The economic cost of brain disorders in Europe

J. Olesen[a], A. Gustavsson[b,c], M. Svensson[d], H.-U. Wittchen[e] and B. Jönsson[f] on behalf of the CDBE2010 study group* and the European Brain Council†

[a]*Department of Neurology, Glostrup Hospital, University of Copenhagen, Copenhagen, Denmark;* [b]*i3 Innovus, Stockholm;* [c]*KI Alzheimer's Disease Research Center, Karolinska institutet, Stockholm;* [d]*Department of Economics and Statistics, Karlstad University, Karlstad, Sweden;* [e]*Institute of Clinical Psychology and Psychotherapy, Centre of Clinical and Epidemiological and Longitudinal Studies, Technische Universitaet Dresden, Dresden, Germany; and* [f]*Department of Economics, Stockholm School of Economics, Stockholm, Sweden*

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Background and purpose: In 2005, we presented for the first time overall estimates of annual costs for brain disorders (mental and neurologic disorders) in Europe. This new report presents updated, more accurate, and comprehensive 2010 estimates for 30 European countries.

Methods: One-year prevalence and annual cost per person of 19 major groups of disorders are based on 'best estimates' derived from systematic literature reviews by panels of experts in epidemiology and health economics. Our cost estimation model was populated with national statistics from Eurostat to adjust to 2010 values, converting all local currencies to Euros (€), imputing cost for countries where no data were available, and aggregating country estimates to purchasing power parity–adjusted estimates of the total cost of brain disorders in Europe in 2010.

Results: Total European 2010 cost of brain disorders was €798 billion, of which direct health care cost 37%, direct non-medical cost 23%, and indirect cost 40%. Average cost per inhabitant was €5.550. The European average cost per person with a disorder of the brain ranged between €285 for headache and €30 000 for neuromuscular disorders. Total annual cost per disorder (in billion € 2010) was as follows: addiction 65.7; anxiety disorders 74.4; brain tumor 5.2; child/adolescent disorders 21.3; dementia 105.2; eating disorders 0.8; epilepsy 13.8; headache 43.5; mental retardation 43.3; mood disorders 113.4; multiple sclerosis 14.6; neuromuscular disorders 7.7; Parkinson's disease 13.9; personality disorders 27.3; psychotic disorders 93.9; sleep disorders 35.4; somatoform disorder 21.2; stroke 64.1; and traumatic brain injury 33.0.

Conclusion: Our cost model revealed that brain disorders overall are much more costly than previously estimated constituting a major health economic challenge for Europe. Our estimate should be regarded as conservative because many disorders or cost items could not be included because of lack of data.

Introduction

The economic cost of diseases is becoming an increasingly important parameter for health and research policies, but solid estimates are often missing. At the European level, this is the rule rather than the exception. For policy analysis (the main aim of cost estimates), it is useful to keep mental and neurologic disorders together under the term brain disorders, just like cardiovascular diseases are viewed together despite differing etiology [1]. Also, research discovers mechanisms that are of equal importance to mental and neurologic disorders [2]. World Health Organization (WHO) data indicate that, together, these disorders account for one-third of the burden of all diseases in the wealthy part of the world [3]. Estimates of the cost of brain disorders complement burden of disease estimates, providing information about the economic consequences of morbidity. The European Brain Council (EBC) is a federation of European wide organizations with an interest in the brain and its disorders (http://www.europeanbraincouncil.org). It initiated a

Correspondence: Prof. J. Olesen, Faculty of Health Science, University of Copenhagen and Department of Neurology, Glostrup Hospital, Nordre Ringvej 57, 2600 Glostrup, Denmark (tel.: +45 43233036; fax: +45 43233033; e-mail: jeol@glo.regionh.dk).

*Members listed in Appendix 1.

†Information about the sponsoring organization, the European Brain Council, is available at its Web site: http://www.europeanbraincouncil.org

study of the economic cost of brain disorders in Europe in 2004, revealing that the total cost for Europe was 386 billion € for the year 2004 [4]. In many ways, that study was covering new ground by focusing on Europe as an entity, by presenting cost for all European countries and by studying mental and neurologic disorders together. However, the necessary epidemiologic and/or economic data were not available for many items or for many disorders. In the mean time, more such data have become available allowing a major new study that includes 30 European countries. Essentials of that study are presented here, whilst a very extensive report will be published separately [5].

