Implementation of Evidence-Based Practice for Benign Paroxysmal Positional Vertigo in the Emergency Department: A Stepped-Wedge Randomized Trial

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Study objective: We evaluated a strategy to increase use of the test (Dix-Hallpike's test [DHT]) and treatment (canalith repositioning maneuver [CRM]) for benign paroxysmal positional vertigo in emergency department (ED) dizziness visits.

Methods: We conducted a stepped-wedge randomized trial in 6 EDs. The population was visits with dizziness as a principal reason for the visit. The intervention included educational sessions and decision aid materials. Outcomes were DHT or CRM documentation (primary), head computed tomography (CT) use, length of stay, admission, and 90-day stroke events. The analysis was multilevel logistic regression with intervention, month, and hospital as fixed effects and provider as a random effect. We assessed fidelity with monitoring intervention use and semistructured interviews.

Results: We identified 7,635 dizziness visits during 18 months. The DHT or CRM was documented in 1.5% of control visits (45/3,077; 95% confidence interval 1% to 1.9%) and 3.5% of intervention visits (159/4,558; 95% confidence interval 3% to 4%; difference 2%, 95% confidence interval 1.3% to 2.7%). Head CT use was lower in intervention visits compared with control visits (44.0% [1,352/3,077] versus 36.9% [1,682/4,558]). No differences were observed in admission or 90-day subsequent stroke risk. In fidelity evaluations, providers who used the materials typically reported positive clinical experiences but provider engagement was low at facilities without an emergency medicine residency program.

Conclusion: These findings provide evidence that an implementation strategy of a benign paroxysmal positional vertigo–focused approach to ED dizziness visits can be successful and safe in promoting evidence-based care. Absolute rates of DHT and CRM use, however, were still low, which relates in part to our broad inclusion criteria for dizziness visits. [Ann Emerg Med. 2020;75:459-470.]

Please see page 460 for the Editor's Capsule Summary of this article.

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INTRODUCTION

Background

Benign paroxysmal positional vertigo is a common cause of dizziness that can lead to disabling symptoms.[1] The Dix-Hallpike's test (DHT) is the criterion standard test for benign paroxysmal positional vertigo,[2] and the result is considered positive when the hallmark triggered and transient pattern of nystagmus is identified. The canalith repositioning maneuver (CRM) has been shown in numerous randomized controlled trials to be a highly effective treatment for benign paroxysmal positional vertigo and is supported by multidisciplinary clinical guideline statements.[2-6]

The DHT and CRM are underused in emergency department (ED) dizziness visits.[7] Of visits that included a benign paroxysmal positional vertigo diagnosis, 78% did not have the DHT documented and 96% did not have the CRM documented.[7] The underuse is confirmed by other studies including provider and patient interviews.[1,8-10] Barriers to the use of the DHT and CRM are previous negative experiences, forgetting how to perform them, reliance on the history of present illness, and misattributing patterns of nystagmus.[10] The principal facilitator of DHT or CRM use is previous positive experiences.[10]

Editor's Capsule Summary

What is already known on this topic

Benign positional vertigo is a common and frequently disabling emergency department (ED) presenting condition for which assessment and treatment options are available but frequently underused.

What question this study addressed

This 7,635-patient stepped-wedge trial evaluated an implementation strategy to increase the use of Dix-Hallpike's test and canalith repositioning maneuvers in a community ED setting.

What this study adds to our knowledge

The intervention increased use of these diagnostic and therapeutic techniques by a small amount.

How this is relevant to clinical practice

This study demonstrated the difficulty in modifying physician behavior, even for topics for which there is solid evidence in support of the targeted behavior.

Importance

The increased use of the DHT and CRM in the ED setting has the potential to improve patients' symptoms, reduce unnecessary tests such as head computed tomography (CT), and reduce length of stay, and may also help to reduce misdiagnosis of dangerous causes of dizziness such as stroke. However, it is also possible that increased use of DHT and CRM could result in missed cases of stroke or other adverse events if there are continued problems with the use or interpretation of them. To our knowledge, no previous study has attempted to implement DHT and CRM use by ED providers.

Goals of This Investigation

In this study, we aimed to evaluate the effect of an implementation strategy to increase the use of DHT and CRM in a community ED setting. The strategy was developed with a multidisciplinary group of investigators and informed by interviews with ED providers about barriers and facilitators to use of the test and treatment.[10,11]

MATERIALS AND METHODS

Study Design

The Dizziness Treatment Through Interventional Behavior Change Tactics (DIZZTINCT) study was a provider-focused implementation trial. We previously reported the protocol and statistical analysis plan.[11] We used a stepped-wedge design with randomization by site to test multifaceted educational and care-process-based strategies aimed at increasing appropriate use of the DHT and CRM. A stepped-wedge design was used because randomization at the provider level was not logistically feasible. The design also enabled contemporaneous controls with a small number of centers. The data are reported in accordance with the Consolidated Standards of Reporting Trials guidelines (Appendix E1, available online at http://www.annemergmed.com).[12] The final approved versions of the protocols (medical provider and patient level) are provided as supplemental material (Appendix E2, available online at http://www.annemergmed.com).

Setting

The setting was Corpus Christi, TX, which has 6 hospital-based EDs. One ED site had an academic program with an Accreditation Council for Graduate Medical Education–approved emergency medicine residency.

