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Practice variation in neuroimaging to evaluate dizziness in the ED^{☆,☆☆}

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Abstract

Background—The appropriate role of neuroimaging to evaluate emergency department (ED) patients with dizziness is not established by guidelines or evidence.

Methods—We identified all adults with a triage complaint of dizziness who were evaluated at 20 EDs of a large Northern California integrated health care program in 2008. Using comprehensive medical records, we captured all head computed tomographies (CTs) or brain magnetic resonance images (MRIs) completed at presentation or within 2 days and all stroke diagnoses within 1 week. We assessed variation in neuroimaging use by site using a random-effects logistic model to account for differences in patient- (demographic and vascular risk factors) and site-level factors (volume, % patients with dizziness, and % patients with dizziness admitted) and linear regression to assess the relationship between neuroimaging rates and stroke diagnosis rates by site.

Results—Of 378 992 patients seen in 2008, 20 795 (5.5%) had at least one ED visit for dizziness. Overall, 5585 patients (26.9%) had a head CT and 652 (3.1%) had a brain MRI. Between 21.8% and 32.8% of ED patients with dizziness at each site had a head CT ($P < .001$). For brain MRI, the range was 0.8% to 6.2%—a nearly 8-fold variation ($P < .001$) that persisted after adjustment for patient- and site-level factors. Higher neuroimaging rates did not translate into higher stroke diagnoses rates, with 0.7% to 2.5% of patients with dizziness diagnosed with stroke by site.

Conclusion—The use of neuroimaging for ED patients with dizziness varies substantially without an associated improvement in stroke diagnosis, which is identified only rarely.

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1. Introduction

Dizziness is one of the most common reasons for visiting the emergency department (ED) and accounts for more than 1.5 million ED visits in the United States each year [1–3]. Although most patients can be discharged home with a benign diagnosis and prognosis, some patients have potentially serious underlying diagnoses such as stroke [4,5]. Therefore, ED evaluations are often prolonged and involve significant use of health care resources to adequately evaluate for these serious causes [3], although a substantial proportion of these patients are still discharged home without a specific diagnosis [3,6,7]. The stakes for developing a rational, efficient, and cost-effective approach for this symptom are particularly high in the ED setting where the goals of providing efficient, timely, and appropriate diagnostic workups may conflict with general concerns about the medicolegal consequences of missing an important diagnosis and the pressures of maintaining patient flow. However, consensus on an optimal management approach for dizziness has remained elusive, and the specific role of neuroimaging for evaluating these patients has not been established.

Although neuroimaging studies such as head computed tomography (CT) scans and brain magnetic resonance imaging (MRI) studies have the potential to improve management and triage decisions for ED patients with dizziness, little is known about how these studies are currently selected or applied in clinical practice or the diagnostic yield of these tests for uncommon but serious conditions such as stroke. For instance, although head CTs are widely available, they have limited sensitivity for detecting posterior-circulation strokes that can cause dizziness symptoms and they require exposing patients to ionizing radiation [8]. On the other hand, brain MRIs have greater sensitivity for detecting cerebral ischemia and posterior fossa lesions but are not as widely available in the ED setting and carry higher initial costs [8]. Moreover, both imaging modalities have the potential to increase morbidity and costs by triggering unnecessary workups for incidental findings when applied in an untargeted fashion. Despite the relative lack of comparative effectiveness research on the application and yield of these studies in the ED, well over 600 000 neuroimaging studies were obtained in the United States to evaluate ED patients with dizziness in 2008, which represents at least \$400 million in direct annual imaging costs alone [9].

Our goals were to characterize the extent of practice variation in the use of neuroimaging studies for ED patients with dizziness, including the frequency and type of studies obtained, and to examine the impact of this variation on the rate of initial and delayed cerebrovascular diagnoses. We theorized that unexplained variation in the use of neuroimaging studies that was not accompanied by improved detection of stroke could present an attractive target for efforts to rationalize the clinical management of these patients, perhaps through the development of a clinical decision rule.

2. Methods

2.1. Study design

We conducted a retrospective cohort study using comprehensive medical records for follow-up.