Methods

A description of the methodology of this study is presented elsewhere in greater detail [5,6].

Study organization and search criteria

The study was planned and organized by the present authors who formed a steering group. Nineteen subcommittees, one for each group of disorders, consisting of epidemiologic and health economic experts from all over Europe [5] performed systematic literature reviews with explicit search criteria regarding the prevalence and cost of brain disorders in Europe, using relevant search terms in all major search engines as well as reference lists from recovered articles. To be included, studies needed to report (i) state-of-art data on the prevalence or cost or resource use, (ii) diagnostic information according to the World Health Organization's ICD-10 (http://apps.who.int/classifications/apps/icd/icd10online/or) Diagnostic and Statistical Manual of Mental Disorders (DSM-IVTR [7]), and (iii) data from any of 30 European countries (EU27, Iceland, Norway, and Switzerland) or combinations of countries. Additionally, reanalysis of available epidemiologic studies was conducted to estimate effects of comorbidity, age, and gender. Studies should have a sound and robust methodology for patient selection, data collection, instrumentation, statistical analysis, and reporting of results. We selected the most common brain disorders for which a preliminary search indicated that a necessary minimum of data were available. This applied to 12 group of disorders already addressed in our 2004 report, namely addictive disorders (i.e., alcohol dependence, opiate dependence), affective disorders (i.e., bipolar disorder and major depression), psychotic disorders (i.e., schizophrenia), anxiety disorders (panic and generalized anxiety disorder, obsessive-compulsive and post-traumatic stress disorders, agoraphobia, social, and specific phobia) and somatoform disorders, brain tumor, dementia, epilepsy, migraine, multiple sclerosis, Parkinson's disease, stroke, and traumatic brain injury. Further seven disorders were newly considered, namely specific eating disorders (anorexia and bulimia nervosa), child and adolescent disorders (i.e., attention deficit and hyperkinetic disorders, conduct disorders), mental retardation, personality disorders, sleep disorders as well as neuromuscular disorders.

A large number of the full spectrum of over 500 mental and neurologic disorders could not be included owing to lack of appropriate epidemiologic and economic data.

Geographic scope and cost approach

We included all member states of the European Union (EU) plus Iceland, Norway, and Switzerland with a total 2010 population of 514 million. Age-specific 12-month prevalence for each disorder was derived from the epidemiologic reviews and was estimated on the basis of age-specific prevalence in terms of number of persons affected by this disorder. As a result of a substantial proportion of patients with more than one diagnosis (for example, depression and anxiety disorders), the aggregate number of patients was reduced based on the available evidence of comorbidity in each disorder to reduce the risk of double counting (for details see Ref. [6]). We included the direct health care, direct non-medical, and indirect cost of all resources used or lost owing to illness, irrespective of payer. Direct health care cost, direct non-medical cost, and indirect cost were estimated separately and added to give the total disease cost. For most disorders and countries, cost data collected with a bottom–up approach were available, which provided a direct source for estimating the cost per patient. In a few instances (e.g., addiction in France and Spain), only aggregated cost data collected with a top–down approach was available from which we could estimate a per patient cost by dividing by the estimated number of patients. Our approach was prevalence based (in terms of 12-month diagnoses) as most brain disorders are long lasting or chronic and usually incur cost over many years. To the extent possible, cost data were derived from populations comparable to those used for estimating prevalence and adjusted where needed, e.g., by only considering direct health care costs for the proportion of patients on active treatment.

European cost-of-illness model and validation

Epidemiologic data were available for many, but not for all countries. We therefore conducted separate surveys with country-specific experts in all European

countries to assess whether available rates from other countries were also considered appropriate for each respective country. In case of evidence for differences, adjustments were made (for example, for addiction).The resulting 'best-prevalence estimate' (EU: 12-month median) was used in countries where no prevalence data were available.

Cost data were available for fewer countries, and we imputed values for countries with no data. Furthermore, cost data were from different years. To arrive at values for all of Europe in 2010, imputations were made to adjust for such differences [5]. Cost data were multiplied with the inflation rate in the relevant country using the consumer price index. National currencies were converted into € using nominal exchange rates from the European Central Bank adjusted for comparative price levels (i.e., purchasing power parity–adjusted exchange rates). The national health care expenditure was used to adjust direct health care cost, the gross domestic product for direct non-medical cost, and the wage level for indirect cost.

