 | 16 | 19.1 | 20.3 | 1834 | 6407 | 20 | 19 | 18.2 | 27.3 | 1715 | 6743 |
| GP | 135 | 92 | 4.8 | 4.0 | 113 | 103 | 92 | 94 | 4.9 | 4.7 | 88 | 101 | 90 | 86 | 3.5 | 2.8 | 152 | 176 |
| Physiotherapist | 92 | 63 | 55.4 | 31.4 | 708 | 789 | 58 | 59 | 27.5 | 17.8 | 467 | 567 | 45 | 43 | 7.5 | 10.2 | 153 | 389 |
| Social worker | 10 | 7 | 41.8 | 66.2 | 1026 | 8316 | 1 | 1 | 26.0 | - | 35 | 347 | 30 | 29 | 2.8 | 3.4 | 91 | 309 |
| Nurse | 44 | 30 | 94.0 | 107.6 | 314 | 874 | 14 | 14 | 93.1 | 143.0 | 434 | 2047 | 35 | 33 | 9.9 | 30.2 | 65 | 380 |
| Speech therapist | 51 | 35 | 31.1 | 20.3 | 228 | 439 | 21 | 21 | 19.4 | 12.1 | 145 | 364 | 44 | 42 | 2.4 | 2.4 | 37 | 71 |
| Home help | 47 | 32 | 85.0 | 65.2 | 1859 | 5985 | 11 | 11 | 46.6 | 52.5 | 158 | 733 | 25 | 24 | 111.0 | 114.3 | 1009 | 5405 |
| Blood test | 73 | 49 | 1.7 | 1.6 | 21 | 37 | 78 | 79 | 2.7 | 3.0 | 65 | 88 | 45 | 43 | 2.4 | 4.2 | 26 | 74 |
| CT scan | 16 | 11 | 1.0 | 0.0 | 18 | 54 | 16 | 16 | 1.1 | 0.3 | 19 | 44 | 8 | 8 | 1.0 | 0.0 | 17 | 60 |
| EEG | 17 | 11 | 1.0 | 0.0 | 5 | 14 | 33 | 33 | 1.3 | 0.8 | 11 | 20 | 7 | 7 | 1.0 | 0.0 | 3 | 10 |
| MRI | 30 | 20 | 1.2 | 0.4 | 79 | 173 | 45 | 46 | 1.1 | 0.4 | 111 | 138 | 29 | 28 | 1.1 | 0.3 | 133 | 225 |
| Prostheses | 84 | 54 | - | - | 31 | 37 | 52 | 52 | - | - | 35 | 42 | 47 | 45 | - | - | 29 | 38 |
| Adaptations | 65 | 42 | - | - | 74 | 132 | 48 | 48 | - | - | 107 | 143 | 47 | 45 | - | - | 82 | 122 |
| Unpaid care ⁴ | 99 | 66 | 61.6 | 64.2 | 15814 | 24077 | 79 | 81 | 57.1 | 51.7 | 21574 | 25183 | 92 | 88 | 50.2 | 48.9 | 19327 | 21770 |
| Medication | 144 | 92 | - | - | 195 | 205 | 88 | 87 | - | - | 196 | 306 | 89 | 85 | - | - | 130 | 207 |
| Total | 149 | 100 | - | - | 24491 | 25231 | 98 | 100 | - | - | 30643 | 26209 | 105 | 100 | - | - | 25655 | 22823 |

¹Data on contacts are only for those using services,

²Data on costs are for whole sample,

³Contacts refer to number of days,

⁴Contacts refer to weekly hours.

