

ORIGINAL RESEARCH CONTRIBUTION

Rising Annual Costs of Dizziness Presentations to U.S. Emergency Departments

Ali S. Saber Tehrani, MD, Diarmuid Coughlan, MPharm, MSc, Yu Hsiang Hsieh, PhD, MS, Georgios Mantokoudis, MD, Fredrick K. Korley, MD, Kevin A. Kerber, MD, MS, Kevin D. Frick, PhD, and David E. Newman-Toker, MD, PhD

Abstract

Objectives: Dizziness and vertigo account for roughly 4% of chief symptoms in the emergency department (ED). Little is known about the aggregate costs of ED evaluations for these patients. The authors sought to estimate the annual national costs associated with ED visits for dizziness.

Methods: This cost study of adult U.S. ED visits presenting with dizziness or vertigo combined public-use ED visit data (1995 to 2009) from the National Hospital Ambulatory Medical Care Survey (NHAMCS) and cost data (2003 to 2008) from the Medical Expenditure Panel Survey (MEPS). We calculated total visits, test utilization, and ED diagnoses from NHAMCS. Diagnosis groups were defined using the Healthcare Cost and Utilization Project's Clinical Classifications Software (HCUP-CCS). Total visits and the proportion undergoing neuroimaging for future years were extrapolated using an autoregressive forecasting model. The average ED visit cost-per-diagnosis-group from MEPS were calculated, adjusting to 2011 dollars using the Hospital Personal Health Care Expenditures price index. An overall weighted mean across the diagnostic groups was used to estimate total national costs. Year 2011 data are reported in 2011 dollars.

Results: The estimated number of 2011 US ED visits for dizziness or vertigo was 3.9 million (95% confidence interval [CI] = 3.6 to 4.2 million). The proportion undergoing diagnostic imaging by computed tomography (CT), magnetic resonance imaging (MRI), or both in 2011 was estimated to be 39.9% (39.4% CT, 2.3% MRI). The mean per-ED-dizziness-visit cost was \$1,004 in 2011 dollars. The total extrapolated 2011 national costs were \$3.9 billion. HCUP-CCS key diagnostic groups for those presenting with dizziness and vertigo included the following (fraction of dizziness visits, cost-per-ED-visit, attributable annual national costs): otologic/vestibular (25.7%; \$768; \$757 million), cardiovascular (16.5%, \$1,489; \$941 million), and cerebrovascular (3.1%; \$1059; \$127 million). Neuroimaging was estimated to account for about 12% of the total costs for dizziness visits in 2011 (CT scans \$360 million, MRI scans \$110 million).

Conclusions: Total U.S. national costs for patients presenting with dizziness to the ED are substantial and are estimated to now exceed \$4 billion per year (about 4% of total ED costs). Rising costs over time appear to reflect the rising prevalence of ED visits for dizziness and increased rates of imaging use. Future economic studies should focus on the specific breakdown of total costs, emphasizing areas of high cost and use that might be safely reduced.

ACADEMIC EMERGENCY MEDICINE 2013; 20:689–696 © 2013 by the Society for Academic Emergency Medicine

From the Department of Neurology (AST, GM, DENT) and the Department of Emergency Medicine (YHH, FKK), Johns Hopkins University School of Medicine, Baltimore, MD; the Department of Health Policy and Management, Johns Hopkins Bloomberg School of Public Health (DC, KDF), Baltimore, MD; and the Department of Neurology, University of Michigan Health System (KAK), Ann Arbor, MI.

Received October 18, 2012; revision received February 6, 2013; accepted February 16, 2013.

The authors have no relevant financial information or potential conflicts of interest to disclose.

Supervising Editor: Sandra Schneider, MD.

Address for correspondence and reprints: David E. Newman-Toker, MD PhD; e-mail: toker@jhu.edu.

There are more than 2 million U.S. emergency department (ED) visits annually for dizziness or vertigo,¹ comprising roughly 4.4% of all ED chief symptoms in awake patients.² A wide range of causes must be considered, including potentially morbid strokes and life-threatening cardiac diseases.¹ As a consequence, patients with dizziness undergo more diagnostic tests and have greater lengths of stay (LOS) than those without dizziness,¹ comparable to what is seen in those with chest pain.³ Resource use, particularly neuroimaging, is increasing over time.⁴ These resources are not being used optimally, with mounting data suggesting brain computed tomography (CT) is substantially overused.^{5–7} Although CT is often used to “rule out”

stroke,^{8–10} this practice is ineffective in patients with dizziness because of the test's extremely low sensitivity¹¹ and documented low yield.^{12–15}

Little is known about the aggregate national costs of ED evaluations for patients with dizziness or vertigo. To our knowledge, the only prior estimate (\$1.1 billion/year in 1992) comes from an unpublished meeting presentation.³ In part, this may be because national databases generally offer disease- rather than symptom-specific cost estimates. Because there is no single database for ED cost estimates relative to presenting symptoms, we sought to combine disease-specific cost data with symptom-specific disease prevalence data from nationally representative databases to estimate symptom-specific costs. Our primary aim was to estimate the costs of ED visits for chief symptoms of dizziness and vertigo. We hypothesized the absolute costs associated with dizziness visits are rising and sought to analyze likely contributors such as visit prevalence and imaging utilization.