To arrive at a value for Europe, the cost per patient was multiplied by the number of persons affected as derived from the 12-month estimates for each country. Finally, cost values for each country were added to arrive at the cost in Europe.

The results of this study were validated by comparing to the former cost study, to external data from administrative data bases, to other European reviews and data from the United States.

Role of funding sources

The sponsor of the study, the EBC, is a professional, not for profit organization, representing a number of European wide professional and patient organizations. Funding was given to the EBC with the only restriction being that the funds must be used for the study of the cost of brain disorders. The present authors were appointed by the EBC, but the organization had no influence on the planning, execution, or writing up of the study. The funding came from two professional organizations and one pharmaceutical company. Neither of them had anything to do with planning, execution, or writing up of the study. Thus, the present report is entirely the responsibility of the authors and the study group behind them.

Results

Prevalence and cost per person of different disorders

The cost per subject with a disorder of the brain was highly variable by disorder. A person with a neuromuscular disorder, for example, was estimated to cost € 30 000 per year and a subject with a headache disorder € 285. The prevalence and cost of each of the 19 groups of disorders and of their subdiagnoses for all of Europe are presented in Table 1. Headache disorders and anxiety disorders were the most prevalent but at the same time had the lowest cost per patient. Neuromuscular disorders and brain tumors were comparatively rare but very costly per case. Mood disorders (bipolar disorder and major depression), dementia, and stroke were common as well as costly per case. The high cost of mental retardation, sleep disorders, and headache disorders is perhaps surprising, considering the low level of attention devoted to these disorders. In Fig. 1, we present the total cost for each of the 19 groups of brain disorders.

Distribution on different types of costs

There was a large variation in the distribution of cost categories across disorders. The relative distribution is shown in Fig. 2. Persons with eating disorders had the highest proportion of direct health care cost (72%), whereas these only constituted 12% in child/adolescent or personality disorders. The direct non-medical cost constituted the highest proportion in child/adolescent disorders (88%) and dementia (84%). Indirect cost made up the bulk of the cost in personality disorders (78%) and headache (79%).

Aggregated cost

The aggregated cost was € 798 billion for all 19 groups of disorders in the whole of Europe in 2010. The majority of the estimated cost of brain disorders was direct cost, 60%, divided into direct health care cost 296 billion and direct non-medical cost 186 billion. Indirect cost at 315 billion constituted the remaining 40% (Fig. 3).

Country-specific estimates

Per capita costs for all European countries are given in Table 2. The mean cost per capita in Europe was estimated at € 1550. The total cost for all brain disorders in individual countries ranged between 437 million in Malta and 153 billion in Germany (Table 2). The country-specific estimates should be interpreted with some caution as they are a result of model estimations from the European cost model.

Validations

Our estimate of the cost in 2010 of the 12 disorders included in our previous study [4] was almost exactly

Table 1 Number of subjects affected and cost of brain disorders in Europe by diagnostic group and selected specific diagnoses