The order of the intervention delivery was randomized at the hospital level (2 closely integrated EDs were paired) into 5 waves, using a sequence generated with an R program (version 3.3.2, The R foundation, Vienna, Austria).[11]

Visits for dizziness, vertigo, or imbalance were identified from October 13, 2016, to April 16, 2018, with surveillance methods (Appendix E2, available online at http://www.annemergmed.com). For active surveillance, abstractors manually searched ED triage logs for dizziness terms. For passive surveillance, ED discharge logs were queried for dizziness diagnostic codes. Inclusion criteria were dizziness as a reason for visit on ED triage logs or a dizziness diagnostic code in ED discharge logs, and documentation on the physician report that dizziness was 1 of the first 3 listed complaints or a dizziness diagnosis was made. We excluded visits with patients younger than 18 years, prisoners, and the cognitively impaired.

Interventions

The intervention was multifaceted (Figure 1). The content was informed by previous research about barriers and facilitators to DHT and CRM use.[10] The benign paroxysmal positional vertigo–based approach was described to providers as being applicable to patients without an obvious general medical or neurologic cause of dizziness. Providers were instructed to first look for spontaneous or gaze nystagmus, which indicates a cause other than benign paroxysmal positional vertigo. If no spontaneous or gaze nystagmus was present, then the DHT was recommended. If triggered and transient nystagmus

Implementation Strategy Components	Component Description
Educational sessions. Interactive and hands-on sessions.*,†	Sessions reviewed BPPV mechanisms and evidence, used videos, included hands-on demonstrations of the DHT and CRM, and addressed previously identified barriers. Advantages of a BPPV-centric approach were conveyed, including the potential to improve symptoms, reduce unnecessary testing, reduce length of stay, and reduce stroke misdiagnosis. CME credit was offered.
Decision aid. Multimedia Web-based decision aid application and print materials.‡	Included an algorithm for selecting patients for the DHT and CRM, and high-yield text and video instruction about how to perform and interpret the DHT and how to perform the CRM. Print materials were posters and note cards, which included the algorithm and links to the Web site and applications.
Local champions	Local champions (ED providers) were recruited and trained in BPPV testing and diagnosis. They were asked to facilitate attendance at educational sessions and the use of educational materials.
Referral resource.	List of outpatient providers who treat BPPV.
Partnered development and other resources.	Other resources, identified by and developed by the local medical providers, may be provided.

BPPV, Benign paroxysmal positional vertigo; *CME*, continuing medical education.

*Developed in collaboration with our multidisciplinary research team of clinicians (vestibular specialists in neurology and otolaryngology, emergency medicine, vascular neurology, and general medicine), a behavioral psychologist, an implementation specialist, and professionals in health communications, technical engineering, media, design, and programming.

†Providers not able to attend their designated educational session were invited to all subsequent sessions.

‡Links to decision aids were e-mailed to providers. Print materials were distributed to sites.

Figure 1. Multifaceted intervention overview.

was identified on the DHT, then the CRM was recommended. The material content was preliminarily evaluated for its effect on providers' planned management of dizziness visits.[13] On the date of intervention release at the site, we held the educational session and distributed print materials and access codes or links for the Web site and application. The educational sessions and electronic resources were advertised through e-mail. Physicians and advanced practice practitioners were offered $50 for attending the educational session or registering on the Web site.

Data Collection and Processing

For visits meeting the eligibility criteria, research assistants abstracted data, including demographic and clinical information, DHT or CRM documentation, adverse events related to the DHT or CRM use, and referral for subsequent benign paroxysmal positional vertigo evaluation. Unique individuals were identified by using name, birth date, address, and medical record number. To standardize categorization of DHT or CRM documentation and account for variation in provider descriptions, we made a list of DHT and CRM descriptions (eg, "Hallpike's test," "otolith repositioning maneuver") based on our previous work.[7] DHT and CRM documentation was double scored at different points. The first evaluator was blinded to the order of interventions by site but not to the date of the ED visit or general intervention points. For the second abstraction, the start was delayed until approximately 6

months from study initiation, visits were placed in random order, and dates were redacted. Agreement between abstractions was excellent (κ=0.90). Disagreements were adjudicated by a third evaluator blinded to visit dates.

We planned an initial 4-month observational period followed by randomized staggered intervention with a new hospital entering approximately every 2 months, finalized by approximately 4 postintervention months. We estimated this would result in approximately balanced numbers of 867 control visits and 933 intervention visits based on an anticipated total of 100 dizziness visits per month. From our previous work, we expected the DHT or CRM to be conducted in approximately 5% of visits before the intervention.[7] Using a conservative estimate of the number of visits, we would have 90% power to detect an increased DHT or CRM rate of 9% with a 2-sided test of significance at 5%.