METHODS

Study Design

This was a symptom-specific, time-series, cost analysis leveraging publically available data derived from two large, national public health databases. This cost study of U.S. ED visits presenting with dizziness or vertigo combined diagnosis-specific cost data from the Medical Expenditure Panel Survey (MEPS; 2003 through 2008)¹⁶ with symptom-specific disease prevalence estimates from the National Hospital Ambulatory Medical Care Survey (NHAMCS; 1993 through 2009),¹⁷ with some of these latter data published previously.¹ We used all nondizziness or vertigo visits as a control population for comparison. The study involved only publicly available, deidentified data so was considered exempt from institutional review board review.

Sources of Data

The MEPS is a large-scale, nationally representative set of surveys of families, individuals, and some of their medical providers and employers.¹⁶ The surveys collect detailed data on health care use and expenditures, sources of payment, and health insurance coverage. The household component of MEPS obtains comprehensive information on payments from all payers related to each medical event. A nationally representative subsample of households and individuals participating in the prior year's National Health Interview Survey (NHIS) provides information on their demographics, health conditions, health status, and use of medical services. The NHIS data sampling protocol follows a multistage area probability design that permits representative sampling of households and noninstitutional group quarters.¹⁸

The MEPS study years (2003–2008) were utilized based on the availability of fully reconciled consolidated data files at the start of the analysis (May 2012). A single author (DC) extracted relevant data from MEPS. Total ED expenditures were derived from the publicly available full-year consolidation file, condition file, ED event file, and condition-event link file for each calendar year.

To ensure enough observations per disease classification category, 6 years of data were pooled. The condition-event link file allowed us to identify condition-specific ED events. The full-year consolidated file allowed us to identify information regarding expenditures.

The NHAMCS is an annual national survey based on a sample of hospitals rather than households; it reports ED visit reasons as well as final ED diagnoses. NHAMCS is a four-stage probability sample of visits to randomly selected U.S. hospitals, including noninstitutional general and short-stay hospitals, but excluding federal, military, and Veterans Affairs hospitals.¹⁷

NHAMCS study years (1995–2009) were used based on the availability of data files at the start of the analysis (May 2012). We estimated the number of ED dizziness and nondizziness visits and proportions undergoing advanced imaging (CT, MRI, or either) (1995–2000, 2005–2009) directly from NHAMCS; we extrapolated projected results for 2010–2015 from these 1995–2009 data. Data on the body region imaged (head vs. not head vs. not specified) were available only in a subset of NHAMCS years (2007–2009 for CT, 2007–2008 for MRI). Thus, our analyses of the fraction of advanced imaging that was neuroimaging reflect only those years; for this calculation we excluded imaging reports where the body part was not specified.

Study Protocol

"Dizziness" has been defined variably as either an umbrella term encompassing "vertigo" or as an entirely separate entity.^{2,19} Dizziness and vertigo are difficult to distinguish in the ED.² This study reflects both patient groups aggregated because NHAMCS data classify the two symptoms together and do not discriminate between them, grouping "falling sensation, giddiness, dizziness, lightheadedness, loss of equilibrium or balance, and room spinning," into a single category—reason-for-visit (RFV) code "vertigo/dizziness" (1225.0).²⁰ While there is some degree of natural overlap between vertigo and dizziness and patients experiencing other symptoms such as nausea or vomiting (RFV codes 1525.0, 1530.0), gait instability, or falls (RFV codes 1095.0, 5810.0), and syncope (RFV code 1030.0), these patients were only included as dizziness or vertigo visits if they were also coded with 1225.0 as a visit reason. Otherwise, they were classified with nondizziness controls. Because children experience dizziness less often than adults, have a different spectrum of causes, and are tested differently, we restricted our analysis to visits involving patients aged 16 years or older, as in our prior study.¹

We assessed the disease-specific attributable fractions of ED visits for dizziness/vertigo visits or nondizziness controls from NHAMCS (1993–2005) using our previously published data.¹ We used time trend regression with an autoregressive model analysis (see "Data Analysis" section) of NHAMCS data (1995–2009) to estimate current total numbers of ED visits for dizziness and nondizziness presentations. We used a 2011 visit projection as "current" to match the most recent available price index for inflation adjustment. Dizziness cases were defined as a NHAMCS visit reason of vertigo/dizziness in any of the three reason-for-visit fields or a

final International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis of vertigo/dizziness (780.4) or vestibular disorder (386.x) in any of three final diagnosis fields.¹ Nondizziness controls were defined as not containing NHAMCS RFV code 1225.0, ICD-9-CM 386.x, or ICD-9-CM 780.4 in any of the three reason-for-visit fields.¹

Outcome Measures

The primary outcome was the total national annual costs of ED dizziness and vertigo in 2011 and the attributable fraction of total national ED costs in that year. Aggregate national cost estimates were derived as a weighted average of costs (MEPS) for each of 17 major etiologic categories associated with a dizziness or nondizziness visit (NHAMCS). We made no adjustment for the discrepancy in sampling years between MEPS and NHAMCS data. Secondary outcomes were the proportion of visits in which patients underwent neuroimaging and demographic subgroup analysis by age (≥ 65 years old), since an older age distribution could confound the association between the costs of dizziness and pure visit prevalence.