2.2. Setting

Kaiser Permanente Northern California is a large integrated health program with sociodemographic characteristics that closely mirror that of the greater San Francisco Bay Area, although high and low extremes of socioeconomic status are relatively underrepresented [10]. The EDs included in this study (Deer Valley, Fremont, Fresno, Hayward, Manteca, Modesto, Oakland, Richmond, Roseville, Redwood City, Sacramento, Santa Clara, San Francisco, San Rafael, Santa Rosa, South Sacramento, South San Francisco, Stockton, Vallejo, and Walnut Creek) are community-based facilities with a median of 25 878 adult visits and a median of 18 347 unique adults seen in 2008. There is one level II trauma center in the network (South Sacramento). Nearly all of the patients seen at these facilities are members of the Kaiser Permanente integrated health program. Kaiser Permanente maintains detailed documentation of medical care provided through its comprehensive inpatient and outpatient network as well as for care provided to its members outside this network through out-of-network billing records. During the study period, there was no standard imaging protocol in place for the evaluation of dizziness in the ED and all EDs had access to urgent MRI studies.

2.3. Selection of participants

We identified all adult Kaiser Permanente members who visited one of the 20 EDs within the Northern California region from January 1, 2008, to December 31, 2008, with a primary complaint of dizziness as recorded by the triage nurse at initial presentation. We restricted our study to patients who were 18 years or older because the risk factors and causes for cerebrovascular outcomes may be different in the pediatric population [11]. We also restricted our analysis to only members of Kaiser Permanente to enhance our ability to longitudinally capture subsequent patient encounters. For patients with multiple ED visits for dizziness during the study period, the first ED visit during the study period was used as the index visit. A data analyst with specific and extensive expertise with the clinical databases and electronic medical record systems used at Kaiser Permanente designed the queries that were used to identify the members of the cohort and to abstract the clinical data elements used for this study.

2.4. Demographic information and vascular risk factors

Demographic information (age, sex, race/ethnicity), ED facility, and ED disposition were derived from ED encounter records. Vascular risk factors at the index ED visit were determined by searching for corresponding *International Classification of Diseases, Ninth Revision* codes (hypertension [401.x or 405.x], diabetes [250.x], hyperlipidemia [272.x], and atrial fibrillation [437.3x]) within outpatient active problem lists, inpatient or outpatient encounters within 1 year before the index ED visit, and from active medication lists for antihypertensive, diabetic, and cholesterol-lowering medications.

2.5. Neuroimaging studies

We identified all head CT or brain MRI scans ordered from the ED using comprehensive system-wide clinical databases. To capture imaging studies that were ordered but not completed in the ED (eg, patients who were discharged with the plan for an outpatient

imaging study and a subsequent follow-up in clinic pending the results), we also included any head CT or brain MRI scan done within the next 2 days after the initial ED visit.

2.6. Stroke outcomes

We identified all stroke diagnoses that were made at either the initial ED visit or any subsequent inpatient or outpatient patient encounter by applying a previously validated algorithm with high sensitivity and specificity to the patient's comprehensive medical records [12]. Specifically, we identified inpatient or outpatient encounters with a diagnosis code for hemorrhagic or ischemic stroke (430, 431, 433.x1, 434.x1, or 436.x) in any position but excluded any encounters that listed diagnosis codes for rehabilitation (V57) or trauma (800, 801, 802, 803, 804, or 85x). In this way, we were able to capture stroke diagnoses made in the ED, stroke diagnoses made only after patients were admitted to the hospital from the ED, as well as delayed stroke diagnoses and incident strokes that were diagnosed during the follow-up period.

2.7. Data analysis

We generated descriptive statistics for demographic and clinical characteristics of the overall cohort and stratified by facility. We used a random-effects model to evaluate facility-level effects on the proportion of ED patients with dizziness referred for neuroimaging studies. χ^2 tests were used to test for statistically significant variation by site. We present unadjusted and adjusted analyses. In the adjusted analysis, to account for potential differences in baseline cerebrovascular risk for patients seen at each facility, we adjusted for patient-level factors (age, sex, race, and vascular risk factors [hypertension, hyperlipidemia, diabetes, and atrial fibrillation]). We also adjusted for site-level factors such as the percentage of patients with dizziness complaints, the percentage of patients with dizziness admitted to hospital, and overall hospital volume to account for differences in case definitions of dizziness, overall patient acuity, and ED resources, respectively. For examining the association between neuroimaging rates and stroke diagnoses by site, we used a linear regression model with each site weighted by the absolute number of patients with dizziness seen at each site with separate models for head CT and brain MRI. Stata (MP version 11.1; Stata Corporation, College Station, TX) was used for all statistical analyses.

2.8. Institutional review board approval

This study was approved by both the Kaiser Permanente Division of Research Institutional Review Board and the local Committee on Human Research.

