Journal of Neurology (2019) 266:2120–2128
https://doi.org/10.1007/s00415-019-09386-x

ORIGINAL COMMUNICATION

Vertigo and dizziness cause considerable more health care resource use and costs: results from the KORA FF4 study

X. Wang[1,2] · Ralf Strobl[1,2] · R. Holle[3] · H. Seidl[3] · A. Peters[4] · E. Grill[1,2,5]

Received: 1 March 2019 / Revised: 14 May 2019 / Accepted: 16 May 2019 / Published online: 22 May 2019

Abstract

Objectives Vertigo is a common reason for primary care consultations, and its diagnosis and treatment consume considerable medical resources. However, limited information on the specific cost of vertigo is currently available. The aim of this study is to analyse the health care costs of vertigo and examine which individual characteristics would affect these costs.

Study design We used cross-sectional data from the German KORA ("Cooperative Health Research in the Augsburg Region") FF4 study in 2013.

Methods Impact of personal characteristics and other factors was modelled using a two-part model. Information on health care utilisation was collected by self-report.

Results We included 2277 participants with a mean age of 60.8 (SD = 12.4), 48.4% male. Moderate or severe vertigo was reported by 570 (25.0%) participants. People with vertigo spent 818 Euro more than people without vertigo in the last 12 months (2720.9 Euro to 1902.9 Euro, SD = 4873.3 and 5944.1, respectively). Consultation costs at primary care physicians accounted for the largest increase in total health care costs with 177.2 Euro ($p < 0.01$). After adjusting for covariates, the presence of vertigo increased both the probability of having any health care costs (OR = 1.6, 95% CI = [1.2;2.4]) and the amount of costs ($\exp(\beta) = 1.3$, 95% CI = [1.1;1.5]). The analysis of determinants of vertigo showed that private insurance and a medium level of education decreased the probability of any costs, while higher income increased it.

Conclusions The presence of vertigo and dizziness required considerable health care resources and created significantly more related costs in different health care sectors for both primary and pertinent secondary care.

Keywords Health data · Population health · Medical care · Vertigo · Cost of illness · Health care cost · Two-part model · Analysis of health care markets

Introduction

Acute or chronic vertigo and dizziness are common reasons for primary care consultations [1, 2] but also for the use of emergency services [3]. Still, management of vertigo and dizziness often remains insufficient with repeated primary and secondary care consultations, irrational prescription patterns [4], and unnecessary diagnostic procedures [5]. Since burden of disease and burden of disability of vertigo are considerable [1, 6], prolonged courses of diagnosis and treatment do not only impair quality of life and employability of the individual, they arguably also have an economic impact on health systems.

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00415-019-09386-x) contains supplementary material, which is available to authorized users.

✉ Ralf Strobl
ralf.strobl@med.uni-muenchen.de

[1] Institute for Medical Information Processing, Biometrics and Epidemiology, Ludwig-Maximilians Universität München, Munich, Germany

[2] German Center for Vertigo and Balance Disorders, University Hospital, Ludwig-Maximilians Universität München, Marchioninistr 15, 81377 Munich, Germany

[3] Institute of Health Economics and Health Care Management, Helmholtz Zentrum München, German Research Center for Environmental Health (GmbH), Neuherberg, Germany

[4] Institute of Epidemiology II, Helmholtz Zentrum München, German Research Center for Environmental Health (GmbH), Neuherberg, Germany

[5] Munich Center of Health Sciences, Ludwig-Maximilians Universität München, Munich, Germany

Attempts have been made to quantify current health care utilization and its economic impact for diverse vestibular diagnoses, e.g., for benign paroxysmal positional vertigo [7], Menière's disease [8], or vestibular hypofunction [9]. However, these studies were designed using data samples from specialized clinical settings, and results are, therefore, hardly comparable across populations. In addition, the contribution of vertigo to the total amount of health care utilization, i.e., its incremental monetary burden in the general population, and the determinants of utilization in persons with vertigo are currently unknown.

The objective of this study is to quantify health care utilization and its costs in a population reporting vertigo and dizziness and compare these results to the utilization that could be expected in a control population without vertigo. Specifically, we wanted to investigate if vertigo is an independent predictor of health care resource utilization and of costs when other relevant health-related factors are taken into account, which factors are specifically driving utilization among persons with vertigo.

Methods

Study design

This cross-sectional study used data from the German KORA ("Cooperative Health Research in the Augsburg Region") FF4 study.

Setting

The KORA FF4 study is the 14-year follow-up of the KORA S4 study, a population-based health survey conducted in the city of Augsburg and two surrounding counties between 1999 and 2001. Of all 4261 participants of the S4 baseline study, 2279 also participated in the FF4 study. More information on the study population can be found in the Online Appendix.

All investigations were carried out in accordance with the Declaration of Helsinki. All participants gave written informed consent. The study was approved by the ethics committee of the Bavarian Chamber of Physicians, Munich (FF4: EC No. 06,068).