Visit diagnoses were aggregated into categories using Healthcare Cost and Utilizations Project's Clinical Classifications Software (HCUP-CCS). We used standard multilevel codes but, as done previously,¹ separated otologic/vestibular diagnoses and cerebrovascular diagnoses from their parent categories and combined the two most infrequent categories (congenital and perinatal disorders). We took this approach because the former categories have special relevance in the dizziness/vertigo population and the latter categories are rare causes. This yielded 17 total categories for analysis. For costs associated with each diagnostic category, data from the household component of the survey, including the medical conditions file and ED event file, were used. As recommended by the Agency for Healthcare Research and Quality (AHRQ), a minimum sample of 100 was required to estimate costs for each diagnostic category.^{11,21} We calculated average visit costs associated with each HCUP-CCS diagnostic category from the MEPS database. All cost values were adjusted to 2011 dollars using the Hospital Personal Health Care Expenditures price index as recommended by AHRQ. We chose 2011 values because this was the most recently available index at the time of analysis.

We calculated the attributable fraction of dizziness and nondizziness presentations for each of the 17 diagnostic categories using our prior NHAMCS analysis.¹ Each ED visit in NHAMCS may be given up to three diagnostic codes. In our prior analysis, those with dizziness or vertigo received an average of 1.7 diagnoses, and those with more than one diagnosis were coded twice (yielding a sum of coded categories greater than 100%). To estimate the attributable fraction in this study, we normalized the proportion of dizziness and nondizziness presentations for each diagnostic category (i.e., divided each category proportion by the sum of all category proportions). The attributable fraction was multiplied by the estimated mean annual national total ED visits for 2011 to derive the total per-diagnostic-category annual national costs. These results were summed to estimate the total national annual costs of ED dizziness

and vertigo in 2011 (primary outcome). We also calculated the total national annual costs of ED nondizziness presentations in 2011 so we could assess the attributable fraction of costs for dizziness visits. The congenital and perinatal disorders category did not contribute to the weighted average or total because of an insufficient number of cases in the NHAMCS database (<30 from 1995–2005).²²

Data Analysis

We report descriptive statistics on dizziness visits, utilization, and dizziness-related average and total costs. To estimate the attributable fraction of diagnostic categories, we normalized the proportion of dizziness and nondizziness presentations for each diagnostic category (i.e., we divided each category proportion by the sum of all category proportions). We calculated the average ED visit cost-per-diagnosis-group from MEPS and adjusted the results to 2011 dollars using the Hospital Personal Health Care Expenditures price index (i.e., for each year of MEPS data, we calculated the ratio of price indices in 2011 to the target year being adjusted [e.g., 2011:2005]; we then multiplied that result by the target year costs to derive the costs in 2011 dollars). To extrapolate visit numbers and imaging proportions to recent and future years, we performed a time-series forecasting analysis using a stepwise autoregressive method that combines time-trend regression with an autoregressive model and uses a stepwise method to select the lags to use for the autoregressive process. Data analysis was performed using SAS 9.3 statistical software (SAS Institute Inc., Cary, NC).

RESULTS

Table 1 provides weighted national estimates for ED visits for dizziness or vertigo and nondizziness visits, along with the associated imaging fraction from NHAMCS (1995–2009) and extrapolated (2010–2015). The total NHAMCS 15-year sample for dizziness visits was 12,202 and for nondizziness visits 360,424. There was a clear rising trend in the number of visits for dizziness and vertigo (2.0 million in 1995, 2.8 million in 2000, 3.0 million in 2005, 3.8 million in 2009) without an obvious shift in demographics towards an older population (fraction age ≥ 65 years: 25.6% in 1995, 31.9% in 2000, 29.7% in 2005, 28.5% in 2009). The fraction of all ED visits attributable to dizziness may have risen slightly during this time frame (2.7% in 1995, 3.4% in 2000, 3.4% in 2005, 3.6% in 2009). There was a dramatic rising trend in CT scan use (9.4% in 1995, 17.1% in 2000, 22.8% in 2005, and 37.4% in 2009). For patients with dizziness, CT use was predominantly neuroimaging (proportion head CT 87.6% vs. nondizziness 50.0%, $p < 0.001$). Although there was probably also an upward trend in use of magnetic resonance imaging (MRI) scans from a much lower baseline (1.2% in 1995, 1.0% in 2000, 1.8% in 2005, and 2.4% in 2009), the available raw sample of patients with dizziness undergoing MRI was too small to offer a stable national estimate in any individual year. For patients with dizziness, MRI use was virtually all neuroimaging (proportion head MRI 96.3% vs. nondizziness 48.3%, $p < 0.001$).