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The regression analyses for formal care costs (i.e. excluding unpaid care from family/friends) reveals that costs were significantly associated with the NNIPPS-PPS scale, and this relationship was very similar in each country. In France, a one-unit increase in the PPS was associated with a 1.9% increase in costs, whilst in Germany and the UK the figure was 1.7%. In each country there was also an inverse relationship between formal care and unpaid care costs. If the latter increase by €1000 then there is a reduction in formal care costs of 1.2% in France and 1.1% in both Germany and the UK. In France women had formal care costs that were 35% higher on average than for men and those with further education had 63% higher costs than those with the most limited education. In Germany participants with MMSE scores between 28 and 30 had costs that were 48% higher than those with lower scores.

Unpaid care costs were also significantly associated with NNIPPS-PPS scores, with a slightly greater impact of a one-unit increase in Germany (2.2%) compared to France (1.6%) and the UK (1.3%). The inverse relationship with formal care costs was again apparent with similar impacts one a €1000 increase in France (3.7%), Germany (4.1%) and the UK (3.5%). Secondary education was associated with significantly lower unpaid care costs in both France and the UK, with the latter also having significantly lower costs for patients with a university education. In France, patients with PSP had significantly lower unpaid care costs than those with MSA whilst in the UK women had significantly lower costs than men.

There was no relation between costs, formal or unpaid, and age or disease duration.

Discussion

This is the first study of the costs of providing care for people with PSP and MSA, and we have found that patients with PSP and MSA use a wide range of services and that the mean six-month costs reported are substantial. Most of the costs are related to unpaid care. The costs detailed here are for only three countries and any extrapolation needs to be made with caution. However, using the lowest and highest costs for PSP (€24491 and €30643) and for MSA (€19103 and €28924) and the prevalence figures reported in the introduction suggests annual costs in the 27-country European Union of €1.2–2.7 billion for PSP and €1.1–3.0 billion for MSA. These are likely to be underestimates as the data used in these analyses relate to the six months prior to inclusion in the study (although average disease duration at that point was still approximately 4 years).

Service and unpaid family costs were higher for patients with higher scores on the NNIPPS-PPS which is what we would expect if resources are more likely to be required by those with greater levels of symptom severity. This suggests that interventions which successfully modify disease progression may reduce the economic burden of these conditions. Data on changes in the NNIPPS-PPS have been reported elsewhere [21]. If an intervention was able to

Table 3. Service use and costs (2007/8 €s) for patients with multiple system atrophy (MSA).