Measures

Outcome: health care utilization and costs

All information about health care utilization was collected by self-report in the face-to-face interview. Eight different cost components of health care utilization were recorded, namely, doctor consultations, outpatient hospital visits, inpatient hospital days, days in the intensive care unit (ICU), days in rehabilitation, alternative practitioner consultations, physiotherapy sessions, and drug utilization. The information of each cost component referred to different time spans which reflect the ability to remember in- and outpatient visits [10-14], e.g., the time spans referred to the last 3 months for medical consultation and outpatient treatment, while, for components that are easily remembered or rare, it referred to the last 12 months. The mean direct costs per contact were based on the unit costs provided by Bock et al. [15]. Here, each unit cost was calculated from a societal perspective, and covered the societal opportunity costs, e.g., for maintenance and staff. The unit costs can be found in Online Appendix Table 1. However, since sick leave was the only measure in this study to reflect indirect costs, it is reasonable to adopt the health system perspective [16, 17].

The yearly health care costs of each component were estimated as the product of frequency of utilization and the unit price cost of each. If health care utilization referred to the period of the last 3 months, its frequency was multiplied by four to get an estimate for the year.

Sick leave was quantified as an indirect economic burden by the question: "How many days have you been unable to work for the last 12 months because of illness?" In this part, only gainfully employed persons were included. An average calendar day labor cost of 122.9 Euro was used to calculate the monetary burden due to sick leave [18, 19]. Since all costs were reported for the last 12 months, no discount was applied.

Exposure

The presence or absence of vertigo or dizziness was assessed using a standardized question from the balance section of the National Health and Nutrition Examination Survey (NHANES) questionnaire [20] in the face-to-face interview. If the initial question on life-time vertigo "Have you ever had vertigo or dizziness?" was affirmed, the following question "During the last 12 months, have you had vertigo or dizziness?" was used to confirm the presence of vertigo or dizziness.

Covariates—determinants of utilization

Covariates selection for determinants of utilization was based on the Andersen health care utilization model [21]. This conceptual model divides factors that might affect health care utilization into three domains: predisposing factors, enabling factors, and need factors. It has been widely used and shown its applicability [22]. We included six predisposing factors (namely, age, gender, family status, education level, present job status, and physical activity) and two enabling factors (namely, personal monthly income

and health insurance type). Comorbidities were included as need factors. Age was divided into five 10-year age groups (39–48, 49–58, 59–68, 69–78, 79–88). Education level was categorized into three levels: standard education as up to 9 years of schooling, medium education as 10 years of schooling, and high education as 12 or 13 years of schooling and entering a university [23]. Family status was defined as: single and lives alone, single and live with partner, married and live separately, married and live with partner, divorced, and widowed. The present job status was categorized as full-time employed, part-time employed or temporary employed, and not at work. Leisure time physical activity was assessed with two separate questions concerning leisure time sport activity in winter and in summer (cycling included) and was categorized into inactive ('no activity' and 'low activity') and active ('moderate activity' and 'high activity') [24]. Personal monthly income was measured in Euro. Health insurance type was measured as either public or private. We included the following health conditions as comorbidities for need factors: obesity, high blood pressure, myocardial infarction, cancer, stroke, angina pectoris, anxiety, and depression. Obesity was defined as a BMI (Body Mass Index) > 30. Information on myocardial infarction, angina pectoris, and cancer was self-reported. Anxiety was assessed by the German version of Generalized Anxiety Disorder scale (GAD-7) [25] and categorized as minimal (score < 5), mild (5 ≤ score < 10), and moderate-to-severe (10 ≤ score) level. As anxiety was only measured in participants aged 73 and younger, we did not include it in the main regression analysis. Results of regression analyses including anxiety are shown in Online Appendix Table 5. Depression was assessed using the German version of "Patient Health Questionnaire" (PHQ-D) questionnaire [26] and categorized into no depression, mild depression, and severe depression. High blood pressure was defined as a pressure of 140/90 mmHg or higher [26].

Statistical analyses

We reported means and standard deviations for continuous variables, and absolute and relative frequencies for categorical variables. Student's *t* test and Chi-squared test were used to compare the baseline characteristics for continuous variables and categorical variables.

Since the cost data were skewed, contained considerable zero values, and few outliers, we applied a hurdle model, also known as two-part model to examine both, the bivariate and multivariable relationship between the dependent and independent variables, following recent recommendations [27].

In brief, hurdle models separate the analysis into two parts: the hurdle part and the non-zero part. In the hurdle part, each participant's probability to cross the threshold of non-zero costs was modeled using a logistic regression model. In the non-zero part, the magnitude of costs among those who crossed the threshold, i.e., whose costs exceeded zero, was modeled using a log-normal model. We used a log-normal model, as it performed best by comparing the Akaike Information Criterion [28]. We reported the natural exponential of the coefficients as odds ratios (OR) for the hurdle part and for the non-zero part, each together with their respective 95%-confidence intervals (95% CI). The natural exponential in the log-normal model corresponds to the magnitude of costs and can be interpreted as changes in the ratio of the expected geometric means of the untransformed outcome variable. For example, given $\exp(\beta_1) = 1.15$, we can say that an increase of one unit in x_1 means a 15% higher outcome.