Table 1
National Estimates* of ED Dizziness and Nondizziness Visits With Imaging Fraction

Year	All Visits Sample (n)	All Visits Weighted National Estimate (n, Thousands)	Dizzy Visits Sample (n)	Dizzy Weighted National Estimate (n, Thousands)	95% CI Lower Bound (n, Thousands)	95% CI Upper Bound (n, Thousands)	% of All Visits With Dizzy (%)	% of Dizzy Visits >65 yr (%)	Dizzy CT or MRI† (%)	Dizzy CT (%)	Dizzy MRI‡ (%)	Nondizzy CT or MRI† (%)	Nondizzy CT (%)	Nondizzy MRI (%)
1995	16,569	72,680	468	1,986	1,641	2,332	2.7	25.6	10.0	9.4	1.2	3.4	3.2	0.2
1996	16,764	68,293	533	2,219	1,957	2,482	3.2	32.6	12.4	12.3	0.1	3.9	3.7	0.2
1997	17,153	73,310	531	2,421	2,104	2,738	3.3	31.6	10.4	10.3	0.0	4.2	4.0	0.3
1998	18,701	76,839	569	2,474	2,118	2,829	3.2	31.8	13.4	13.1	0.3	4.5	4.4	0.2
1999	16,566	79,766	542	2,562	2,217	2,907	3.2	33.9	14.5	13.4	1.1	5.5	5.3	0.3
2000	20,056	83,285	658	2,848	2,494	3,202	3.4	31.9	17.6	17.1	1.0	5.7	5.6	0.2
2001	27,042	84,059	901	2,892	2,519	3,266	3.4	32.4	19.4	NA	NA	6.9	NA	NA
2002	29,421	84,968	1031	2,978	2,550	3,407	3.5	33.2	18.3	NA	NA	8.1	NA	NA
2003	31,576	87,930	1121	3,125	2,733	3,516	3.6	32.5	23.6	NA	NA	8.8	NA	NA
2004	28,871	86,017	1078	3,313	2,853	3,774	3.9	30.3	26.1	NA	NA	10.2	NA	NA
2005	26,327	89,483	899	3,000	2,517	3,482	3.4	29.7	24.0	22.8	1.8	12.6	12.3	0.5
2006	27,552	96,031	935	3,317	2,893	3,740	3.5	25.6	29.5	29.3	0.6	13.2	12.8	0.6
2007	28,527	93,250	991	3,295	2,828	3,762	3.5	27.9	32.1	30.7	2.0	16.1	15.7	0.7
2008	27,569	99,107	982	3,519	3,138	3,899	3.6	28.1	36.3	35.3	1.4	16.6	16.2	0.7
2009	27,730	106,241	963	3,836	3,267	4,405	3.6	28.5	38.3	37.4	2.4	16.6	16.1	0.8
2010	—	103,553	—	3,804	3,511	4,096	3.7	28.5	37.8	37.0	1.8	17.6	17.6	0.8
2011	—	105,820	—	3,914	3,615	4,213	3.7	28.3	39.9	39.4	2.3	18.6†	19.0†	0.8
2012	—	108,087	—	4,025	3,718	4,331	3.6	28.2	41.9	39.4	1.9	19.7	18.8	0.8
2013	—	110,354	—	4,135	3,821	4,450	3.7	28.0	43.9	41.2	2.4	20.7	20.2	0.9
2014	—	112,621	—	4,246	3,923	4,569	3.8	27.9	45.9	45.0	2.3	21.7	22.0	1.0
2015	—	114,888	—	4,356	4,024	4,688	3.8	27.8	47.9	46.6	2.7	22.8	22.7	1.0

MRI = magnetic resonance imaging; NA = not available (in 2001–2004 NHAMCS only collected combined MRI and CT data together, not individual CT or MRI data).

*Sample from the National Hospital Ambulatory Medical Care Survey (NHAMCS) 1995–2009. Weighted results and proportions extrapolated 2010–2015.

†“CT or MRI” does not equal the sum of CT and MRI because some patients had both types of scan. For forecasted years, values do not sum and may be implausible (e.g., 2011).

‡NHAMCS data for dizzy MRI scans in each year were based on small raw sample sizes (n<30), so are not considered stable, nationally representative figures.

Forecasting model results are shown in Table 1 (2010 through 2015) and Data Supplement S1 (e-Figures 1 through 4, available as supporting information in the online version of this paper). The projected total number of dizziness and vertigo presentations to the ED in 2011 was estimated at 3.9 million (95% confidence interval [CI] = 3.6 to 4.2 million). The proportion undergoing diagnostic imaging by CT or MRI in 2011 was estimated to be 39.9% (39.4% CT, 2.3% MRI). From 1995 to 2011, the annual number of dizziness visits

increased from 2.0 to 3.9 million (97% increase), while the number of nondizziness visits increased from 70.7 million to 101.9 million (44% increase). From 1995 to 2011, the proportion of dizziness visits undergoing advanced imaging increased from 10.0% to 39.9% (4.0-fold increase) and the proportion of nondizziness visits undergoing advanced imaging increased from 3.4% to 19.0% (5.6-fold increase). Thus, dizziness visits are rising out of proportion to all ED visits, but advanced imaging for dizziness visits is not (although the