3. Results

During the 12-month study period in 2008, we identified 20 795 adult Kaiser Permanente members (5.5%) with at least one ED visit listing a triage chief complaint of dizziness from among the 378 992 unique individuals who visited one of 20 EDs within the network. (Table 1). The median age of patients in the cohort was 57 (interquartile range [IQR], 42–72) with substantially more women (12 515; 60.2%) than men. Vascular risk factors were common overall, and the race/ethnic makeup of the cohort appeared broadly reflective of the diverse population of Northern California (Table 1).

Overall patient volumes and the median percentage of patients presenting with dizziness symptoms by ED are shown in Table 2. The median age, proportion of female patients, and overall prevalence of vascular risk factors of the patients with dizziness seen at each facility was comparable, whereas the race/ethnic makeup and the overall patient volume varied by site. Overall, 5660 (27.2%) of these ED patients with dizziness had at least one neuroimaging study. A total of 5008 patients (24.1%) had only a head CT scan, 577 (2.8%) had both head CT and brain MRI scans, and 75 (0.4%) had only a brain MRI scan. In the unadjusted analysis, there was a 1.5-fold variation in the rate of any neuroimaging by site from a low of 21.8% to a high of 32.8% (Fig. 1).

In univariate analysis, age, male sex, and vascular risk factors were all associated with obtaining a neuroimaging study (Table 3). There was significant heterogeneity in the use of neuroimaging studies across sites. The proportion of ED patients with dizziness who had a CT scan at each site varied from 21.3% to 32.8%, which represents a 1.5-fold difference in head CT use in these patients between sites with the lowest and the highest use rates ($P < .001$). After adjustment for patient-level factors such as age, sex, and vascular risk factors and for facility-level factors such as the overall proportion of patients with dizziness, patient volume, and proportion of patients with dizziness who were admitted (Table 3), this degree of variation persisted with a range of 22.6% to 31.1% from low- to high-use sites (a 1.4-fold variation). Patients with dizziness who presented to the ED on a weekend received head CT scans at similar rates as those who presented on a weekday (odds ratio [OR], 1.01; 95% confidence interval [CI], 0.91–1.12; $P = .86$). Computed tomography and MRI were both strongly associated with hospital admission (OR, 2.0; 95% CI, 1.8–21 for CT; OR, 12; 95% CI, 10–14 for MRI).

Advancing age, male sex, and the presence of vascular risk factors, with the exception of atrial fibrillation, were all associated with obtaining a brain MRI (Table 3). Again, there was substantial heterogeneity in the use of brain MRIs by site with a nearly 7.9-fold variation in the use of brain MRI by site from a low of 0.8% to a high of 6.2% (Fig. 2). After adjustment for patient- and site-level factors, we observed a persistent 6.4-fold variation in the rate of MRI use from 1.0% to 6.1% in low- and high-use sites. Patients with dizziness who presented to the ED on a weekend had similar rates of MRI scans as those who presented to the ED on a weekday (OR, 1.16; 95% CI, 0.88–1.52; $P = .29$).

Overall, 339 patients (1.6%) were diagnosed with a stroke within the 7 days of the index ED visit with a range of 0.7% to 2.5% by site. Among the 5660 patients who had a neuroimaging study from the ED, 306 (5.4%) were diagnosed with stroke within 7 days, with a range of 1.5% to 8.1% by site. However, among the 15 135 patients who did not have a neuroimaging study ordered by the ED, 33 (0.2%) were diagnosed with stroke within 7 days. An additional 167 patients were later diagnosed with a stroke in the next 90 days after the index ED visit. Of the 577 patients who had both CT and MRI, 157 (27.2%) were diagnosed with stroke within 90 days and 393 (68.1%) were admitted to hospital.

A higher neuroimaging rate by site was poorly predictive of a higher rate of stroke diagnoses by site with a 1% increase in the percentage of patients diagnosed with stroke (95% CI, –7%–9%; $P = .83$) per 10% increase in ED neuroimaging rate (see Fig. 3). Higher rates of

MRI use by site were also poorly predictive with a higher rate of stroke diagnoses by site, with an increase of 8% (95% CI, -4%–20%; $P = .17$) per 10% increase in the ED MRI scan rate (Fig. 4).