| | France | | | | | | Germany | | | | | | UK | | | | | |
|------------------------------|--------|-----|-----------------------|-------|-------------------|-------|---------|-----|-----------------------|-------|-------------------|-------|-------|-----|-----------------------|-------|-------------------|-------|
| | Users | | Contacts ¹ | | Cost ² | | Users | | Contacts ¹ | | Cost ² | | Users | | Contacts ¹ | | Cost ² | |
| | N | % | Mean | SD | Mean | SD | N | % | Mean | SD | Mean | SD | N | % | Mean | SD | Mean | SD |
| Neurologist | 137 | 87 | 2.8 | 1.6 | 99 | 116 | 111 | 83 | 4.6 | 4.4 | 130 | 169 | 86 | 87 | 1.6 | 1.2 | 434 | 400 |
| Other doctor | 49 | 31 | 2.2 | 2.0 | 27 | 61 | 67 | 50 | 3.1 | 2.9 | 52 | 98 | 33 | 33 | 2.2 | 1.4 | 103 | 184 |
| Day patient | 37 | 23 | 4.8 | 3.8 | 342 | 850 | 4 | 3 | 4.8 | 2.9 | 51 | 332 | 8 | 8 | 32.4 | 42.8 | 759 | 4200 |
| Residential care | 11 | 7 | 94.9 | 66.9 | 954 | 4349 | 1 | 1 | 174.0 | - | 224 | 2605 | 7 | 7 | 84.4 | 89.9 | 839 | 4373 |
| Neurology inpat ³ | 19 | 12 | 8.5 | 7.7 | 395 | 1504 | 51 | 38 | 16.5 | 11.0 | 1982 | 3327 | 15 | 15 | 7.7 | 4.8 | 547 | 1554 |
| Other inpat ³ | 28 | 18 | 15.5 | 33.6 | 1664 | 8481 | 21 | 16 | 16.7 | 16.2 | 1445 | 4925 | 17 | 17 | 8.0 | 8.5 | 676 | 2241 |
| GP | 145 | 92 | 5.1 | 4.1 | 126 | 114 | 115 | 86 | 5.4 | 7.3 | 92 | 161 | 86 | 87 | 3.4 | 2.9 | 137 | 174 |
| Physiotherapist | 108 | 68 | 54.2 | 33.2 | 773 | 808 | 104 | 78 | 37.8 | 21.5 | 864 | 733 | 43 | 43 | 9.3 | 11.3 | 205 | 490 |
| Social worker | 18 | 11 | 22.3 | 53.5 | 560 | 4600 | 4 | 3 | 1.5 | 0.6 | 3 | 21 | 28 | 28 | 3.5 | 3.1 | 86 | 207 |
| Nurse | 44 | 28 | 113.4 | 128.1 | 365 | 1026 | 11 | 8 | 117.3 | 132.0 | 321 | 1626 | 46 | 47 | 11.8 | 29.3 | 107 | 440 |
| Speech therapist | 52 | 33 | 34.4 | 24.0 | 240 | 500 | 44 | 33 | 21.8 | 16.2 | 234 | 475 | 37 | 37 | 3.4 | 4.2 | 59 | 195 |
| Home help | 33 | 21 | 88.2 | 65.2 | 627 | 1843 | 9 | 7 | 60.4 | 52.7 | 358 | 2600 | 13 | 13 | 117.1 | 163.2 | 347 | 1219 |
| Blood test | 68 | 43 | 1.9 | 2.1 | 21 | 43 | 93 | 69 | 2.4 | 3.1 | 50 | 86 | 44 | 44 | 2.0 | 1.7 | 22 | 38 |
| CT scan | 11 | 7 | 1.0 | 0.0 | 13 | 50 | 15 | 11 | 1.2 | 0.6 | 15 | 46 | 8 | 8 | 1.0 | 0.0 | 18 | 62 |
| EEG | 8 | 5 | 1.3 | 0.5 | 3 | 13 | 32 | 24 | 1.3 | 0.8 | 8 | 18 | 6 | 6 | 1.2 | 0.4 | 3 | 12 |
| MRI | 25 | 16 | 1.0 | 0.2 | 56 | 136 | 41 | 31 | 1.1 | 0.3 | 72 | 114 | 16 | 16 | 1.1 | 0.3 | 78 | 183 |
| Prostheses | 89 | 54 | - | - | 35 | 42 | 67 | 50 | - | - | 36 | 45 | 45 | 46 | - | - | 23 | 31 |
| Adaptations | 55 | 34 | - | - | 76 | 133 | 62 | 46 | - | - | 120 | 177 | 35 | 35 | - | - | 79 | 144 |
| Unpaid care ⁴ | 110 | 70 | 77.4 | 72.2 | 21130 | 28581 | 103 | 77 | 49.8 | 47.6 | 19036 | 24049 | 75 | 77 | 42.2 | 49.4 | 14186 | 20639 |
| Medication | 157 | 96 | - | - | 362 | 334 | 120 | 89 | - | - | 317 | 509 | 90 | 91 | - | - | 226 | 326 |
| Total | 158 | 100 | - | - | 28924 | 29317 | 134 | 100 | - | - | 25645 | 24284 | 98 | 100 | - | - | 19103 | 21372 |

¹Data on contacts are only for those using services,
²Data on costs are for whole sample,
³Contacts refer to number of days,
⁴Contacts refer to weekly hours.
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reduce the rate of progression by 30% this would lead to NNIPPS-PPS scores being 7.5 points lower for PSP and 5.4 points lower for MSA. While costs will still increase with progression, the regression models in Tables 5 and 6 suggest that services will be

13–14% lower for PSP and 9–10% lower for MSA. For unpaid care costs the reductions will be 10–17% and 7–12% lower respectively.