Table 2
Average Costs by Diagnostic Category, Ordered by Estimated Total 2011 Attributable Cost for Dizziness

HCUP Level 1 Diagnostic Category*	Proportion of Nondizziness Visits (%)	Proportion of Dizziness Visits (%)	MEPS Sample (n)	Average Visit Cost in 2011 Dollars	Standard Error (\$)	2011 Nondizziness - attributable Costs [†] (\$)	2011 Dizziness - ATTRIBUTABLE Costs [‡] (\$)
Cardiovascular (circulatory diseases excluding cerebrovascular)	9.89	16.47	2,620	1,489.00	131.76	15,011,562,987	959,889,928
Otologic/vestibular	1.25	25.68	458	768.33	98.98	976,976,377	772,282,063
Metabolic (endocrine, nutritional, and metabolic diseases and immunity disorders)	3.92	8.59	855	998.84	85.51	3,991,690,301	335,832,117
Respiratory	13.28	8.98	2,729	855.86	38.61	11,582,364,659	300,823,807
Injury/poisoning	27.36	8.27	6,095	891.46	23.2	24,856,986,294	288,562,910
Neurologic (nervous system and sense organ diseases excluding otologic/vestibular)	5.70	5.15	1,193	1,117.36	101.51	6,495,032,528	225,233,760
Diseases of the digestive system	8.29	5.46	2,500	1,043.39	37.51	8,813,285,823	222,983,357
Psychiatric (mental disorders)	5.35	5.62	718	921.65	71.06	5,022,564,401	202,738,151
Diseases of the genitourinary system	7.40	3.98	1,594	1,229.51	52.27	9,268,690,790	191,535,057
Cerebrovascular disease	0.89	3.12	390	1,059.39	111.97	962,197,237	129,372,986
Diseases of the musculoskeletal system and connective tissue	7.22	2.19	1,647	840.11	44.35	6,180,582,522	72,013,415
Infectious and parasitic disease	2.67	2.26	450	736.04	67.76	2,005,538,058	65,109,295
Diseases of blood and blood-forming organs	0.98	1.64	117	979.12	194.4	978,220,688	62,851,104
Complications of pregnancy, childbirth, and the puerperium	2.05	1.33	767	902.78	56.49	1,885,897,139	46,996,629
Neoplasms	0.89	0.7	287	1,274.54	153.66	1,157,608,498	34,920,837
Diseases of the skin and subcutaneous tissue	2.76	0.55	582	788.51	63.22	2,220,123,509	16,974,736
Congenital anomalies/certain conditions originating in perinatal period	0.09	NC	29	1,347.48	455.76	122,385,668	NC
Total/weighted mean	100.00	100	23,031	1,003.70	NA	101,531,707,480	3,928,120,151

HCUP = Healthcare Cost and Utilization Project; MEPS = Medical Expenditure Panel Survey; NA = not available (combined variance calculations with adjustment were not performed); NHAMCS = National Hospital Ambulatory Medical Care Survey. NC = not calculated due to low sample size (below 30 in NHAMCS, or below 100 in MEPS). Note that as a result, weighted averages and totals do not reflect any results from the congenital and perinatal conditions category.
 *Standard HCUP top-level (Level 1) major etiologic categories are used except that (a) cerebrovascular and otovestibular diagnoses (Level 2) are pulled from their parent categories and displayed separately; and (b) congenital and perinatal conditions are combined.
[†]Attributable costs for nondizziness = (101.9 million annual ED nondizziness visits extrapolated for the year 2011) × (normalized NHAMCS-derived attributable fraction of ED nondizziness visits 1995–2005) × (MEPS-derived average visit cost 2003–2008 by diagnostic category in 2011 dollars).
[‡]Attributable costs for dizziness = (3.9 million annual ED dizziness visits extrapolated for the year 2011) × (normalized NHAMCS-derived attributable fraction of ED dizziness visits 1995–2005) × (MEPS-derived average visit cost 2003–2008 by diagnostic category in 2011 dollars).

imaging fraction for dizziness visits is double that for nondizziness).

The total MEPS 6-year sample of ED visits for any diagnosis was 23,031. Table 2 summarizes the average and total costs associated with each diagnostic category for ED visits due to dizziness or vertigo. Cardiovascular diagnoses, with the second highest attributable fraction of dizziness visits (16.5%), were associated with the highest average per-visit cost and total annual national attributable cost (\$0.94 billion). Otologic/vestibular diagnoses, with the highest attributable fraction of dizziness visits in NHAMCS (25.7%), ranked second in total annual attributable costs (\$0.76 billion). The average cost for ED dizziness visits was \$1,004. The total estimated cost of dizziness and vertigo presentations to the ED in 2011 was \$3.9 billion (95% CI = \$3.6 to 4.2 billion). In 2011, ED visits for dizziness comprised 3.7% of all ED visits nationally and 3.9% of total ED visit costs. Thus, costs of dizziness visits were slightly greater, on average, than costs of other ED visits.