Outcome Measures

The primary outcome was documentation of the DHT or CRM. The first step of the CRM is the DHT. The secondary outcome was documentation of the DHT, CRM, or an outpatient referral for a benign paroxysmal positional vertigo evaluation. The main safety outcome was 90-day cumulative incidence of stroke in patients aged 45 years or older. Cumulative incidence of stroke was a safety outcome because providers might misuse the benign paroxysmal positional vertigo–centric approach and misdiagnose dizziness-stroke presentations. Subsequent stroke events (ischemic and intracerebral hemorrhage) were identified through July 15, 2018, by merging the DIZZTINCT with data from the Brain Attack Surveillance In Corpus Christi (BASIC) project. BASIC is an ongoing stroke surveillance study conducted in Corpus Christi, TX.[14,15] Briefly, stroke cases among Nueces County residents aged 45 years and older are identified from all acute care hospitals in the area through the use of active and passive surveillance and are validated by study physicians. DIZZTINCT and BASIC data were merged with probabilistic record linkage (Appendix E2, available online at http://www.annemergmed.com). Additional outcomes were head CT use, length of stay in the ED, and hospital admission. Adverse events related to the use of DHT or CRM were abstracted, reviewed, and classified by severity, expectedness, issued treatments, and outcome.

Primary Data Analysis

The prespecified statistical analysis plan is available as supplemental material (available online at http://www.annemergmed.com). Descriptive statistics were used to summarize visit characteristics. Absolute differences in 2

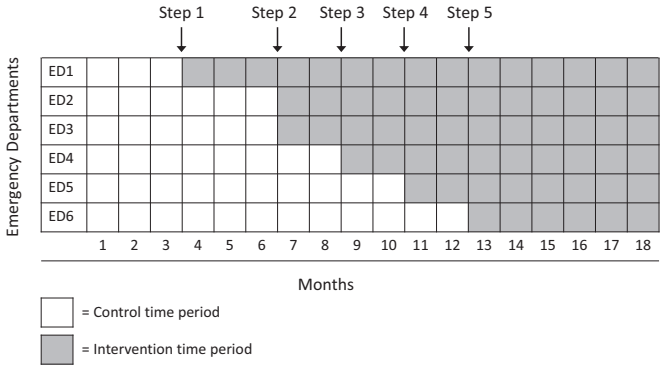


Figure 2. Diagram of the stepped-wedge study design across the EDs over time.

proportions were calculated with 95% confidence intervals (CIs). The proportion of visits with a DHT or CRM documentation was calculated for all visits and in the estimated target population of dizziness visits. The primary analysis was a multilevel generalized linear model with logistic link. The outcome was DHT or CRM use, with fixed covariates of intervention visit indicator (0/1), hospital, month (to account for secular trends), and random intercept of ED provider. The analysis was repeated with the outcome of DHT or CRM use or referral for a benign paroxysmal positional vertigo evaluation. We assessed the interaction of intervention period with month (effect of the intervention is modified by increasing months) and separately the interaction of intervention period with hospital. Both were nonsignificant. Preliminary analysis found that categorizing the ED provider by using a hierarchy of the type theorized to have the most patient interaction (ie, resident>midlevel provider>attending physician) had a higher intraclass correlation coefficient with primary outcome than did using only the attending physician (intraclass correlation coefficient hierarchy 0.25;

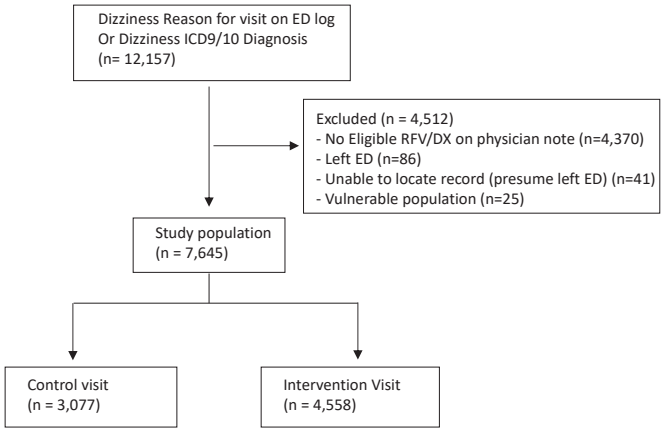


Figure 3. Study flow diagram. *RFV/DX*, Reason for visiting/diagnosis.

Table 1. Characteristics of ED dizziness visits.