Disorders	Estimated number of subjects affected (millions)	Cost per patient (€PPP 2010)				Total costs (million €PPP 2010)			
		Direct health care costs	Direct non-medical costs	Indirect costs	Total	Direct health care costs	Direct non-medical costs	Indirect costs	Total
Addiction	15.5	1782	873	1572	4227	27 685	13 569	24 430	65 684
Alcohol dependence	14.6	1689	922	1671	4281	24 596	13 430	24 336	62 361
Opioid dependence	1.0	3176	143	98	3416	3089	139	95	3323
Anxiety disorders	69.1	670	2	405	1077	46 267	144	27 969	74 380
Agoraphobia	8.8	337	0	760	1097	2959	0	6675	9634
GAD	8.9	988	0	226	1214	8786	0	2014	10 800
OCD	2.9	555	0	225	779	1617	0	656	2272
Panic disorder	7.9	844	0	661	1505	6670	0	5224	11 894
PTSD	7.7	1064	19	0	1082	8241	144	0	8385
Social phobia	10.1	721	0	476	1196	7277	0	4806	12 083
Specific phobia	22.7	472	0	378	850	10 717	0	8595	19 312
Brain tumor	0.2	13 387	0	8203	21 590	3208	0	1966	5174
Child/Adolescent disorders	5.9	439	3156	0	3595	2601	18 724	0	21 326
ADHD	3.3	477	304	0	781	1555	992	0	2546
Autism	0.6	1255	26 006	0	27 261	695	14 413	0	15 109
Conduct disorder	2.1	166	1569	0	1735	352	3319	0	3671
Dementia	6.3	2673	13 911	0	16 584	16 949	88 214	0	10 5163
Eating disorders	1.5	400	48	111	559	593	70	164	827
Anorexia	0.8	710	80	188	978	583	65	154	803
Bulimia	0.7	15	8	15	38	10	5	10	25
Epilepsy	2.6	2461	625	2136	5221	6503	1653	5644	13 800
Headache	152.8	59	0	226	285	9039	0	34 475	43 514
Medicine overuse headache	8.3	305	0	1986	2291	2533	0	16 503	19 037
Migraine	49.9	84	0	286	370	4181	0	14 282	18 463
Other headaches	10.2	33	0	24	57	333	0	249	582
Tension type headache	84.4	24	0	41	64	1991	0	3441	5433
Mental retardation	4.2	6970	3364	0	10 334	29 204	14 097	0	43 301
Mood disorders	33.3	781	464	2161	3406	26 016	15 437	71 952	11 3405
Bipolar disorder	3.0	622	560	6002	7183	1860	1675	17 956	21 491
Major depression	30.3	797	454	1782	3034	24 156	13 762	53 996	91 914
Multiple sclerosis	0.5	9811	8438	8725	26 974	5295	4554	4709	14 559
Neuromuscular disorders	0.3	7133	5641	17 278	30 052	1834	1450	4442	7726
ALS	0.1	11 240	11 559	4665	27 463	596	613	247	1457
CIDP	0.0	15 507	2746	3759	22 012	223	40	54	317
GBS	0.0	51 682	0	2319	54 001	342	0	15	358
MMN	0.0	15 507	2747	3759	22 012	40	7	10	57
Muscular dystrophies	0.1	1320	5547	30 186	37 053	177	744	4050	4972
Myasthenia gravis	0.0	9124	779	1111	11 014	375	32	46	453
PDN	0.0	15 507	2746	3759	22 012	80	14	19	113
Parkinson's disease	1.2	5626	4417	1109	11 153	7029	5519	1386	13 933
Personality disorders	4.3	773	625	4929	6328	3342	2701	21 301	27 345
Antisocial PD	2.0	561	0	2737	3297	1118	0	5458	6576
Borderline PD	2.3	956	1161	6809	8925	2224	2701	15 843	20 769
Psychotic disorders	5.0	5805	0	12 991	18 796	29 007	0	64 920	93 927
Sleep disorders	44.9	441	0	348	790	19 796	0	15 630	35 425
Hypersomnia	3.1	820	0	458	1278	2562	0	1430	3992
Insomnia	29.1	153	0	0	153	4465	0	0	4465
Narcolepsy	0.1	1851	0	3784	5635	170	0	347	516
Sleep apnea	12.5	1008	0	1109	2117	12 599	0	13 853	26 452
Somatoform disorder	20.4	468	0	570	1037	9547	0	11 622	21 169
Stroke	8.2	5141	2035	599	7775	42 352	16 769	4932	64 053
Stroke (incident)	1.3	13 850	5534	1616	21 000	17 570	7021	2050	26 641
Stroke (prevalent)	7.0	3556	1399	413	5368	24 782	9748	2882	37 412

Table 1 (*Continued*)

Disorders	Estimated number of subjects affected (millions)	Cost per patient (€PPP 2010)				Total costs (million €PPP 2010)			
		Direct health care costs	Direct non-medical costs	Indirect costs	Total	Direct health care costs	Direct non-medical costs	Indirect costs	Total
Traumatic brain injury	3.7	2697	893	5219	8809	10 106	3348	19 560	33 013
Trauma (incident)	1.2	4158	52	4156	8366	5023	62	5021	10 106
Trauma (prevalent mod/sev)	2.5	2002	1294	5725	9020	5083	3285	14 539	22 907
Total	Number of diagnoses 380.1					296 374	18 6250	315 101	797 725

GAD, generalized anxiety disorder; OCD, obsessive-compulsive disorder; PTSD, post-traumatic stress disorder; ADHD, attention deficit hyperactivity disorder; ALS, amyotrophic lateral sclerosis; CIDP, chronic inflammatory demyelinating polyradiculoneuropathy; GBS, Guillain–Barré syndrome; MMN, multifocal motor neuropathy; PDN, paraproteinemic polyneuropathies; PD, personality disorder.