For all analyses, the predefined level of significance was set to 0.05. IBM SPSS Statistics for Windows Version 20.0 (Armonk, NY: IBM Corp.) was used for the descriptive tables, and R version 3.3.2 was used to calculate the hurdle model [29].

Results

Of the 2279 participants in the KORA FF4 study, two had to be excluded due to missing values in the exposure variable. Thus, data were available for 2277 participants with a mean age of 60.8 (SD = 12.4), 48.4% male. 570 (25.0%) participants reported to have had moderate or severe dizziness or vertigo at least once in the last 12 months.

Table 1 shows the characteristics of the participants stratified by the presence of vertigo. Participants with vertigo were on average 3 years older (63.0–60.0), more likely to be female (62.1–48.2%), more likely to live without a partner (31.7–24.6%), and more likely to be not at work (54.2–41.1%). "Mild-to-severe" depression (9.1–2.7%) and anxiety (47.5–29.7%) symptoms were more frequent in this group. Cases with stroke were more prevalent in persons with vertigo (4.8–2.1%). In addition, compared to those without vertigo, individuals with vertigo were less active regarding leisure time physical activity (46.7–41.4%), more likely to have statutory health insurance (84.4–78.9%) and they had a lower average monthly income (1274.4 Euro to 1338.5 Euro).

The resulting total direct health care costs are shown in Table 2. Persons with vertigo spent on average 818 Euro more for health care services than those without vertigo in the last 12 months (2720.9 Euro to 1902.9 Euro). Consultation costs at physicians accounted for the largest increment in total health care costs with 177.2 Euro (p value hurdle < 0.01, p value magnitude < 0.01). This increment was most prominently seen in the costs for primary care

Table 1 Descriptive statistics of basic demographic factors ($n=2277$) from KORA FF4 survey

	Individuals with vertigo ($n=570$) Mean (SD)/frequency (%)	Individuals without vertigo ($n=1707$) Mean (SD)/frequency (%)	p value
Predisposing factors			
Age			
Mean	63.0 (12.5)	60.00 (12.2)	< 0.01
39–48	94 (16.5%)	381 (22.3%)	
49–58	118 (20.7%)	437 (25.6%)	
59–68	154 (27.0%)	416 (24.4%)	
69–78	127 (22.3%)	340 (19.9%)	
79–88	77 (13.5%)	133 (7.8%)	
Gender			< 0.01
Male	216 (37.9%)	885 (51.8%)	
Family status			< 0.01
Single, live alone	43 (7.5%)	113 (6.6%)	
Single, live with partner	18 (3.2%)	45 (2.6%)	
Married, live with partner	371 (65.1%)	1243 (72.8%)	
Married, live separately	11 (1.9%)	35 (2.1%)	
Divorced	52 (9.1%)	142 (8.3%)	
Widowed	75 (13.2%)	129 (7.6%)	
Education level			< 0.01
Standard education level	303 (53.4%)	806 (47.3%)	
Medium education level	148 (26.1%)	437 (25.6%)	
High education level	116 (20.5%)	462 (27.1%)	
Present job status			< 0.01
Full employed	142 (24.9%)	636 (37.3%)	
Part time job	91 (16.0%)	259 (15.2%)	
Temporary employed	28 (4.9%)	109 (6.4%)	
Not at work	309 (54.2%)	701 (41.1%)	
Physical activity			0.03
Active	304 (53.3%)	1001 (58.6%)	
Need factors			
Depression			< 0.01
No depression	517 (90.9%)	1660 (97.2%)	
Mild depression	29 (5.1%)	24 (1.4%)	
Severe depression	23 (4.0%)	22 (1.3%)	
Anxiety[a]			< 0.01
Minimal anxiety	218 (52.5%)	988 (70.3%)	
Mild anxiety	151 (36.4%)	359 (25.6%)	
Moderate-to-severe anxiety	46 (11.1%)	58 (4.1%)	
Diabetes	73 (12.8%)	146 (8.6%)	< 0.01
High blood pressure[b]	67 (11.8%)	234 (13.7%)	0.23
Myocardial infarction	20 (3.5%)	59 (3.5%)	1.00
Angina pectoris	73 (12.9%)	111 (6.5%)	< 0.01
Stroke	27 (4.8%)	36 (2.1%)	< 0.01
Cancer	71 (12.5%)	185 (10.8%)	0.29
Obesity[c]	177 (31.1%)	461 (27.0%)	0.06
Enabling factors			
Mean monthly income in Euro	1274.4 (613.5)	1338.5 (673.3)	0.05
Insurance type			< 0.01
Statutory	481 (84.4%)	1346 (78.9%)	
Private	87 (15.3%)	358 (21.0%)	

SD Standard deviation

[a]Anxiety was measured for participants younger than 73 years only, i.e., for 415 participants with vertigo and for 1405 participants without vertigo

Table 1 (continued)

[b]Blood pressure classification is defined as: normal, < 140/90 mmHg; high, ≥ 140/90 mmHg

[c]Obesity is defined as: normal, body mass index (BMI) < 30; overweight, BMI ≥ 30

physicians (PCP) (108.8 Euro to 75.5 Euro) and psychotherapist consultations (88.8 Euro to 21.6 Euro).