	All Visits, N=7,635	Control Visits, N=3,077	Intervention Visits, N=4,558
Age, mean (SD), y	52.5 (19.0)	53.9 (19.1)	51.6 (18.9)
Women	4,676 (61.2)	1,881 (61.1)	2,795 (61.3)
Ethnicity			
Mexican American	4,936 (64.7)	1,918 (62.3)	3,018 (66.2)
Non-Hispanic white	2,254 (29.5)	1,004 (32.6)	1,250 (27.4)
Other	437 (5.8)	149 (4.8)	288 (6.3)
Missing	8 (0.1)	6 (0.2)	2 (0.1)
ED			
1	2,265 (29.7)	727 (23.6)	1,538 (33.7)
2	1,796 (23.5)	363 (11.8)	1,433 (31.4)
3	1,214 (15.9)	782 (25.4)	432 (9.5)
4	1,131 (14.8)	628 (20.4)	503 (11.0)
5	655 (8.6)	324 (10.5)	331 (7.3)
6	574 (7.5)	253 (8.2)	321 (7.0)
Emergency Severity Index score			
1 (life threatening)	5 (0.07)	4 (0.1)	1 (0.1)
2 (high risk)	731 (9.6)	339 (11.0)	392 (8.6)
3 (>1 resource)	6,358 (83.3)	2,514 (81.7)	3,844 (84.3)
4 (1 resource)	496 (6.5)	203 (6.6)	293 (6.4)
5 (no resources)	23 (0.3)	9 (0.3)	14 (0.3)
Missing	22 (0.3)	8 (0.3)	14 (0.3)
Medical history			
Previous stroke	574 (7.5)	250 (8.1)	324 (7.1)
Previous CAD	712 (9.3)	317 (10.3)	395 (8.7)
Atrial fibrillation	312 (4.1)	142 (4.6)	170 (3.7)
High cholesterol	1,446 (18.9)	645 (21.0)	801 (17.6)
Hypertension	3,873 (50.7)	1,655 (53.8)	2,218 (48.7)
Diabetes	2,155 (28.3)	904 (29.4)	1,251 (27.5)
Current smoker	1,620 (21.2)	610 (19.8)	1,010 (22.2)
Systolic BP, mean (SD), mm Hg*	147 (30)	149 (30)	145 (30)
Diastolic BP, mean (SD), mm Hg	80 (15)	80 (15)	80 (15)
Primary diagnosis			
Dizziness NOS or vestibular	2,560 (33.5)	1,118 (36.3)	1,142 (31.6)
Headache	390 (7.7)	139 (7.1)	251 (8.1)
Syncope/collapse	257 (5.1)	125 (6.4)	132 (4.2)
Infection	229 (4.5)	70 (3.6)	159 (5.1)
Hypertension	204 (4.0)	87 (4.4)	117 (3.8)
Stroke (validated)†	56 (1.4)	26 (1.6)	30 (1.3)
Any dizziness or vestibular diagnosis‡	3,642 (47.7)	1,650 (53.6)	1,992 (43.7)
Admitted/transferred	1,181 (15.5)	501 (16.3)	680 (14.9)

CAD, Coronary artery disease; *BP*, blood pressure; *NOS*, not otherwise specified.
Data are presented as No. (%) unless otherwise indicated.
*Blood pressure missing for 246 patients.
†Validated stroke cases limited to those meeting eligibility for the BASIC study: Nueces County residents and aged 45 years and older (n=3,944).
‡In the first 3 listed diagnoses.

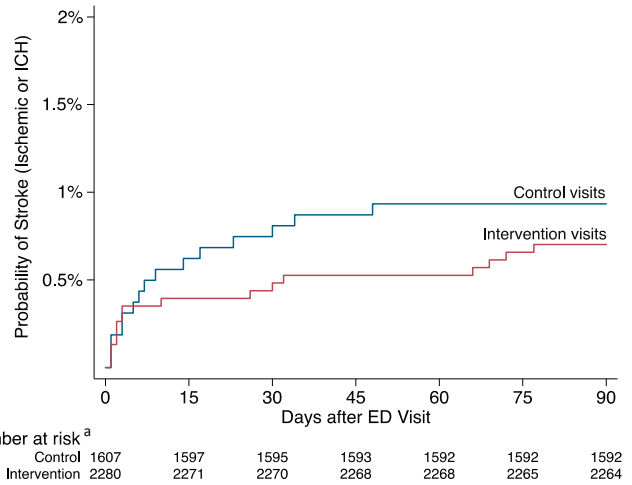
Table 2. Multilevel models to determine the association of intervention period, month, ED, and provider with documentation of DHT or CRM (model 1).*

	Model 1: Documentation of DHT or CRM	Model 2: Documentation of DHT or CRM or Referral
Postintervention	2.44 (1.42–4.20)	2.07 (1.27–3.37)
Month†	1.00 (0.95–1.04)	0.98 (0.94–1.02)
ED		
1	1 [Reference]	1 [Reference]
2	1.20 (0.69–2.09)	1.17 (0.72–1.90)
3	0.82 (0.51–1.33)	0.76 (0.50–1.16)
4	0.48 (0.24–0.97)	0.47 (0.25–0.88)
5	0.91 (0.49–1.71)	0.97 (0.56–1.67)
6	0.42 (0.18–1.02)	0.38 (0.17–0.87)
Random-effect parameter		
Provider, ICC	0.22 (0.14–0.33)	0.16 (0.10–0.25)
BIC	1,855	2,118
c Statistic	0.82 (0.79–0.84)	0.78 (0.75–0.81)

ICC, Intraclass correlation coefficient; *BIC*, Bayesian information criterion.
Data are presented as odds ratio (95% CI) unless otherwise indicated.
*Model 2 evaluates the association with the documentation of DHT, CRM, or a referral for treatment of benign paroxysmal positional vertigo.
†Month is a continuous variable (1 to 18) of the number of months since study initiation. It was included to account for possible secular trends.

intraclass correlation coefficient attending physician only 0.13). Therefore, the hierarchy was retained. Secondary outcomes were analyzed similarly. The primary safety outcome, 90-day cumulative incidence of stroke, was determined with Kaplan-Meier product limit estimates and Cox proportional hazards model with censoring at 90 days excluding visits when the patient was younger than 45 years, residence was outside Nueces County, or the visit was validated as stroke at the index visit. Adverse events related to the use of the DHT and CRM were tabulated and compared by intervention period. The analysis was conducted with Stata (version 15.1; StataCorp, College Station, TX).