The costs of unpaid care were significantly lower for women than men in the UK. Life expectancy and caring roles help to explain this finding, although it is surprising that it was not observed in France or Germany. There was an inverse relationship between unpaid family care costs and service care costs, indicating that one substitutes for the other (although the percentage change associated with a €1000 increase is not great. Other variables were associated with cost but not in a consistent way.

Based on studies using a similar methodology, the six-month service costs of multiple sclerosis are around £8500 in the UK and €10000 in Germany [28,29]. Likewise, the six-month costs of Alzheimer’s disease in the UK is approximately €13000 per person and schizophrenia €5500 [30,31]. Whilst these figures indicate the high care needs of PSP and MSA relative to other conditions, it should be recognised that the total ‘burden’ will be less given the lower prevalence rates. Of particular interest, and in common with other degenerative conditions, is the fact that unpaid family care accounts for most of the cost [32].

There were a number of limitations with the study presented here. First, in order to measure service use comprehensively it was necessary to rely on patient self-report, with help from a carer if necessary. Whilst the schedule used to measure service use is well developed and has been used in numerous other studies, it may

Table 4. Distribution of service costs (%).

| Service | PSP | | | MSA | | |
|---------------------------|--------|---------|------|--------|---------|------|
| | France | Germany | UK | France | Germany | UK |
| Hospital doctor | 1.5 | 1.6 | 8.7 | 1.9 | 2.8 | 11.3 |
| Day patient | 3.7 | 4.7 | 14.8 | 5.1 | 0.8 | 16.1 |
| Residential care | 16.9 | 20.2 | 5.8 | 14.2 | 3.5 | 17.8 |
| Inpatient | 16.2 | 50.7 | 40.2 | 30.6 | 53.4 | 25.8 |
| GP | 1.5 | 1.1 | 2.4 | 1.9 | 1.4 | 2.9 |
| Other health professional | 16.5 | 12.6 | 4.0 | 20.5 | 22.1 | 7.9 |
| Social care | 38.1 | 2.4 | 17.4 | 17.6 | 5.6 | 8.9 |
| Investigations/tests | 1.6 | 2.5 | 2.8 | 1.4 | 2.3 | 2.6 |
| Prostheses/adaptations | 1.6 | 2.2 | 1.9 | 1.9 | 3.1 | 2.2 |
| Medication | 2.5 | 2.2 | 2.1 | 5.1 | 4.9 | 4.7 |