In MEPS, the general trend is for costs to rise with increasing age and comorbidity. Subgroup analysis (data not shown) of the interactions between age and condition showed a variable relationship to costs (i.e., some HCUP categories were associated with greater ED costs in those aged ≥ 65 years, others had lesser ED costs in those age ≥ 65 years). For otovestibular diagnoses (of particular interest here), ED costs were unexpectedly lower in those age ≥ 65 years compared to younger patients, but inpatient costs (explored because of this unexpected finding) were higher. In part, these lower ED costs for older patients with vestibular disorders may simply reflect differences in the likelihood of admission and redistribution of costs as a result. This finding suggests that our estimate of the total ED cost burden of dizziness could be influenced by the inpatient admission fraction, a finding that may deserve future study.

DISCUSSION

To our knowledge, this study offers the first nationally representative estimate of total costs for dizziness and vertigo presentations in the ED. We found that evaluation and management of dizziness and vertigo in the ED is very costly (~\$3.9 billion/year in 2011). While otologic and vestibular causes are the most common diagnoses, cardiovascular diseases are estimated to be associated with the highest average and total costs in dizziness presentations. Although cerebrovascular diagnoses (3.1% of diagnoses rendered) accounted for only \$127 million/year in total costs, the pursuit of stroke diagnoses likely accounted for a larger fraction, given the rising rates of CT scan use over time, now occurring at roughly 40% of all visits.

Our total cost estimate is 70% higher than a prior national estimate (\$1.1 billion/year in 1992,³ the equivalent of \$2.32 billion in 2011 dollars). The methods used to derive the prior estimate were never published, so different estimation procedures might partly account for the discrepancy. More likely, however, the increase mostly reflects the rising numbers of ED visits over time (2.0 million visits in 1995 to 3.9 million in 2011) and the rising proportion of dizziness visits receiving diagnostic

testing (10% imaged by CT or MRI in 1995 to 40% in 2011). It does not appear from our data, however, that rising costs are attributable to a demographic shift in patients with dizziness toward an older age group. It is unknown whether our methods understate or overstate actual costs, but, based purely on temporal trends, it is likely that our estimate, which used average 2003–2008 cost data, is conservative. The figure also does not include the costs of subsequent hospitalization for those admitted, nor outpatient diagnostic or treatment options recommended for those discharged.

Our work accords with prior studies demonstrating diagnostic tests are used disproportionately in patients with dizziness and may account for a large fraction of the ED costs and LOS.^{3,6} As in Dallara et al.,³ most of the imaging tests for dizziness visits in our study were head CTs (82.8% of all advanced imaging). In 2011, the Medicare global payment national average for a non-contrast brain CT, including technical and professional fees, was \$236.²³ Combining that value with our current data, we estimate \$360 million was spent that year on CT scans alone for ED patients with dizziness and vertigo. This does not consider the costs of contrast-enhanced CT scans, additional sequences (e.g., sinus or temporal bone CT), higher costs paid by private insurers, nor out-of-pocket costs for patients. MRI scans likely accounted for another \$110 million, given a Medicare payment of \$1222 for a noncontrast stroke-protocol MRI that includes magnetic resonance angiography of the head and neck.²⁴

There may be important opportunities to reduce these costs without reducing the quality of care. Much as with overuse in minor head injury²⁵ and syncope,²⁶ there is substantial CT overuse in dizziness. There are many possible reasons for test overuse, some of which are unrelated to EP judgment (e.g., patient or neurology consultant requests). Nevertheless, CT scans offer little benefit in the evaluation of dizziness and vertigo because of their low sensitivity (around 16%) for detecting acute ischemic stroke,¹¹ particularly in the posterior fossa. Several studies have pointed to very low (<1%) yields of brain CT in patients with dizziness or vertigo who lack clear neurologic signs,^{12–14} even when stroke is the cause.¹⁵ Nationally, an increasing fraction of ED patients being scanned has led to an increased LOS, but has not led to greater diagnostic yield of nervous system diagnoses.⁶ Furthermore, negative CT scans may be falsely reassuring to providers,^{8,9} increasing the risk of dangerous misdiagnosis.¹⁰ Finally, there is substantial unwarranted practice variation in the use of neuroimaging (e.g., 1.5-fold variation in rates of CT scanning for dizziness across northern California EDs, ranging from 22% to 33% in 2008).⁷

In the minority of cases where ischemic stroke is a legitimate diagnostic possibility, MRI is clearly the neuroimaging test of choice.^{27,28} At a minimum, CT scans are clearly overused in those with peripheral vestibular disorders such as benign paroxysmal positional vertigo²⁹ and vestibular neuritis,^{27,30} which are effectively diagnosed and treated at the bedside. In such cases, there is rarely need for any neuroimaging, especially CT, which has very limited diagnostic utility.⁵ Given known costs and radiation risks³¹ without clear

benefit, optimal care would dictate that CT use should generally be curtailed in patients with dizziness, and guidelines should be developed to determine appropriate use. Federal resources now allocated to use of CT might be better spent on improving the quality of bedside diagnosis in suspected vestibular patients.³² An international survey of emergency physicians found that the top adult emergency medicine priority for clinical decision rules was a rule for when to image patients with vertigo.³³ Using a rule that curtails the use of CT in the nearly two-thirds of dizziness patients without neurologic symptoms and signs¹² could eliminate nearly \$200 million per year in unnecessary costs, likely while improving the safety of care.