We conducted implementation- and progress-focused formative evaluations to monitor and identify potential influences on the progress and effectiveness of the implementation efforts, the fidelity of the intervention, exposure to the intervention, and the design of future efforts.[16] Fidelity was monitored through attendance at educational sessions by facility and the use of the Web site or application. Feedback about the educational components and confidence and intent to use the DHT or CRM was solicited from providers using a survey sent approximately 2 months after educational sessions or Web site registration. We conducted semistructured interviews



a Population limited to Nueces County residents age 45 years and older.

Figure 4. Cumulative incidence curves depicting stroke risk after dizziness nonstroke index presentations to the ED in patients aged 45 years or older. *ICH*, Intracerebral hemorrhage.

with providers, using an interview guide with questions about memorable clinical experiences with dizziness patients, use of the study materials, and approach to dizziness (Appendix E2, available online at http://www.annemergmed.com). Interviews were deidentified, transcribed, and analyzed qualitatively for themes by using qualitative content analysis.[17]

This visit-level data collection, with waiver of informed consent, was approved by the University of Michigan institutional review board and the institutional review boards of both Corpus Christi hospital systems (Christus Spohn Health System and Corpus Christi Medical Center). Data collection from providers was either approved or determined to be exempt by the institutional review boards. We initially received approval to collect data on 3,600 visits. After evaluation of initial accrual, a higher number of ED visits for dizziness met our inclusion criteria, and as such we revised the maximum sample sizes. Our revised total expected sample was 6,800, with a maximum of 10,800. We believe the higher-than-anticipated number of visits related to a lower threshold for inclusion in the current study than in the previous study and an increase in dizziness presentations to the ED. The revision of the maximum sample size was conducted while investigators were blinded to any group comparisons.

RESULTS

From October 13, 2016, to April 16, 2018, we initiated the intervention at the sites in 5 steps (Figure 2). We screened 12,157 visits and 7,635 (63%) met the eligibility criteria for principal dizziness (Figure 3 and Appendix E2 [available online at http://www.annemergmed.com]).

Table 3. Adverse events related to DHT or CRM performance.

Variable	Preintervention Visits, N=44	Postintervention Visits, N=155
Adverse events,* No. (%)		
Any	5 (11.4)	7 (4.5)
Serious	0	0
Expected		
Nausea	3 (7)	3 (2)
Vomiting	1 (2)	3 (2)
Unexpected		
Headache	1 (2)	0
Agitation	1 (2)	0
Neck pain	0	1 (<1)
Ear pain	0	1 (<1)

*All adverse events were either documented as resolved or improved or were not further mentioned during the ED visit.

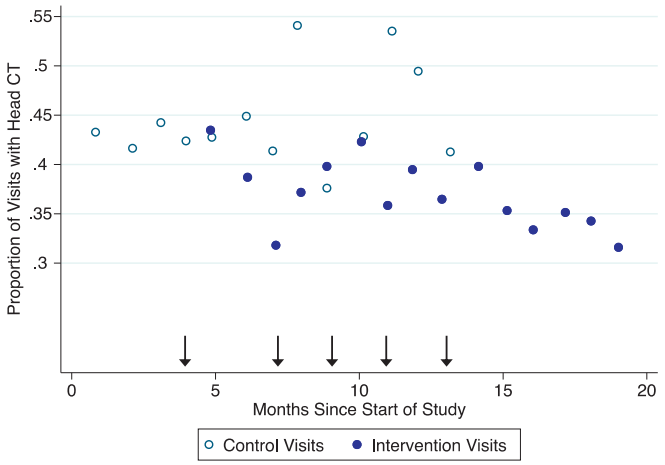


Figure 5. Proportion of visits including head CT scans over time by intervention status. Arrows indicate intervention initiation points.

There were 6,794 unique patients (eg, 841 return visits [11.0%]). Study population characteristics are presented in Table 1. Mean age was 52.5 years and 61.2% were women. There were 287 providers, consisting of 173 attending physicians and 136 advanced practice providers or residents (22 providers served in more than 1 provider status during the study period). The mean number of dizziness visits per provider was 47 (SD 67; median 13; interquartile range [IQR] 2 to 77; range 1 to 398). There were 102 providers (102/287; 36%) with 40 or more visits, and they were involved in 95% of visits. Advanced practice providers were involved in 58% of visits and residents in 19% of visits (advanced practice provider or resident in 70.8%).

MAIN RESULTS

We identified 204 visits with DHT or CRM documentation. For all dizziness visits, the DHT or CRM was documented in 1.5% of control visits (45/3,077; 95% CI 1.0% to 1.9%) and 3.5% of intervention visits (159/4,558; 95% CI 3.0% to 4.0%; difference 2.0%, 95% CI 1.3% to 2.7%). Overall, the DHT result was reported as positive in approximately half of the visits in which it was documented (83/161). The CRM was included in approximately half of the documentations (0.6% [19/3,077] control versus 1.8% [82/4,558] intervention visits). In the prespecified primary analysis that adjusted for month (secular trends), ED facility, and provider, the odds of DHT or CRM use increased in postintervention visits (odds ratio 2.44; 95% CI 1.42 to 4.20) (Table 2). When referral for benign paroxysmal positional vertigo management was also included in DHT or CRM outcome, the results were similar to those of the primary analysis (Table 2).