Indirect costs due to sick leave among the 1262 (55.4%) gainfully employed participants are shown in Table 3. Among persons with vertigo, 57.1% reported having been on sick leave in the last 12 months (without vertigo: 44.5%). The average duration of sick leave was 7.5 days (SD = 17.2), while persons without vertigo reported 7.2 days (SD = 25.0).

Table 2 Descriptive statistics of total direct cost and component cost per person per year ($n = 2277$)

	With vertigo ($n = 570$) Mean (€) (SD)	Without vertigo ($n = 1707$) Mean (€) (SD)	Difference in €	p value hurdle	p value magnitude
Total cost[a]	2720.9 (4873.3)	1902.9 (5944.1)	818.0	< 0.01	< 0.01
Doctor consultations	461.8 (753.8)	284.6 (568.8)	177.2	< 0.01	< 0.01
Primary care	108.8 (179.1)	75.5 (129.7)	33.4	< 0.01	0.01
Specialist internist	48.5 (192.4)	39.5 (240.1)	9.0	0.04	0.93
Gynecologist	17.1 (44.9)	11.2 (40.9)	6.0	< 0.01	0.23
Ophthalmologist	39.7 (106.8)	23.1 (77.8)	16.5	< 0.01	0.05
Orthopedist	42.4 (112.7)	27.4 (89.3)	15.0	< 0.01	0.35
ENT	16.6 (59.7)	10.5 (57.0)	6.2	< 0.01	0.92
Surgeon	12.1 (71.1)	9.9 (82.2)	2.2	0.25	0.99
Dermatologist	15.2 (45.1)	11.7 (45.1)	3.5	< 0.01	0.27
Urologist	8.6 (33.18)	7.0 (31.2)	1.6	0.19	0.82
Neurologist	24.0 (79.9)	11.9 (84.0)	12.1	< 0.01	0.49
Radiologists	31.0 (106.7)	24.2 (218.1)	6.8	0.06	0.12
Psychotherapist	88.9 (522.7)	21.6 (214.3)	67.3	< 0.01	0.10
Other doctors	8.9 (53.9)	11.3 (181.1)	− 2.4	0.25	0.58
Inpatient hospital	1014.3 (3194.1)	879.0 (4985.4)	135.3	0.01	0.76
Outpatient hospital	37.4 (394.0)	21.7 (183.3)	15.7	0.09	0.69
ICU	181.0 (1103.4)	63.6 (560.0)	117.4	< 0.01	0.12
Rehabilitation	202.7 (1042.5)	97.7 (511.6)	105.1	0.05	0.06
Alternative practitioners	34.0 (242.0)	18.2 (94.2)	15.8	0.12	0.75
Physiotherapy	134.8 (308.0)	76.7 (217.5)	58.1	< 0.01	< 0.01
Medication	682.1 (1597.9)	463.4 (1624.0)	218.7	< 0.01	< 0.01

[a]Total cost was measured in the cost of eight components: doctor consultations, outpatient hospital days, inpatient hospital days, days in intensive care units (ICU), rehabilitation, alternative practitioners, physiotherapy, and medicine utilization

ENT Ear, nose and throat specialist

Table 3 Descriptive statistics of inability to work among gainfully employed participants from KORA FF4 survey ($n = 1262$)

	Individuals with vertigo ($n = 261$) Frequency (percentage)/mean (SD)	Individuals without vertigo ($n = 1001$) Frequency (percentage)/mean (SD)	Difference	p value hurdle	p value magnitude
Persons on sick leave during the last 12 months	149 (57.1%)	445 (44.5%)	12.6%	< 0.01	–
Average duration of sick leave (days)	7.5 (17.2)	7.2 (25.0)	0.3	< 0.01[a]	0.75[a]
Average cost per year in Euro	920.9 (2111.2)	880.3 (3072.2)	40.6		

[a]Same result for both outcomes, because cost is calculated as a linear transformation of days, i.e., each day is multiplied by €122.95

The projected difference of sick leave costs between two groups was 40.6 Euro per year (p value hurdle < 0.01, p value magnitude = 0.75).

For the multivariable analyses, 149 (6.6%) participants had to be excluded due to missing covariate values, yielding a total of 2128 participants for the hurdle model analysis. No health care costs were observed in 303 participants. After controlling for predisposing, enabling, and need factors, the presence of vertigo (OR = 1.6, 95% CI = [1.2; 2.4]) increased the odds of having any health care costs. The presence of vertigo was also a significant and independent predictor of the magnitude of costs (exp(β) = 1.3, 95% CI = [1.1; 1.5]) (see Table 4).

Persons with vertigo also had significantly higher combined consultation costs for primary care physicians, internal medicine specialists, otorhinolaryngologists, ophthalmologists and neurologists (OR = 1.3, 95%CI [1.0;1.6]), and also an increased magnitude of these costs (exp(β) = 1.2, 95%CI = [1.1;1.3]) (see Online Appendix Table 2). The presence of vertigo increased the probability of any costs in primary care alone (see Online Appendix Table 3). Anxiety was a significant predictor for increased health care costs in the age bracket under 73 years of age (see Online Appendix Table 5).