Although likely an appropriate place to initially focus cost-reduction interventions, imaging costs (~\$470 million/year) appear to account for only about 12% of the total ED visit costs in patients with dizziness. Prior studies suggest many patients with dizziness undergo routine laboratory diagnostics (e.g., blood chemistry and glucose measurement), electrocardiography, and cardiac monitoring at high rates,^{1,3} sometimes inappropriately.⁵ They also frequently undergo therapeutic procedures and receive medication treatments,¹ sometimes inappropriately.⁵ It is likely that controlling unnecessary costs for ED patients presenting with dizziness and vertigo will require systematic study of symptom-specific diagnostic algorithms and treatment pathways and may also require approaches that reduce unnecessary ED visits in the first place. Such an approach is particularly relevant from a societal perspective, given the steadily rising number of ED visits for dizziness over time.

LIMITATIONS

Limitations include the lack of detailed component costs, potential classification errors in MEPS or NHAMCS, and the inferential method used to derive national estimates. We lack granular clinical data that might speak directly to the issue of CT overuse at a national level. The mismatch between sampling years for MEPS (2003 through 2008) and NHAMCS (1995 through 2009) might have influenced our analysis. If the distribution of diagnoses for ED dizziness has changed in recent years, our total cost estimate (based on average diagnosis category distributions from 1995 through 2005) might differ from the true current value. Average per-diagnosis costs (e.g., cardiovascular diagnoses presenting with any symptoms) might be higher or lower than actual costs in the subset presenting specifically with dizziness. Our estimates reflect costs associated with diagnoses rendered, rather than diagnoses pursued (e.g., neuroimaging obtained to “rule out” cerebrovascular disease in a patient ultimately diagnosed with a peripheral vestibular or cardiovascular disorder after neuroimaging results were normal).

CONCLUSIONS

Total U.S. national costs for patients presenting with dizziness to the ED are substantial, estimated to now exceed \$4 billion per year. Because diagnostic test use (e.g., neuroimaging) is likely an important driver of

these costs, greater attention should be paid to streamlining diagnostic evaluations of dizziness and vertigo. Future economic analyses should measure the specific breakdown and principal drivers of total costs. New diagnostic pathways should be assessed for both their cost-effectiveness and outcomes.

References

1. Newman-Toker DE, Hsieh YH, Camargo CA Jr, Pelletier AJ, Butchy GT, Edlow JA. Spectrum of dizziness visits to US emergency departments: cross-sectional analysis from a nationally representative sample. *Mayo Clin Proc.* 2008; 83:765–75.
2. Newman-Toker DE, Cannon LM, Stofferahn ME, Rothman RE, Hsieh YH, Zee DS. Imprecision in patient reports of dizziness symptom quality: a cross-sectional study conducted in an acute care setting. *Mayo Clin Proc.* 2007; 82:1329–40.
3. Dallara J, Lee C, McIntosh L, Sloane PD, Morris D. ED length-of-stay and illness severity in dizzy and chest-pain patients. *Am J Emerg Med.* 1994; 12: 421–4.
4. Kerber KA, Meurer WJ, West BT, Fendrick AM. Dizziness presentations in U.S. emergency departments, 1995-2004. *Acad Emerg Med.* 2008; 15:744–50.
5. Newman-Toker DE, Camargo CA Jr, Hsieh YH, Pelletier AJ, Edlow JA. Disconnect between charted vestibular diagnoses and emergency department management decisions: a cross-sectional analysis from a nationally representative sample. *Acad Emerg Med.* 2009; 16:970–7.
6. Kerber KA, Schweigler L, West BT, Fendrick AM, Morgenstern LB. Value of computed tomography scans in ED dizziness visits: analysis from a nationally representative sample. *Am J Emerg Med.* 2010; 28:1030–6.
7. Kim AS, Sidney S, Klingman JG, Johnston SC. Practice variation in neuroimaging to evaluate dizziness in the ED. *Am J Emerg Med.* 2012; 30:665–72.
8. Stanton VA, Hsieh YH, Camargo CA, et al. Overreliance on symptom quality in diagnosing dizziness: results of a multicenter survey of emergency physicians. *Mayo Clin Proc.* 2007; 82:1319–28.
9. Edlow JA, Newman-Toker DE, Savitz SI. Diagnosis and initial management of cerebellar infarction. *Lancet Neurol.* 2008; 7:951–64.
10. Savitz SI, Caplan LR, Edlow JA. Pitfalls in the diagnosis of cerebellar infarction. *Acad Emerg Med.* 2007; 14:63–8.
11. Chalela JA, Kidwell CS, Nentwich LM, Luby M, Butman JA, Demchuk AM. Magnetic resonance imaging and computed tomography in emergency assessment of patients with suspected acute stroke: a prospective comparison. *Lancet.* 2007; 369:293–8.
12. Wasay M, Dubey N, Bakshi R. Dizziness and yield of emergency head CT scan: is it cost effective? *Emerg Med J.* 2005; 22:312.
13. Lawhn-Heath C, Buckle C, Christoforidis G, Straus C. Utility of head CT in the evaluation of vertigo/dizziness in the emergency department. *Emerg Radiol.* 2013; 20:45–9.