The 90-day cumulative incidence of stroke in patients aged 45 years or older with a nonstroke index dizziness visit did not identify evidence of a difference between the control and intervention visits: 0.93% control visits (15/1,607; 95% CI 0.46% to 1.14%) versus 0.70% intervention visits (16/2,280; 95% CI 0.36% to 1.04%) (difference –0.23%, 95% CI –0.81% to 0.35%; hazard ratio 0.75, 95% CI 0.37 to 1.52) (Figure 4). Two visits with DHT or CRM documentation had a subsequent stroke visit. We reviewed these visits and did not think that the subsequent stroke was related to the use or misinterpretation of the DHT or CRM (see Appendix E2 for details, available online at http://www.annemergmed.com).

We did not identify serious adverse events from the DHT or CRM (Table 3). Nonserious adverse events related to the DHT or CRM were identified in 11.4% of control visits (5/44) and 4.5% of intervention visits (7/155). Most adverse events were due to expected events of nausea.

Head CTs were performed in 44.0% of control visits (1,353/3,077) compared with 36.7% of intervention visits (1,671/4,558) (difference –7.3%; 95% CI –5.1% to –9.6%). Figure 5 displays the proportion of visits with a head CT over time by intervention status. The difference, however, was not significant in the model with month, hospital, and provider (Table 4). The attenuation was attributable to the month variable, suggesting that time (eg, increase in month) had a stronger association with decline in head CT use than did the precise date of the intervention initiation. Other neuroimaging studies were infrequently

Table 4. Multilevel model to determine the association of intervention period, month, ED, and provider with head CT use.*

	Odds Ratio (95% CI)
Postintervention	1.14 (0.96–1.36)
Month	0.96 (0.94–0.97)
ED	
1	1 [Reference]
2	0.60 (0.49–0.74)
3	0.89 (0.75–1.04)
4	1.15 (0.93–1.44)
5	1.86 (1.50–2.32)
6	1.03 (0.79–1.34)
Random-effect parameter	
Provider, ICC	0.05 (0.03–0.08)
BIC	10,043
c Statistic	0.65 (0.64–0.67)

Month is a continuous variable (1 to 18) of the number of months since study initiation. It was included to account for possible secular trends.
*There were no substantial changes to the results with any neuroimaging (ie, any of head CT, CT angiography, magnetic resonance imaging [MRI], or magnetic resonance angiography [MRA]) as the dependent variable.

Table 5. Use of common diagnostic tests in control versus intervention dizziness visits.

	Control Visits, %*	Intervention Visits, %*	Absolute Difference (95% CI), %
Head CT	44 (1,353/3,077)	37 (1,671/4,558)	−7 (−10 to −5)
MRI brain	5 (155/3,077)	4 (188/4,558)	−1 (−2 to 0)
CT angiography	2 (54/3,077)	2 (71/4,558)	0 (−1 to 0)
MRA	1 (30/3,077)	1 (29/4,558)	0 (1 to 0)
Any head imaging	46 (1,403/3,077)	38 (1,725/4,558)	−8 (−10 to −5)
CBC	83 (2,565/3,075)	85 (3,878/4,556)	2 (0 to 3)
Chemistry	83 (2,555/3,076)	81 (3,686/4,554)	−2 (−4 to 0)
Cardiac markers	46 (1,400/3,066)	49 (2,232/4,524)	4 (1 to 6)
Urinalysis	41 (1,269/3,065)	48 (2,193/4,548)	7 (5 to 9)
ECG	67 (2,043/3,060)	64 (2,896/4,539)	−3 (−1 to 5)
Chest radiograph	47 (1,435/3,074)	52 (2,388/4,555)	6 (3 to 8)

CBC, Complete blood count; *ECG*, electrocardiogram.
*Variations in denominators are caused by small amounts of missing data.

used (≤5%) and either slightly decreased or did not change in control compared with intervention visits (Table 5 and Appendix E2 [available online at http://www.annemergmed.com]). Differences in the use of 6 other commonly ordered tests varied from small decreases to small to moderate increases (Table 5 and Appendix E2, available online at http://www.annemergmed.com). Length of stay was lower in control compared with intervention visits (284 minutes control versus 299 minutes intervention; difference 15 minutes; 95% CI 5 to 26 minutes). Patients were admitted to the hospital or transferred in 16.3% of control visits (501/3,077) compared with 14.9% of intervention visits (680/4,558) (difference −1.4%; 95% CI −3.0% to 0.3%).

The planned 5 educational sessions were performed (Figure 3). Sixty-three providers attended a session. Forty-two percent of providers (43/102) with 40 or more visits attended a session, which differed in the academic facility (65%; 30/46) compared with nonacademic facilities (23%; 13/56). An additional 15 providers received education through work site visits. Eighty-one providers registered on the Web site, 52 of whom continued to the educational content pages. Twenty-six providers used the application educational content. The median number of unique days of use was 1 (IQR 1 to 2; range 1 to 4) for the Web site and 2 (IQR 1 to 5; range 1 to 11) for the application. The median number of time stamps (eg, pages viewed, videos launched) was 10 (IQR 3 to 28; range 2 to 136) for the Web site and 10 (IQR 6 to 19; range 2 to 96) for the application. The response rate to the provider survey soliciting feedback about the interventions was 25 of 69 (36.2%). Respondents rated the usefulness of the education sessions, Web site, and application consistently high (mean rating >8.2 on a 0 to 10 scale, with 0=not useful at all and 10=extremely useful). The local champion for one health system that included the academic center participated throughout the project. The local champion for the other health system that included exclusively nonacademic sites relocated before the intervention and was not able to be replaced. We asked providers in the area about competing interventions and initiatives for DHT and CRM or head CT use, but none were aware of any.