4. Discussion

Our study has identified significant variation in how often neuroimaging studies are used to evaluate dizziness in the ED, particularly for the use of brain MRI scans. Furthermore, higher use rates at a given site did not translate into a higher number of patients diagnosed with stroke, especially when using head CT scans. These findings persisted after adjustment for baseline differences in patient- and site-level factors. Because all of the sites for this study were part of a regional integrated health program, we hypothesize that even greater variation may exist across other more fragmented practice settings or across more widely dispersed geographic areas. Although the decision to obtain a neuroimaging study for an individual patient with dizziness is complex and involves a variety of individual patient- and system-level factors, we believe that unexplained practice variation that is not correlated with improvements in patient outcomes could provide opportunities to better target these studies and rationalize care. Accordingly, we propose that this observed variation in the use of neuroimaging studies for dizziness, particularly in the use of MRI scans, may reflect a general lack of consensus on which patients would benefit most from the diagnostic information provided by these studies.

Several factors combine to create a general incentive for increased-use neuroimaging studies to evaluate ED patients with dizziness. First, many patients have difficulty describing their symptoms [13] and the differential diagnosis includes a wide range of both benign and serious etiologies [3]. Therefore, the diagnostic evaluation of dizziness is often challenging, misdiagnosis is common [6], and many patients are still discharged without a specific diagnosis [3,7]. Therefore, with information from highly sensitive tests, especially in the case of MRI scans, clinicians may be able to reduce this diagnostic uncertainty. Second, there is limited information or understanding of the actual frequency of uncommon but potentially serious diagnoses such as stroke. Better information on the pretest probability of serious outcomes would inform any estimates of the diagnostic yield and posttest probability of disease in a given patient. Estimates of the overall stroke risk for patients with dizziness presenting to the ED varies range from 2.4% in our study to as low as 0.7% for ED patients with normal neurologic examination to 3% to 4% overall [3,6], but effective methods for stratifying this risk for individual patients or important subgroups of patients have not been established. Finally, there can be direct clinical and medicolegal consequences [14] for missing an acute presentation of stroke. Other factors such as direct financial incentives for increased use, or concerns about the availability of outpatient follow-up after discharge home, would be less relevant in our cohort because all patients were enrolled in an integrated health care program but may play a role in the availability and use of these studies in other practice settings.

The factors that are driving increased use of studies for dizziness evaluations are balanced against distinct drawbacks for expanding the use of neuroimaging studies in general. Chief among them is the high cost of these studies combined with the high prevalence of dizziness

symptoms. With 1.5 million ED visits for dizziness in the United States in 2007, these visits already result in nearly 550 000 head CTs and more than 42 000 brain MRIs [9] for these patients each year and well more than \$400 million in imaging costs alone. Although these costs must be balanced against the value of diagnostic information obtained, including the important information that is provided by a negative test, a low incidence of adverse outcomes in these patients generally and a low diagnostic yield for head CT in particular would argue for development of better ways to target these studies to the most appropriate patients, as has been demonstrated in other clinical setting with the Ottawa ankle rules for example [15].

In our study, higher neuroimaging rates by site did not translate into increased detection and diagnosis of stroke, even after adjustment for differences in patient- and site-level factors. In addition, sites with higher neuroimaging rates were not better protected against having stroke diagnoses made during the follow-up period, which suggests that increasing neuroimaging rates, particularly head CT imaging rates, would not be expected to yield significantly more early stroke diagnoses. This conclusion is supported by longitudinal data on a national level, where a dramatic rise in use of neuroimaging in the ED generally [16] and in ED patients with dizziness specifically [3] has not resulted in a rise in the proportion of patients with dizziness that are diagnosed with stroke.

In our cohort, the head CT imaging rate was 26.8% (compared with the national average of 36.5%) and brain MRI rate was 3.2% MRI (compared with 2.8% nationally) [8] —most neuroimaging studies were head CTs rather than MRI scans. We speculate that lower CT rates and higher MRI rates may derive from the integrated nature of the health care system, which allows for more seamless transitions from ED to outpatient clinic follow-up possible. Therefore, our analysis is largely driven by the diagnostic yield of head CT scans in general. Head CT scans for dizziness in the ED are of particularly low yield for evaluating vertigo symptoms overall [17] and are particularly insensitive to acute ischemia and for lesions in the posterior fossa. When MRI use is analyzed separately, we did find an increased diagnostic yield for stroke at those sites that used brain MRI more frequently, likely because of the much higher sensitivity of MRI scans for detecting acute ischemia in the brainstem and posterior fossa compared with head CT [8]. However, a previous cost-effectiveness analysis has already suggested that brain MRI for vertigo in the outpatient setting is not cost-effective [18]. Better data on the diagnostic yield and value of MRI in this setting with formal cost-effectiveness analysis would be necessary to reevaluate this conclusion in the ED setting for more generalized dizziness symptoms, where there may be a higher prevalence of serious presentations compared with the ambulatory setting [19].