14. Syamal M, Ahsan S, Yaremchuk K. Cost analysis and efficacy of imaging in evaluating dizzy patients in the emergency department. In: Abstracts of the Triological Society Combined Sections Meeting. Miami, FL, 2012. Available at: <http://www.triomeetingposters.org/wp-content/uploads/2012/12/164.pdf>. Accessed May 4, 2013.
15. Chase M, Joyce NR, Carney E, et al. ED patients with vertigo: can we identify clinical factors associated with acute stroke? *Am J Emerg Med.* 2012; 30:587–91.
16. Agency for Healthcare Research and Quality. MEPS: Medical Expenditure Panel Survey. Available at: http://meps.ahrq.gov/mepsweb/about_meps/survey_back.jsp. Accessed May 3, 2013.
17. McCaig LF, McLemore T. Plan and operation of the National Hospital Ambulatory Medical Survey. Series 1: programs and collection procedures. *Vital Health Stat 1.* 1994; 1–78.
18. Centers for Disease Control and Prevention. National Health Interview Survey. Available at: http://www.cdc.gov/nchs/nhis/about_nhis.htm/. Accessed May 3, 2013.
19. Bisdorff A, Von Brevern M, Lempert T, Newman-Toker DE. Classification of vestibular symptoms: towards an international classification of vestibular disorders. *J Vestib Res.* 2009; 19:1–13.
20. Centers for Disease Control and Prevention. 2009 NHAMCS Micro-data File Documentation. Available at: ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHAMCS/doc09.pdf. Accessed May 3, 2013.
21. Machlin SR, Chowdhury SR, Ezzati-Rice T, et al. Estimation Procedures for the 2007 Medical Expenditure Panel Survey Household Component. Rockville, MD: Agency for Healthcare Research and Quality. U.S. Department of Health & Human Services, 2010.
22. McCaig L, Woodwell D. Analyzing data from the NAMCS and the NHAMCS. In: 2006 Data Users Conference Presentations. Available at: http://www.cdc.gov/nchs/ppt/duc2006/Mccaig_28.ppt. Accessed May 4, 2013.
23. Siemens Medical Solutions USA. 2011 Medicare Hospital Outpatient Prospective Payment Schedule Rates: Computed Tomography Procedures. Available at: http://www.medical.siemens.com/siemens/en_US/rg_marcom_FBAs/files/Reimbursement/CT_2011_Final_HOPPS_Payment_Rates.pdf. Accessed May 3, 2013.
24. Siemens Medical Solutions USA. 2011 Medicare Hospital Outpatient Prospective Payment Schedule Rates: Magnetic Resonance Imaging. Available at: http://www.medical.siemens.com/siemens/en_US/rg_marcom_FBAs/files/Reimbursement/MR_2011_Final_HOPPS_Payment_Rates.pdf. Accessed May 3, 2013.
25. Korley FK, Pham JC, Kirsch TD. Use of advanced radiology during visits to US emergency departments for injury-related conditions, 1998-2007. *JAMA.* 2010; 304:1465–71.
26. Grossman SA, Fischer C, Bar JL, et al. The yield of head CT in syncope: a pilot study. *Intern Emerg Med.* 2007; 2:46–9.
27. Tarnutzer AA, Berkowitz AL, Robinson KA, Hsieh YH, Newman-Toker DE. Does my dizzy patient have a stroke? A systematic review of bedside diagnosis in acute vestibular syndrome. *CMAJ.* 2011; 183: E571–92.
28. Turski P, Wippold F, Cornelius R. ACR appropriateness criteria-vertigo and hearing loss. In: American College of Radiology (ACR) Expert Panel on Neurologic Imaging; 2008.
29. Bhattacharyya N, Baugh RF, Orvidas L, et al. Clinical practice guideline: benign paroxysmal positional vertigo. *Otolaryngol Head Neck Surg.* 2008; 139: S47–81.
30. Kattah JC, Talkad AV, Wang DZ, Hsieh YH, Newman-Toker DE. HINTS to diagnose stroke in the acute vestibular syndrome: three-step bedside oculomotor examination more sensitive than early MRI diffusion-weighted imaging. *Stroke.* 2009; 40:3504–10.
31. Smith-Bindman R, Lipson J, Marcus R, et al. Radiation dose associated with common computed tomography examinations and the associated lifetime attributable risk of cancer. *Arch Intern Med.* 2009; 169:2078–86.
32. Kerber KA, Morgenstern LB, Meurer WJ, et al. Nystagmus assessments documented by emergency physicians in acute dizziness presentations: a target for decision support? *Acad Emerg Med.* 2011; 18:619–26.
33. Eagles D, Stiell IG, Clement CM, et al. International survey of emergency physicians' priorities for clinical decision rules. *Acad Emerg Med.* 2008; 15:177–82.

Supporting Information

The following supporting information is available in the online version of this paper:

Data Supplement S1. Rising costs of ED dizziness.