We interviewed 23 providers throughout the postintervention period to obtain more information about clinical experiences. Sixteen of the interviewees attended a continuing medical education session, 20 registered on the Web site, 9 used the application, and 3 did not do any of these. Thematic saturation of provider experiences with the intervention was achieved. Four themes emerged from the qualitative analysis (Figure 6 and Appendix E2 [available online at http://www.annemergmed.com]). The first and second themes related to positive experiences in clinical practice and the use of the interventions. Most of the interviewees who used the resources reported positive experiences. Some descriptions were especially positive: "[It's] like one of those things that you rarely get in emergency medicine where you literally cure them. I literally cured her. It was just the most rewarding feeling. The nurses…[said] that's really great, and I…[said] I was just at a conference and learned how to do that." Providers did not

Theme 1. Providers who used the intervention components typically reported subsequent positive experiences incorporating the DHT and CRM into clinical practice.

"She had all things pretty much just like textbook, what you guys had gone over. She didn't have any resting nystagmus. So I explained the procedure to her. I explained what I wanted to do. She agreed and [reclined]. This was to the left side, so I did it and I had nothing. So we sat back up and then I turned her to the right side and did that way, and that's when it triggered and she had vertical, like, clear vertical nystagmus going on and then it stopped. So then I followed through with the rest of the procedure, and she sat back up and she was just as amazed as I was." (5001)

Theme 2. The intervention influenced DHT/CRM use through multiple intervention components and difference mechanisms.

In regard to posters and note cards: "But then you guys had the cards…. You know…I carried one of those around for a little while." "And even the ones on the wall would sometimes prompt me to think about it." (1130)

In regard to video instructions: "For me, the first time that I used it, it was just like I literally sat in the department, I just watched the videos, and then went back and did it. And then, like, okay, now I'm watching the video on Epley maneuver and then do it, you know what I mean? So, um, all that was super helpful." (3030)

In regard to education sessions. "I think that's the physical—the physical demonstration during the CME, and pointing out how long you need to wait before you move on to each different position was really kind of an eye-opener for a lot of us: that even though we knew how to do it [we] weren't holding each position long enough to allow for reposition. Um, and then I think the app's fantastic. Those…cartoons and the videos and the algorithm are great." (1031)

Theme 3. Barriers to more widespread and frequent DHT/CRM use were time and interest in BPPV or decisionmaking resources, and also complexity/number of steps. Even people who want to use it need reminders.

"The app I probably…you know, I've actually looked at the app 10, 15 times maybe, just to remember what I'm doing and how to do it because I'm not doing it all the time. I mean, to tell you the truth, I'm kind of embarrassed by [the fact that] I've already forgotten some details that you told me." (1012)

Theme 4. Facilitators to intervention engagement and use of the DHT/CRM were provider collegiality, learning environments, additional elements to the resources, and broader provider inclusion.

"Expanding your algorithm to include some of the other causes and, you know, workup for those would be helpful. I think you could probably expand it to other causes of dizziness." (3053)

"She felt better, and she wanted to have the videos to do it at home herself. So that was memorable because I wish I had a link for that, but I didn't."(2001)

Figure 6. Themes and representative quotes from implementation fidelity interviews (see Appendix E2, available online at http://www.annemergmed.com, for additional details). Parenthetical numbers represent individual partipant identification numbers.

describe adverse events, but some reported difficulty using the DHT or CRM in certain situations (eg, older or anxious patients, limited space). A few providers reported negative experiences because of the time to perform the DHT or CRM or patients not improving as a result. Providers who did not use the resources typically mentioned a lack of time or a general lack of interest in either benign paroxysmal positional vertigo or decisionmaking resources. The use of the resources was facilitated by provider collegiality within the ED, formal learning structures, and also expansion of the target providers to include nursing staff and incorporation of additional clinical topics.

LIMITATIONS

The study design was quasi experimental. Although the order of sites was randomized and the intervention visits had contemporaneous controls, confounding from time trends and differences in patient groups is still possible. We had a relatively small number of randomization units and potential for intervention contamination because some providers worked at multiple sites. The primary outcome was determined by medical record review. It is possible some providers performed the DHT or CRM but did not document it. We were not able to assess appropriateness of the use of the DHT or CRM or proper performance.

Adverse events, such as nausea, were infrequent but might have been underdocumented by providers. The analysis of stroke in the follow-up period was limited to residents of Nueces County aged 45 years or older, according to criteria of the BASIC study. The inclusion criteria for our study population was broad because of the limited ability to restrict the population to those relevant for DHT or CRM from medical record review. We were not able to adjust the length-of-stay analysis for current boarding volumes. It is possible that the association of the intervention will not be sustained over time. The qualitative data, although able to provide rich details, are limited to the providers willing and able to participate.