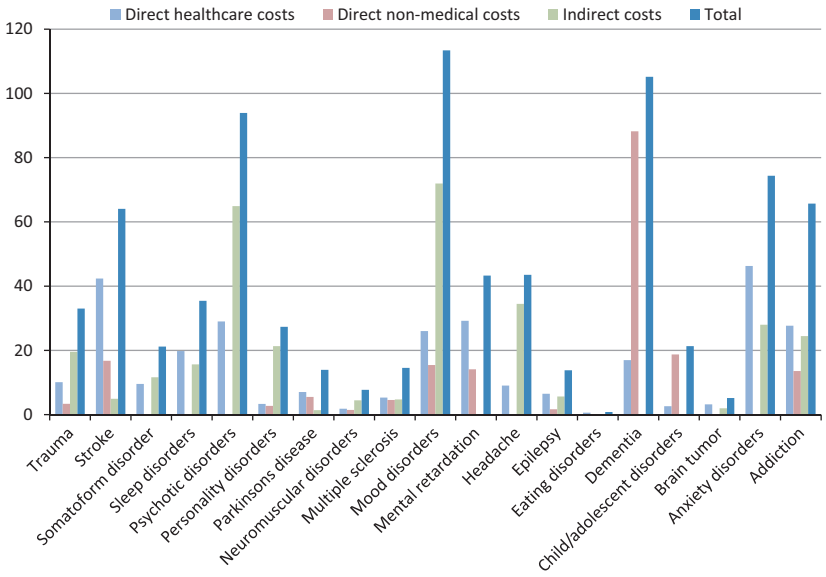

Figure 1 Absolute cost and type of cost of 19 brain disorders in Europe (billion €PPP 2010) (note: type of costs could not be estimated for all disorders).

the same as in 2004 when corrected for inflation and increase in population. The total direct health care cost in Europe in 2010 was € 1.260 billion (OECD statistics, 2011, available at http://stats.oecd.org). Our estimate for brain disorders of 296 billion corresponded to 24% of this figure. Cost of dementia in Europe was estimated by Wimo *et al.* [8] to € 160 billion or 60% higher than our estimate, mostly owing to the rather uncertain estimates of the cost of informal care. Other studies in epilepsy, stroke, and multiple sclerosis obtained results similar to ours [9–11]. US data were compared with our values for Germany because of the similar economic level of the two countries. For anxiety disorders and sleep disorders, similar results were obtained, but for the majority of disorders, cost in the United States was higher in agreement with the much higher cost of direct health care in the United States [12–17].

Discussion

The present study showed that the total cost of brain disorders (mental and neurologic disorders) in Europe in 2010 was € 798 billion. Direct health care cost was 295 billion, non-medical cost (nursing homes etc.) 186 billion, and the indirect cost (absenteeism from work, pensions etc.) 315 billion. This high cost of brain disorders may be surprising, but WHO data suggest that brain disorders cause one-third of the burden of all diseases and are thus in agreement with the present study [3]. Inputs to the present study were the 1-year prevalence and the annual cost per case of 19 groups of brain disorders (mental and neurologic disorders combined) in the European Union plus Iceland, Norway, and Switzerland with a total population of 514 million. Almost one hundred experts participated in this