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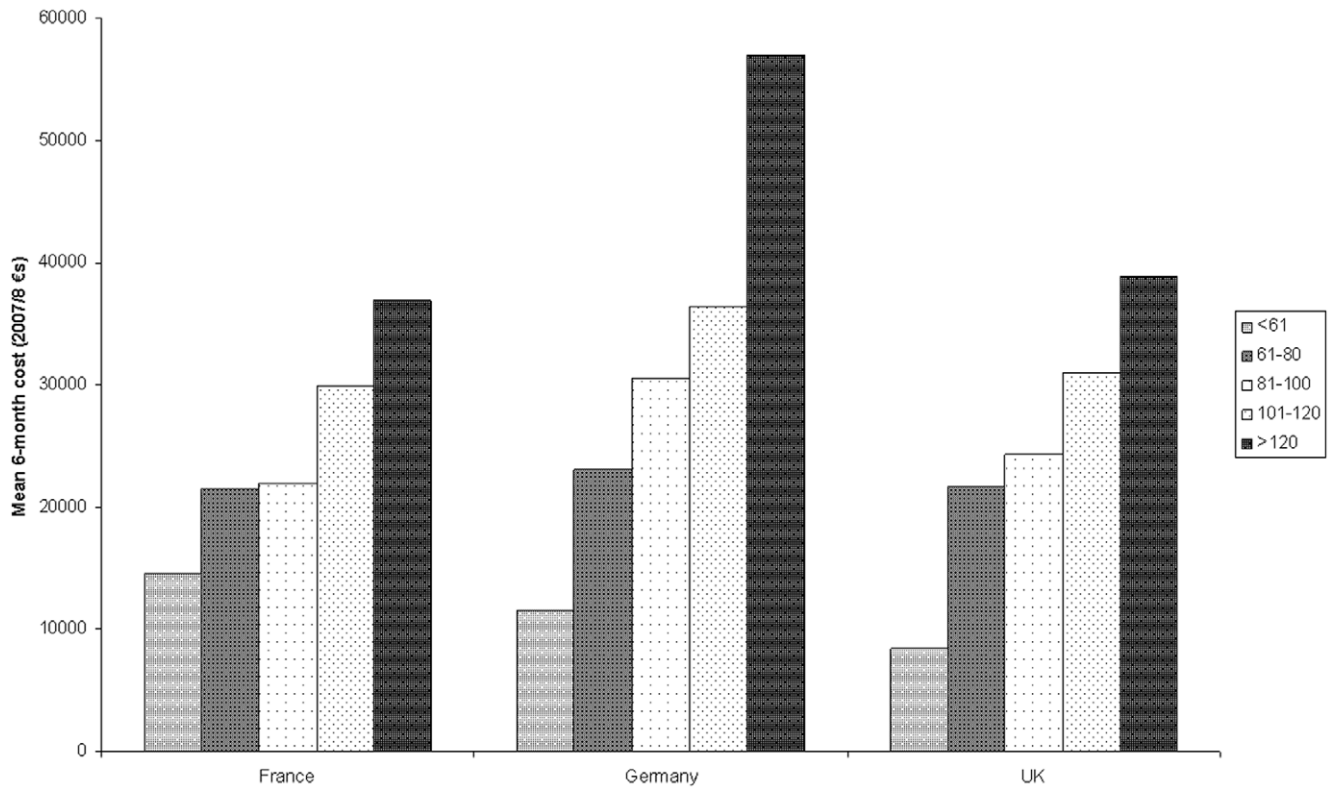