In addition to the cost of MRI scans and sensitivity and radiation exposure concerns for head CT described above, our finding should be viewed in the context of potential harms that may occur from untargeted use of neuroimaging studies as well, particularly for very prevalent symptoms such as dizziness. For CT scans in particular, there has been increasing evidence that medical exposure to ionizing radiation for medical imaging is associated with a measurable increase in the incidence of cancer [20]. For neuroimaging studies generally, there are also harms associated with workups that are triggered by incidental findings, such as small unruptured aneurysms, cavernous malformations, or meningiomas [21]. In addition,

the insensitivity of head CT for lesions in the brainstem or posterior fossa can provide a false sense of diagnostic certainty with a negative result. Therefore, although we are unable to address the medical appropriateness of individual neuroimaging tests, our findings are consistent with the notion that head CT scans should have a more limited role in the ED evaluation of dizziness and that a reduction in the number of low-yield head CTs done for dizziness may be possible without sacrificing diagnostic yield.

These findings should be interpreted in light of several potential limitations. First, because our patient population was limited to members of an integrated health program and to a limited geographic region in Northern California, we cannot necessarily generalize to other practice settings or to other regions of the United States, although we would speculate greater practice variation may exist across regions or across practice settings than in a more integrated health network. Second, we cannot exclude the possibility of residual confounding from unmeasured factors that could explain the degree of practice variation observed across sites. In particular, clinical details about each patient, such as any associated symptoms or abnormal findings on the initial neurologic examination, were not available for this study; and we would expect some variation in the proportion of ED patients with dizziness with stroke at each site. Although we adjusted for the proportion of patients presenting with dizziness at each site, there may be residual confounding based on differences in case selection resulting from different definitions and criteria for listing dizziness as the chief complaint by site. Because the number of sites was relatively limited, adjustment for site-level effects may be incomplete. However, strengths of our study include a large sample size, multiple sites and models that take into account the hierarchical nature of the data, the availability of detailed patient-level information for risk adjustment, and the ability to capture delayed outcomes using a cohort design with longitudinal follow-up. In addition, the relative homogeneity of the care setting mitigates the impact of access to care and economic factors as contributors to the variability seen in our study.

In conclusion, for the evaluation of the ED patients with dizziness, any unexplained variation in the use of neuroimaging that does not translate into improved clinical outcomes may provide an attractive target for future optimizations. Our data are supportive of the need for a validated clinical decision rule to inform the management of dizziness in the ED—a notion that has already been identified as a top priority in a survey of ED physicians [22]. Standardized methods for assessing the risks associated with dizziness and for targeting neuroimaging studies to the most appropriate ED patients with dizziness have the potential to help rationalize the use of neuroimaging without sacrificing diagnostic yield.

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Fig. 1.
Variation in the overall use of neuroimaging to evaluate dizziness across 20 EDs within a Northern California integrated health program in 2008.

Fig. 2.

Variation in the use of brain MRI scans to evaluate dizziness across 20 EDs within a Northern California integrated health program in 2008.

Fig. 3.

Diagnostic yield for stroke within 7 days as a function of head CT use for patients with dizziness across 20 EDs within a Northern California integrated health program in 2008. Each point represents an individual ED and the line represents the best fit for linear regression weighted by the number of ED patients with dizziness seen at each site ($R^2 = 0.01$; slope, 0.8%; 95% CI, -7.1%– 8.7%; $P = .84$).

Fig. 4.

Diagnostic yield for stroke within 7 days as a function of brain MRI use for patients with dizziness across 20 EDs within a Northern California integrated health program in 2008. Each point represents an individual ED and the line represents the best fit for linear regression weighted by the number of ED patients with dizziness seen at each site ($R^2 = 0.10$; slope, 8%; 95% CI, $-3.8\% - 20.0\%$; $P = .17$).