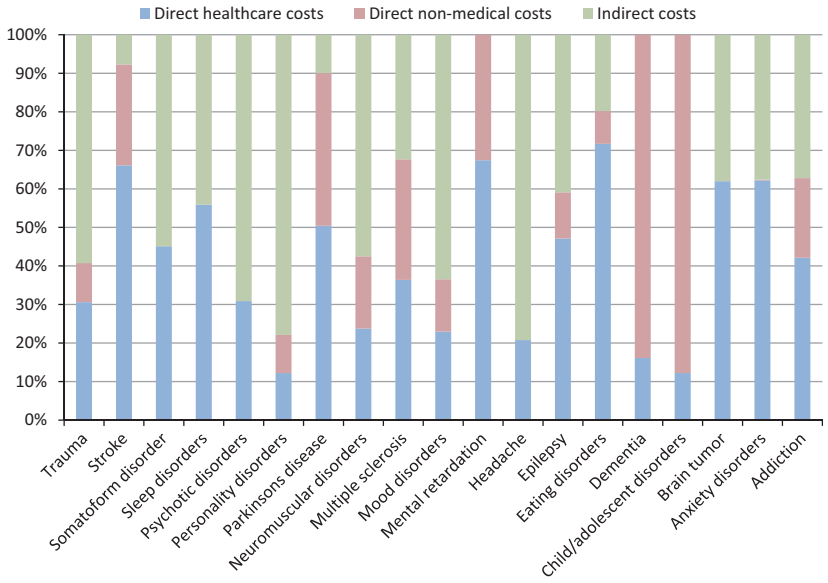

Figure 2 Relative direct health care, direct non-medical, and indirect cost in Europe of 19 brain disorders (note: type of costs could not be estimated for all disorders).

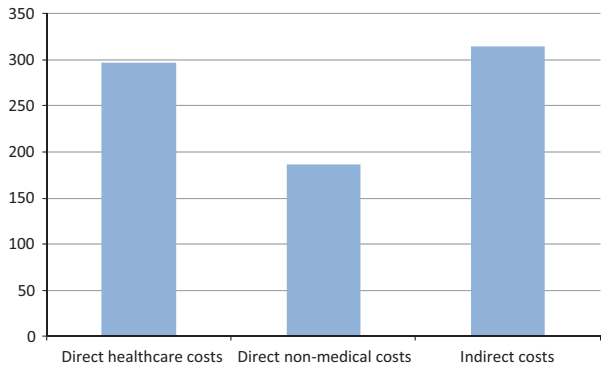

Figure 3 Total cost of brain disorders in Europe (billion €PPP 2010).

extensive project to achieve the best possible estimates. The number of diagnoses of brain disorders in 1 year was 380 million in Europe. This is not the number of affected persons, however, because many have two or more diagnoses. According to our recent estimate, approximately one-third of the population in Europe were affected by at least one brain disorder within a given year [6].

A number of methodological uncertainties must be mentioned. Whilst the epidemiologic data are mostly solid, data were not available from all European countries and had to be imputed for the rest. Economic data were more scarce and in some instances, only available from one or a few countries. Further, indirect costs are dependent on assumptions on the value of lost

Table 2 Population size, cost per capita, and total cost by country in Europe (€PPP 2010)

Country	Population size	Per capita cost	Total costs
Austria	8 375 290	1910	15 996
Belgium	10 827 000	1699	18 396
Bulgaria	7 563 710	421	3181
Cyprus	803 147	1118	898
Czech Republic	10 506 813	970	10 190
Denmark	5 534 738	1773	9813
Estonia	1 340 127	747	1001
Finland	5 351 427	1610	8617
France	64 714 074	1658	107 301
Germany	81 802 257	1867	152 719
Greece	11 305 118	1414	15 990
Hungary	10 014 324	867	8682
Iceland	317 630	1804	573
Ireland	4 467 854	1703	7611
Italy	60 340 328	1433	86 459
Latvia	2 248 374	691	1554
Lithuania	3 329 039	631	2101
Luxembourg	502 066	2607	1309
Malta	412 970	1059	437
The Netherlands	16 574 989	1802	29 861
Norway	4 858 199	2104	10 222
Poland	38 167 329	775	29 588
Portugal	10 637 713	1234	13 130
Romania	21 462 186	525	11 263
Slovakia	5 424 925	735	3988
Slovenia	2 046 976	1185	2425
Spain	45 989 016	1692	77 791
Sweden	9 340 682	1882	17 580
Switzerland	7 785 806	1872	14 573
United Kingdom	62 008 048	2169	134 476