Figure 1. Total costs by symptom severity based on PPS scale (PSP patients).
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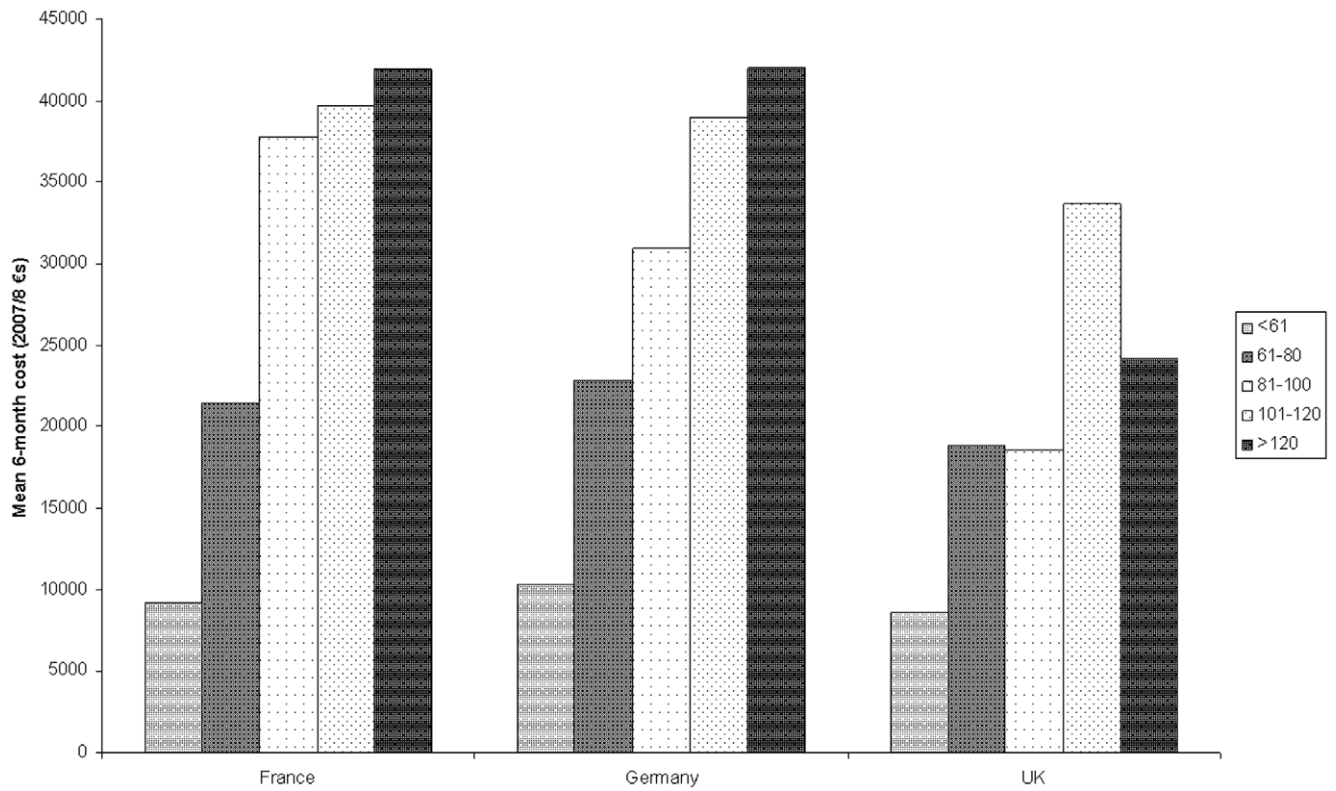


Figure 2. Total costs by symptom severity based on PPS scale (PSP patients).
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Table 5. Regression analysis of formal service costs.

| | France | | | Germany | | | UK | | |
|-----------------------------------|---------------|---------------|----------------|---------------|---------------|----------------|---------------|---------------|---------------|
| | B | 95% CI LL | 95% CI UL | B | 95% CI LL | 95% CI UL | B | 95% CI LL | 95% CI UL |
| PSP strata ¹ | -0.034 | -0.39 | 0.32 | 0.21 | -0.11 | 0.53 | 0.053 | -0.34 | 0.45 |
| Age | 0.007 | -0.0094 | 0.023 | 0.012 | -0.011 | 0.034 | -0.0035 | -0.032 | 0.025 |
| Female gender ² | 0.35 | 0.093 | 0.61 | 0.28 | -0.076 | 0.63 | -0.057 | -0.34 | 0.22 |
| Duration of disease | -0.0038 | -0.076 | 0.069 | -0.056 | -0.12 | 0.011 | -0.0033 | -0.1 | 0.096 |
| Secondary education ³ | 0.27 | -0.049 | 0.6 | 0.036 | -0.37 | 0.44 | -0.12 | -0.51 | 0.28 |
| Further education ³ | 0.63 | 0.24 | 1 | -0.13 | -0.59 | 0.34 | 0.36 | -0.12 | 0.85 |
| University education ³ | 0.23 | -0.19 | 0.64 | -0.03 | -0.35 | 0.29 | -0.16 | -0.84 | 0.51 |
| PPS score | 0.019 | 0.013 | 0.025 | 0.017 | 0.012 | 0.022 | 0.017 | 0.012 | 0.023 |
| MMSE 28–30 ⁴ | 0.13 | -0.13 | 0.39 | 0.48 | 0.099 | 0.87 | -0.26 | -0.66 | 0.14 |
| Unpaid care costs ⁵ | -0.012 | -0.015 | -0.0092 | -0.011 | -0.018 | -0.0047 | -0.011 | -0.018 | -0.046 |