Determents of health care costs among the 570 participants with vertigo (see Online Appendix Table 4). Of these, 49 (8.6%) had missing values in covariates and were excluded for analysis. Of the remaining 521 participants, 42 (8%) had no costs during the last 12 months. Private insurance significantly decreased the probability of any costs, while higher income increased it.

Table 4 Determinants of direct health care costs (n = 2128)

Variables	Health care-related costs > 0 (hurdle model, n = 2128) (Logistic Regression)		Magnitude of costs (log-normal model, n = 1825)	
	OR[a]	95% CI	exp(β)[a]	95% CI
Vertigo (ref = No Vertigo)	1.6	[1.2; 2.4]	1.3	[1.1; 1.5]
Gender (ref = male)	1.8	[1.3; 2.5]	1.0	[0.9; 1.2]
Age (ref = 39–48)				
49–58	1.1	[0.8; 1.5]	1.2	[0.9; 1.4]
59–68	1.4	[1.0; 2.2]	1.2	[0.9; 1.4]
69–78	2.0	[1.1; 3.8]	1.1	[0.8; 1.4]
79–88	2.2	[0.9; 5.7]	1.4	[1.0; 2.0]
Insurance (ref = Public)	0.9	[0.7; 1.3]	1.2	[1.0; 1.4]
Income in 1000 €	1.0	[0.8; 1.3]	1.1	[1.0; 1.2]
Education (ref = Standard level)				
Medium	0.8	[0.6; 1.1]	1.1	[0.9; 1.2]
High	1.0	[0.7; 1.4]	1.0	[0.8; 1.2]
Marital status (ref = Single) [**]				
Married	1.0	[0.6; 1.5]	0.8	[0.6; 1.0]
Divorced	0.9	[0.5; 1.6]	1.2	[0.9; 1.7]
Widowed	0.9	[0.4; 1.9]	1.0	[0.7; 1.3]
Physical activity (ref = Active)	0.7	[0.6; 1.0]	0.9	[0.9; 1.3]
Intercept	2.1	[1.1; 3.9]	398.7	[285.3; 557.1]

[a]Coefficients were adjusted for job status, obesity, high blood pressure, myocardial infarction, cancer, angina pectoris, and depression in the count part. Stroke was excluded in the hurdle part

[b]Due to small-cell count, we combined "Married, live with partner" and "Married, live separately" into the category "Married", and "Single, live with partner" and "Single" into the category "Single"

Discussion

This representative study of the general population in Germany found that persons who reported at least one relevant episode of vertigo or dizziness during the last 12 months had higher health care costs across almost all cost components. This is the first time that costs of vertigo treatment in the general population have been made transparent. In our study, vertigo was an independent predictor of health care resource utilization and related costs after adjusting for covariates, especially in older persons. In addition, persons with vertigo had a higher probability for non-zero costs, consequently, even when controlling for other common factors that might drive heath care costs such as gender, age and chronic disease.

The economic burden of people with vertigo has been postulated repeatedly. Several studies found considerable health care resource use of these people [9, 30, 31]. However, these studies had a major structural problem by asking patients to decide which of the procedures and consultations they experienced in the past were due to vertigo, thus inducing recall bias. In contrast, our study could show the excess costs that were directly attributable to vertigo in comparison with a control group without vertigo and controlling for covariates.

A further notable result is that our study found excess costs caused by psychotherapy, emergency services, and medication. This also accords with our earlier observations that patients with peripheral vestibular disease were mostly over diagnosed but yet without appropriate therapy [4], although diagnosis and therapy of the most frequent vestibular disorders are mostly manageable by the primary care physician without the need for medication, imaging, or emergency services. Likewise, others have also noted the excess utilization of emergency services by persons presenting with vertiginous symptoms in the emergency room [32].

The higher utilization of primary care services in those with vertigo or dizziness found in our study is in line with earlier observations. Using data from the Taiwan insurance database, Lai found that vertigo cases were predominantly treated in primary care [31]. Another study stated an average of 1.6 primary care consultations in the last 3 months for persons with vertigo [30] which is even more extreme than our estimate of 1.35 in the last 3 months, i.e., 5.4 GP consultations in the last 12 months. In the same study [30], the amount of specialist consultations was half of our result, 1.4 to 2 times per 3 months. It has to be noticed that the results in Benecke's study were based on vertigo patients in a multinational registry setting from 2007 to 2009, counting only consultations due to vertigo.

We did find a significant difference in lost working days due to vertigo; however, the difference was too small to be relevant. These results do not confirm the results from a European study that found for Germany that persons with vestibular disease had lost on average 27 working days during the last 3 months due to vertigo [30]. However, it can be argued that participants of the mentioned study were patients of specialized tertiary care centers and, therefore, highly selected, whereas our study presented data from a population-based sample more representative of the general population. Likewise, Benecke et al. found in their study from 13 countries that 63.3% of persons with vertigo had lost working days during the three months preceding the baseline visit which is in line with our results.

The previous studies showed that mental disorders, such as depression or anxiety, were associated with vertigo [33, 34], and could influence health care utilization [34, 35]. This is also reflected in our study, where anxiety was shown to be a significant predictor to health care cost in the younger age groups. However, vertigo remains an independent factor for increased health care utilization, even after controlling for mental disorders including anxiety.