DISCUSSION

In this stepped-wedge trial of an implementation strategy to increase the use of the DHT and CRM in the ED, we found that the documentation of DHT or CRM use more than doubled in intervention visits compared with control visits. Additionally, head CT use was lower in intervention visits compared with control visits, without a corresponding increase in other brain imaging or stroke in the follow-up period. Hospital admissions were somewhat lower but length of stay in the ED increased somewhat in intervention visits compared with control visits. Providers conveyed positive experiences identifying and treating benign paroxysmal positional vertigo. Overall, these findings provide evidence that an implementation strategy of a benign paroxysmal positional vertigo approach to ED dizziness visits can be successful and safe in promoting evidence-based care.

Although the frequency of DHT or CRM use more than doubled in the intervention visits compared with control visits, the absolute use was still low in the intervention group (3.4%). The overall low use rate relates to our purposefully broad inclusion criteria. We used broad inclusion criteria because of the limited ability to select a more targeted population from medical record review. A previous nationally representative sample of dizziness patients suggests that approximately 20% report features of possible benign paroxysmal positional vertigo and therefore constitute a target population for its assessment.[18] If we apply this estimate to our population, then the use of the DHT or CRM in this target population was approximately 7% (45/615) in control visits and 17% (159/912) in intervention visits. It is possible that the frequency of use in the target population could increase further with additional reminder methods (eg, electronic medical record based), broadening the targeted providers to include nurses, and broadening the dizziness topics in the resources.

To our knowledge, this is the first study to implement the DHT and CRM in the ED. Despite the evidence base to support the use of the DHT and CRM, studies consistently indicate they are underused in the ED.[7,10] ED providers have typically tried these but stopped using them because of difficulty remembering the instructions and negative experiences.[10] Negative experiences typically relate to misconceptions (in selecting patients for the DHT and interpreting the results) and possibly errors performing the CRM. Our intervention was designed to address misconceptions and promote proper selection and performance, using readily available resources, reminders, and local champions. We also conveyed additional benefits of using the benign paroxysmal positional vertigo approach such as the potential to reduce unnecessary tests, increase ED throughput, and identify patients at higher risk of stroke when the evaluation result for benign paroxysmal positional vertigo is negative.

Although we were not able to measure whether the DHT or CRM was appropriately used, was accurately performed, or improved patient outcomes, the qualitative interview data provide some insights. Most postintervention interviewees reported positive experiences in using the DHT and CRM, which was in stark contrast to preintervention interviews.[10] Some providers described rich details about first assessing for spontaneous or gaze nystagmus and then describing the hallmark benign paroxysmal positional vertigo pattern of nystagmus. Positive treatment responses were also described. Negative experiences were infrequent and minor. This information supports that the intervention contributed to positive experiences for providers, which we previously found is a key facilitator to future use.[10]

Overall, the increased use of the DHT and CRM by ED providers seems to be safe. Adverse events were infrequent, expected, and transient. Subsequent stroke, a proxy of possible misdiagnosis, was not higher in intervention visits compared with control visits even though use of neuroimaging was lower. Detailed review of subsequent stroke after intervention periods did not suggest misuse or misinterpretation of the DHT or CRM.

The findings in regard to the use of head CT in these dizziness visits warrant specific discussion. Dizziness visits should be a priority in efforts to reduce unnecessary CTs because ED providers have ranked this as a top priority for decision support.[19] Our evaluation of an early version of the intervention found that providers randomized to receive the intervention reported lower intent to use CT in future dizziness visits compared with controls.[13] The current study found that head CT use was 7% lower in the intervention visits compared with the control visits. We are

not aware of any other study that has evaluated the association of dizziness decision materials with use of head CT even though this is a topic ED providers have rated as a top priorty.[19] Decision support to reduce the use of head CT has been studied extensively in head injury visits, and the results have been mixed. Some studies showed a decrease similar in magnitude to ours.[20,21] Other studies, however, showed no change in head CT use or even an increase.[22,23] If our intervention did reduce head CT use, this would be another major advantage of a benign paroxysmal positional vertigo–based approach to dizziness. On the other hand, it is possible the decrease in CT use was due to differences in case mix between the populations or a general trend over time because our design was quasi experimental. After adjusting for month, there was no difference in CT use in intervention compared with control visits. The effect of month on CT use could relate to a general decrease in head CT over time (not related to the intervention) or possibly a building effect of the intervention from gradual dissemination. If the effect of month was from a general trend in decreased use, this trend was specific to CT because similar trends were not observed with other commonly used tests. More definitive conclusions about the effect of this intervention on head CT use would require patient-level interventions or larger randomized cluster designs.

In summary, a multifaceted benign paroxysmal positional vertigo–centric strategy to implement the use of the DHT and CRM in ED dizziness visits was associated with increased documentation of the DHT and CRM. Interviewed providers generally reported positive experiences with the materials and in applying the DHT and CRM in practice. The strategy did not have evidence of an increase in adverse effects. There was a decrease in head CT use in the intervention visits compared with control visits but confounding by time trends or case mix is possible. Our work demonstrates the feasibility and positive influence of implementation of evidence-based practice for dizziness visits.

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