¹compared to MSA strata,
²compared to males,
³compared to illiterate or primary education only,
⁴compared to MMSE score 0–27,
⁵in €000s.
doi:10.1371/journal.pone.0024369.t005

still be the case that for some patients recall was difficult and this would have led to inaccuracies. A number of studies have suggested that patient recall of service use can be acceptable [33–35]. Another study noted a difference between self-report and administrative records, but pointed out that it was unclear which was more accurate [36]. Mirandola et al indicate that agreement between *total* costs based on self-report and administrative systems is good, but that special care is required when focussing on individual cost components [37]. Second, there were within- and between-country variations in the way in which unit costs were

calculated. Between-country variations were addressed to some extent by including country variables in the regression models (and these were not statistically significant). Data for France and Germany consisted of a mixture of actual costs and charges. It is unclear to what extent the inclusion of the (second-best) charge data will have had on the results. If charges were approximately equal to costs then any effects would be small. Third, this paper only examines costs and not the quality of care provided. It may be that some services are not actually having a beneficial impact on health or quality of life (in which case the costs would be too high)

Table 6. Regression analysis of unpaid care costs.

| | France | | | Germany | | | UK | | |
|-----------------------------------|---------------|---------------|----------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | B | 95% CI LL | 95% CI UL | B | 95% CI LL | 95% CI UL | B | 95% CI LL | 95% CI UL |
| PSP strata ¹ | -0.34 | -0.68 | -0.0057 | 0.058 | -0.19 | 0.31 | 0.12 | -0.3 | 0.54 |
| Age | 0.015 | -0.013 | 0.042 | 0.015 | -0.003 | 0.032 | 0.0089 | -0.016 | 0.033 |
| Female gender ² | -0.25 | -0.61 | 0.11 | 0.063 | -0.081 | 0.21 | -0.4 | -0.6 | -0.2 |
| Duration of disease | -0.011 | -0.12 | 0.1 | 0.0066 | -0.048 | 0.061 | 0.0064 | -0.047 | 0.06 |
| Secondary education ³ | -0.34 | -0.68 | -0.0038 | 0.11 | -0.32 | 0.54 | -0.48 | -0.7 | -0.26 |
| Further education ³ | -0.68 | -1.51 | 0.14 | 0.051 | -0.52 | 0.62 | -0.41 | -0.95 | 0.13 |
| University education ³ | -0.37 | -0.8 | 0.06 | -0.11 | -0.53 | 0.3 | -1.2 | -1.8 | -0.62 |
| PPS score | 0.016 | 0.0063 | 0.026 | 0.022 | 0.016 | 0.028 | 0.013 | 0.0063 | 0.02 |
| MMSE 28–30 ⁴ | 0.045 | -0.37 | 0.46 | 0.19 | -0.15 | 0.52 | -0.28 | -0.64 | 0.083 |
| Formal care costs ⁵ | -0.037 | -0.056 | -0.018 | -0.041 | -0.072 | -0.009 | -0.035 | -0.047 | -0.024 |

¹compared to MSA strata,
²compared to males,
³compared to illiterate or primary education only,
⁴compared to MMSE score 0–27,
⁵in €000s.
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or there may be unmet needs (in which case the costs may be too low). Finally, the regression models attempted to identify predictors of cost, but clearly some patient characteristics that could have influenced cost would have been unmeasured.

In conclusion, these results show PSP and MSA to have substantial economic costs, which reveals the many care inputs that these patients require. Costs are appropriately related to indicators of illness severity. Of great importance is the input provided by unpaid carers (family and friends). Costs are significantly associated with symptom severity and if this can be modified then substantial reductions may be realised.

Supporting Information

Appendix S1 Client Service Receipt Inventory. (DOC)

Appendix S2 Unit costs used in cost calculations (Euro's). (DOC)

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