It has to be noted that comparison with the literature is difficult, because most of these studies aim to assess cost-effectiveness of specific treatment methods, technologies, or medicines [5, 7, 36-39]. Other studies discussed resource utilization of a specific component of the health care system, such as the emergency unit [32] or diagnostic procedure costs [40, 41] or nursing cost [42].

In line with the discussion about the role of age for health care costs [43], we did not find any relevant age effects when looking at the determinants of costs in the group of persons with vertigo. This is also plausible, because older participants in surveys tend to be healthier than their non-participant contemporaries [44]. In addition, in line with literature female sex increased, the probability of utilization [45, 46].

Limitations

Our study has several limitations. As the KORA FF4 survey is the second follow-up of a cohort, the mean age of participants was over 60. However, the prevalence of vertigo of 25% is still in line with the literature [1]; thus, we can assume that the results of our study can be generalized to the general population. However, the sample might not be representative of the general population with regard to the exclusion of individuals who chose not to participate because of their health status. Consequently, our study might have underestimated the true impact of vertigo on health care costs. These issues of non-participation in aging research have been studied before [44]. In addition, data of health care utilization were collected based on self-report which is prone to recall bias and might lead to an inaccurate estimation of the true costs. To minimize this bias different time spans were used for out- and inpatient services [10-14].

The 12-month medical consultation and outpatient care were estimated based on participants' last 3-month report. To collect cost data from limited time periods and extrapolate them to 1 year are an efficient method in economic trials when the assumption holds that they are representative of other periods [14]. Considering that all the participants were in a good health state at the time, the questionnaire was filled out [44], our extrapolated cost estimation could have been inaccurate. However, it can still be assumed that the cost difference between the vertigo and non-vertigo groups would not be affected systematically, since the overall bias is likely to be equal to both groups.

Other important factors of indirect cost including job loss, reduction of work capacity, patient traveling expenses, or time spent utilizing health care services [17, 47, 48] were not measured in the FF4 survey. Thus, in our study, indirect costs were underestimated. This is a more conservative approach, but arguably underestimates the true burden of vertigo on society.

Another noteworthy point is that the terms "dizziness and vertigo" in our study were not referring to a specific vestibular disease entity. The NHANES questionnaire [20] used here was already successfully applied in several other studies as a valid approach to characterize these symptoms in absence of a clinically more valid diagnosis [49-51].

Conclusion

In summary, the presence of vertigo and dizziness required considerable health care resources and created significantly more health care-related costs in different health care sectors, both in primary care and pertinent secondary care. Research is needed to design interventions that might

streamline management of vertigo patients in the ambulatory sector.

Acknowledgements Amanda Phillips provided writing assistance and language editing.

Funding This study was funded by the German Federal Ministry of Education and Research (BMBF IFB 01EO1401) and by the State of Bavaria.

Compliance with ethical standards

Conflicts of interest The authors declare that they have no conflict of interest.

Ethical approval The study was approved by the ethics committee of the Bavarian Chamber of Physicians, Munich (FF4: EC No. 06068).