Table 1

Characteristics of adult members of an integrated health program presenting to 20 Northern California EDs with a triage complaint of dizziness in 2008

Variable	All patients (n = 20795)
Age, median y (IQR)	57 (42–72)
Female, n (%)	12515 (60.2)
Race/ethnicity, n (%)	
White	11146 (53.6)
Asian	3193 (15.4)
Black	2246 (10.8)
Hispanic	222 (1.1)
Other	129 (0.6)
Unknown or decline to state	3859 (18.6)
Vascular risk factors, n (%)	
Hypertension	10881 (52.3)
Diabetes	4381 (21.1)
Hyperlipidemia	8936 (43.0)
Atrial fibrillation	1904 (9.2)
Disposition, n (%)	
Admitted	3083 (14.8)
Discharged to clinic	2530 (12.2)
Discharged to home	14505 (69.8)
Other	677 (3.3)

Table 2

Summary of site-level characteristics of patients with dizziness presenting to 20 EDs within a Northern California integrated health program in 2008

Variable	By site (median, IQR)
Total adult visits, n	25878 (20036–34017)
Total adult unique patients, n	18347 (13818–25910)
Patients with dizziness (%)	5.3 (4.4–5.9)
Age, y	56.3 (54.7–58.2)
Female (%)	60.0 (58.6–61.9)
Race/ethnicity (%)	
White	50.3 (46.9–65.7)
Asian	12.9 (6.8–19.5)
Black	6.3 (3.9–14.2)
Hispanic	1.0 (0.5–1.4)
Other	14.1 (8.1–16.4)
Unknown or decline to state	6.1 (1.9–8.8)
Vascular risk factors (%)	
Hypertension	51.7 (50.1–54.6)
Diabetes	21.5 (19.7–22.8)
Hyperlipidemia	42.4 (40.6–45.7)
Atrial fibrillation	9.6 (7.6–11.0)
Disposition (%)	
Admitted	14.9 (13.2–17.0)
Discharged to clinic	10.9 (5.1–17.9)
Discharged to home	70.7 (64.3–74.4)
Other	2.9 (2.2–3.8)

Table 3

Patient- and site-level factors associated with obtaining any neuroimaging study and for brain MRI studies for 20,795 ED patients with dizziness within a Northern California integrated health program in 2008

Variable	Any neuroimaging		MRI	
	Univariate	Multivariable	Univariate	Multivariable
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Patient factors				
Age (per decade)	1.33 (1.30–1.35)	1.31 (1.28–1.34)	1.20 (1.15–1.26)	1.12 (1.06–1.19)
Male sex	1.08 (1.01–1.15)	1.06 (0.99–1.13)	1.31 (1.12–1.53)	1.28 (1.10–1.50)
Race/ethnicity				
White	ref.	ref.	ref.	ref.
Asian	0.86 (0.79–0.95)	1.00 (0.91–1.10)	0.71 (0.56–0.91)	0.75 (0.59–0.96)
Black	0.74 (0.66–0.82)	0.89 (0.79–0.99)	0.77 (0.58–1.02)	0.83 (0.62–1.10)
Hispanic	0.65 (0.47–0.90)	0.81 (0.58–1.13)	0.86 (0.40–1.84)	0.94 (0.43–2.02)
Other	0.78 (0.71–0.86)	1.03 (0.94–1.15)	0.73 (0.56–0.96)	0.84 (0.65–1.10)
Unknown or decline to state	0.32 (0.27–0.38)	0.45 (0.38–0.53)	0.13 (0.58–0.29)	0.16 (0.07–0.37)
Vascular risk factors				
Hypertension	1.85 (1.74–1.97)	1.09 (1.00–1.18)	1.95 (1.64–2.31)	1.39 (1.13–1.71)
Diabetes	1.24 (1.15–1.34)	0.89 (0.82–0.97)	1.38 (1.15–1.65)	0.99 (0.81–1.20)
Hyperlipidemia	1.65 (1.55–1.76)	1.06 (0.99–1.15)	1.76 (1.50–2.06)	1.25 (1.04–1.51)
Atrial fibrillation	1.42 (1.29–1.57)	0.82 (0.73–0.91)	0.92 (0.69–1.21)	0.59 (0.44–0.79)
Site factors				
% of patients with dizziness (per 1%)	0.96 (0.92–1.00)	0.97 (0.92–1.03)	0.85 (0.71–1.03)	0.85 (0.71–1.01)
% of dizzy patients admitted (per 1%)	1.00 (0.98–1.02)	1.00 (0.98–1.02)	1.01 (0.92–1.10)	1.04 (0.96–1.12)
Overall patient volume (per 1000)	1.00 (0.99–1.01)	1.00 (1.00–1.01)	1.02 (0.99–1.06)	1.03 (1.00–1.06)