production, which adds to the uncertainty in our estimates. Despite these uncertainties, data for each individual country are probably reasonably precise because of the use of our robust health economic model [5]. In any case, they are the best European data available. Another issue is whether the aggregated figure of the total cost of brain disorders in all of Europe is correct or over- or underestimated. It is difficult to attribute the resource use and indirect cost to a specific disorder if a person suffers from more than one disorder. This may lead to the same cost being included in more than one disorder, so-called double counting. To the extent possible, we have corrected for double counting in the cost estimates by considering the excess cost for each disorder (i.e., the additional cost that a person with the disorder causes, irrespective of whether they have any other disorders) [6]. Thereby, we have not attempted to correct for double counting in the number of persons with the disorder, but instead in what additional cost they incur. Still, the available evidence is limited, and we have not considered all overlap between the 19 disorders and the individual diagnoses within each of these disorders. The best way of avoiding double counting would have been a field study in all 30 European countries of representative populations who recorded disease-specific cost prospectively. We have previously estimated for a grant application that such a study, even after compromises and simplifications, would cost in excess of 100 million Euros and, hence, be impossible to finance. In the present study, we did everything possible to correct for double counting, but some degree of overestimation cannot be ruled out.

Although we covered the highly prevalent disorders, there are hundreds of less common disorders, some very costly per patient, that were not included because of the lack of data. We also did not include indirect cost of insomnia, mild head trauma, mental retardation, and developmental disorders, all expected to be of considerable magnitude. The cost of crime because of addiction or personality disorder was not included. Appetite regulation is a brain phenomenon, but obesity was not included under eating disorders. On balance, we consider the risk of underestimation far greater than the risk of overestimation.

A comparison to the cost of other major disease categories is important but uncertain because of scarcity of data for other diseases and differing methodologies. The European Heart Network reported a cost of cardiovascular disorders of € 192 billion (http://www.ehnheart.org). The cost of cancer was estimated differently in different studies to be between 150 and 250 billion [18] (http://www.comparatorreports.se). The direct health care cost of diabetes was between 20 and 83 billion, to which unknown indirect cost should be added [19]. The cost of rheumatoid arthritis was 25 billion (http://www.comparatorreports.se) and of chronic obstructive lung disease 39 billion [20]. Thus, several brain disorders were considerably more expensive than conditions otherwise considered to be very costly. WHO previously projected that major depression in future would top the list of the 20 most burdensome disorders in the Western world. This has already happened in Europe [6].

The total annual cost figure of brain disorders, 798 billion Euros, makes it apparent that these disorders are the biggest health challenge of the century, posing a serious threat to our social and health care systems as well as to the future of European economy. Furthermore, the prevalence and cost of brain disorders are going to increase because of increasing life expectancy. In particular, the number of patients with neurodegenerative disorders, stroke, depression, and anxiety will increase. Increased focus on research strategies, prevention, and care is necessary to reduce the future cost of brain disorders. A recent 'disorder of the brain summit' resulted in a series of proposals for future actions [21]. Working toward reducing stigma and ignorance that still clouds the view on many brain disorders should be an immediate action. Current knowledge allows better and earlier diagnosis and better treatment paradigms, but they are not easily implemented in Europe, as there seems to have been no improvement over the last 6 years [6]. Although such actions might be associated with higher initial direct health care cost, it is easily offset by a reduction of direct non-medical cost and indirect costs. Finally, research budgets and teaching plans in medical schools and other health-related educational institutions may need to be revisited in the light of the present data.

Research in context panel

Nineteen subcommittees, one for each group of disorders, consisting of epidemiologic and health economic experts from all over Europe [5] performed systematic literature reviews with explicit search criteria regarding the prevalence and cost of brain disorders in Europe. They used relevant search terms in all major search engines as well as reference lists from recovered articles. To be included, data needed to report (i) state-of-art data on the prevalence or cost or resource use, (ii) diagnostic information according to the World Health Organization's ICD-10 http://apps.who.int/classifications/apps/icd/icd10online/or DSM-IVTR [7], and (iii) data from any of 30 European countries (EU27, Iceland, Norway, and Switzerland) or combinations of countries. Additionally, reanalysis of available epidemiologic studies were conducted to estimate effects of

comorbidity, age, and gender. Studies should have a sound and robust methodology for patient selection, data collection, instrumentation, statistical analysis, and reporting of results.

The only previous European wide data are from our previous study published in 2005. In comparison, we now add a number of cost items and seven further brain disorders plus update to 2010 values. We now find that the previous study grossly underestimated the cost of brain disorders. With 798 billion Euros per year in Europe, the cost is comparable to the cost of cardiovascular diseases, cancer, and diabetes put together.

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Appendix 1

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