References

1. Neuhauser HK, Radtke A, von Brevern M, Lezius F, Feldmann M, Lempert T (2008) Burden of dizziness and vertigo in the community. Arch Intern Med 168(19):2118–2124. https://doi.org/10.1001/archinte.168.19.2118
2. Rieger A, Mansmann U, Maier W, Seitz L, Brandt T, Strupp M, Bayer O (2014) Management of patients with the cardinal symptom dizziness or vertigo. Gesundheitswesen 76(6):e32–38. https://doi.org/10.1055/s-0033-1357145
3. Newman-Toker DE, Hsieh YH, Camargo CA, Pelletier AJ, Butchy GT, Edlow JA (2008) Spectrum of dizziness visits to US emergency departments: cross-sectional analysis from a nationally representative sample. In: Mayo Clinic Proceedings. vol 7. Elsevier, pp 765–775
4. Grill E, Strupp M, Müller M, Jahn K (2014) Health services utilization of patients with vertigo in primary care: a retrospective cohort study. J Neurol 261(8):1492–1498. https://doi.org/10.1007/s00415-014-7367-y
5. Gandolfi MM, Reilly EK, Galatioto J, Judson RB, Kim AH (2015) Cost-effective analysis of unilateral vestibular weakness investigation. Otol Neurotol 36(2):277–281. https://doi.org/10.1097/MAO.0000000000000649
6. Mueller M, Strobl R, Jahn K, Linkohr B, Peters A, Grill E (2014) Burden of disability attributable to vertigo and dizziness in the aged: results from the KORA-Age study. Eur J Public Health 24(5):802–807. https://doi.org/10.1093/eurpub/ckt171
7. Li JC, Li CJ, Epley J, Weinberg L (2000) Cost-effective management of benign positional vertigo using canalith repositioning. Otolaryngol Head Neck Surg 122(3):334–339
8. Bjorne A, Agerberg G (2003) Reduction in sick leave and costs to society of patients with Meniere's disease after treatment of temporomandibular and cervical spine disorders: a controlled six-year cost-benefit study. Cranio 21(2):136–143
9. Sun DQ, Ward BK, Semenov YR, Carey JP, Della Santina CC (2014) Bilateral vestibular deficiency: quality of life and economic implications. JAMA Otolaryngol Head Neck Surg 140(6):527–534. https://doi.org/10.1001/jamaoto.2014.490
10. Seidl H, Meisinger C, Kirchberger I, Burkhardt K, Kuch B, Holle R (2016) Validity of self-reported hospital admissions in clinical trials depends on recall period length and individual characteristics. J Eval Clin Pract 22(3):446–454
11. Stull DE, Leidy NK, Parasuraman B, Chassany O (2009) Optimal recall periods for patient-reported outcomes: challenges and potential solutions. Curr Med Res Opin 25(4):929–942
12. Biemer PP, Groves RM, Lyberg LE, Mathiowetz NA, Sudman S (2011) Measurement errors in surveys. Wiley, Hoboken
13. Althubaiti A (2016) Information bias in health research: definition, pitfalls, and adjustment methods. J Multidiscip Healthcare 9:211
14. Seidl H, Meisinger C, Wende R, Holle R (2012) Empirical analysis shows reduced cost data collection may be an efficient method in economic clinical trials. BMC Health Serv Res 12(1):318
15. Bock JO, Brettschneider C, Seidl H, Bowles D, Holle R, Greiner W, König H (2015) Calculation of standardised unit costs from a societal perspective for health economic evaluation. Das Gesundheitswesen 77(1):53–61
16. Garrison LP, Mansley EC, Abbott TA, Bresnahan BW, Hay JW, Smeeding J (2010) Good research practices for measuring drug costs in cost-effectiveness analyses: a societal perspective: the ISPOR drug cost task force report—part II. Value in Health 13(1):8–13
17. Sanders GD, Neumann PJ, Basu A, Brock DW, Feeny D, Krahn M, Kuntz KM, Meltzer DO, Owens DK, Prosser LA (2016) Recommendations for conduct, methodological practices, and reporting of cost-effectiveness analyses: second panel on cost-effectiveness in health and medicine. JAMA 316(10):1093–1103
18. Krauth C, Buser K, Vogel H (2002) How high are the costs of eating disorders-anorexia nervosa and bulimia nervosa–for German society? Eur J Health Econ 3(4):244–250
19. Bundesamt S (2013) Statistisches Jahrbuch 2013. Die Jugend im wirtschaftlichen und sozialen Leben der Bundesrepublik Deutschland
20. National Center for Health Statistics CfDCP (2002) National Health and Nutrition Examination Survey (NHANES) questionnaire and exam protocol. https://wwwn.cdc.gov/Nchs/Nhanes/2003-2004/BAQ_C.htm#Data_Processing_and_Editing
21. Andersen R, Newman JF (1973) Societal and individual determinants of medical care utilization in the United States. Milbank Meml Fund Q Health Soc 51(1):95–124
22. Babitsch B, Gohl D, von Lengerke T (2012) Re-revisiting Andersen's behavioral model of health services use: a systematic review of studies from 1998–2011. GMS Psycho-Social-Medicine 2012:9
23. Maier W, Holle R, Hunger M, Peters A, Meisinger C, Greiser KH, Kluttig A, Volzke H, Schipf S, Moebus S, Bokhof B, Berger K, Mueller G, Rathmann W, Tamayo T, Mielck A, Consortium D-C (2013) The impact of regional deprivation and individual socioeconomic status on the prevalence of Type 2 diabetes in Germany. A pooled analysis of five population-based studies. Diabet Med 30(3):e78–86. https://doi.org/10.1111/dme.12062
24. Meisinger C, Löwel H, Thorand B, Döring A (2005) Leisure time physical activity and the risk of type 2 diabetes in men and women from the general population. Diabetologia 48(1):27–34. https://doi.org/10.1007/s00125-004-1604-3
25. Spitzer RL, Kroenke K, Williams JB, Löwe B (2006) A brief measure for assessing generalized anxiety disorder: the GAD-7. Arch Intern Med 166(10):1092–1097
26. Löwe B, Spitzer R, Zipfel S, Herzog W (2002) Gesundheitsfragebogen für Patienten (PHQ D). Komplettversion und Kurzform. Testmappe mit Manual, Fragebögen, Schablonen. Karlsruhe: Pfizer
27. Mihaylova B, Briggs A, O'Hagan A, Thompson SG (2011) Review of statistical methods for analysing healthcare resources and costs. Health Econ 20(8):897–916. https://doi.org/10.1002/hec.1653
28. Akaike H (1974) A new look at the statistical model identification IEEE Trans Auto. Control 19(6):716–723
29. Team RC (2017) R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna

30. Benecke H, Agus S, Kuessner D, Goodall G, Strupp M (2013) The burden and impact of vertigo: findings from the REVERT Patient Registry. Front Neurol 4:136. https://doi.org/10.3389/fneur.2013.00136
31. Lai YT, Wang TC, Chuang LJ, Chen MH, Wang PC (2011) Epidemiology of vertigo: a national survey. Otolaryngol Head Neck Surg 145(1):110–116. https://doi.org/10.1177/0194599811400007
32. Saber Tehrani AS, Coughlan D, Hsieh YH, Mantokoudis G, Korley FK, Kerber KA, Frick KD, Newman-Toker DE (2013) Rising annual costs of dizziness presentations to U.S. emergency departments. Acad Emerg Med 20(7):689–696. https://doi.org/10.1111/acem.12168
33. Chen ZJ, Chang CH, Hu LY, Tu MS, Lu T, Chen PM, Shen C-C (2016) Increased risk of benign paroxysmal positional vertigo in patients with anxiety disorders: a nationwide population-based retrospective cohort study. BMC Psychiatry 16(1):238
34. Wiltink J, Tschan R, Michal M, Subic-Wrana C, Eckhardt-Henn A, Dieterich M, Beutel ME (2009) Dizziness: anxiety, health care utilization and health behavior—results from a representative German community survey. J Psychosom Res 66(5):417–424. https://doi.org/10.1016/j.jpsychores.2008.09.012
35. Wei W, Sayyid ZN, Ma X, Wang T, Dong Y (2018) Presence of anxiety and depression symptoms affects the first time treatment efficacy and recurrence of benign paroxysmal positional vertigo. Front Neurol 9:178
36. Rambold HA (2015) Economic management of vertigo/dizziness disease in a county hospital: video-head-impulse test vs. caloric irrigation. Eur Arch Otorhinolaryngol 272(10):2621–2628. https://doi.org/10.1007/s00405-014-3205-1
37. Derks LS, Wegner I, Smit AL, Thomeer HG, Topsakal V, Grolman W (2016) Effect of day-case unilateral cochlear implantation in adults on general and disease-specific quality of life, postoperative complications and hearing results, tinnitus, vertigo and cost-effectiveness: protocol for a randomised controlled trial. BMJ Open 6(10):e012219. https://doi.org/10.1136/bmjopen-2016-012219
38. Kerber KA, Meurer WJ, West BT, Mark Fendrick A (2008) Dizziness presentations in US emergency departments, 1995–2004. Acad Emerg Med 15(8):744–750
39. Lahmann C, Henningsen P, Dieterich M, Radziej K, Schmid G (2015) Tailored care for somatoform vertigo/dizziness: study protocol for a randomised controlled trial evaluating integrative group psychotherapy. J Neurol 262(8):1867–1875. https://doi.org/10.1007/s00415-015-7784-6
40. Pan P, Huang J, Morioka C, Hathout G, El-Saden SM (2016) Cost analysis of vestibular schwannoma screening with contrast-enhanced magnetic resonance imaging in patients with asymmetrical hearing loss. J Laryngol Otol 130(1):21–24. https://doi.org/10.1017/S0022215115002431
41. Rafique I, Wennervaldt K, Melchiors J, Caye-Thomasen P (2016) Auditory brainstem response - a valid and cost-effective screening tool for vestibular schwannoma? Acta Otolaryngol 136(7):660–662. https://doi.org/10.3109/00016489.2016.1157726
42. Reddy VM, Sargent H, Prior MJ (2011) Benign paroxysmal positional vertigo nurse-led follow-up clinic. Eur Arch Otorhinolaryngol 268(6):829–832. https://doi.org/10.1007/s00405-010-1319-7
43. Werblow A, Felder S, Zweifel P (2007) Population ageing and health care expenditure: a school of 'red herrings'? Health Econ 16(10):1109–1126
44. Holle R, Hochadel M, Reitmeir P, Meisinger C, Wichmann HE (2006) Prolonged recruitment efforts in health surveys: effects on response, costs, and potential bias. Epidemiology 17(6):639–643
45. Owens G (2008) Gender differences in health care expenditures, resource utilization, and quality of care. J Manag Care Pharmacy 14(3):2–6. https://doi.org/10.18553/jmcp.2008.14.S6-A.2
46. Seshamani M, Gray A (2004) Ageing and health-care expenditure: the red herring argument revisited. Health Econ 13(4):303–314. https://doi.org/10.1002/hec.826
47. Meerding WJ, IJzelenberg W, Koopmanschap M, Severens JL, Burdorf A (2005) Health problems lead to considerable productivity loss at work among workers with high physical load jobs. J Clin Epidemiol 58(5):517–523
48. van den Berg TI, Elders LA, Burdorf A (2010) Influence of health and work on early retirement. J Occup Environ Med 52(6):576–583
49. Mueller M, Strobl R, Jahn K, Linkohr B, Peters A, Grill E (2013) Burden of disability attributable to vertigo and dizziness in the aged: results from the KORA-Age study. Eur J Public Health 24(5):802–807
50. Agrawal Y, Carey JP, Della Santina CC, Schubert MC, Minor LB (2009) Disorders of balance and vestibular function in US adults: data from the National Health and Nutrition Examination Survey, 2001–2004. Arch Intern Med 169(10):938–944
51. Koo JW, Chang MY, Woo SY, Kim S, Cho YS (2015) Prevalence of vestibular dysfunction and associated factors in South Korea. BMJ open 5(10):e008224