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RESEARCH

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Identifying tests to evaluate in a diagnostic accuracy study for patients with vertigo in general practice: a Delphi study

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Abstract

Introduction Vertigo is a common symptom that strongly impacts patients' quality of life. More than 80% of patients experiencing vertigo are primarily treated by their general practitioner (GP). The GP's 'diagnostic toolkit' for vertigo has serious limitations, though, because diagnostic accuracy studies on conditions that may cause vertigo have never been performed in a general practice setting. Our aim was to determine which tests should be investigated in a diagnostic accuracy study for patients with vertigo in general practice.

Method We conducted an online Delphi procedure involving national and international experts. The experts were asked to judge a selection of 40 diagnostic tests based on the Dutch GP guideline on vestibular symptoms, supplemented by tests identified during a systematic review. Panellists were allowed to suggest additional tests after the first round. In case of consensus of at least 70%, a test was included or excluded. We also conducted a secondary sub-analysis of our Delphi procedure to demonstrate non-dominance of Dutch experts within our expert panel. Data were analysed using descriptive statistics and content analysis. Data were analysed using descriptive statistics and content analysis.

Results A panel of 20 experts from five countries, including 7 specialists in otolaryngology, 6 neurologists and 7 GPs, participated in the Delphi procedure. The panel judged 46 diagnostic tests in total, with 6 additional tests added to the original selection based on suggestions by experts. After the first two rounds (100% response rate), 16 tests were included, 22 tests were excluded and no consensus was reached on 8 tests. During the consensus round, one of the 8 tests was added to the included 16 tests. Of these 17 tests, 15 are recommended by the Dutch GP guideline, supplemented by the non-recommended Tandem walking test and the Romberg test.

Conclusions An international expert panel reached consensus on 17 tests for vertigo in general practice that should be investigated in a diagnostic accuracy study.

Keywords Dizziness, Vertigo, Delphi technique, Consensus, General practice, Primary Health Care

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Background

The Bárány Society, the leading international organization for clinicians and researchers involved in vestibular medicine, developed a uniform way to describe vestibular symptoms. In the International classification of Vestibular Disorders (ICVD), vertigo is described as “the sensation of self-motion when no self-motion is occurring or the sensation of distorted self-motion during an otherwise normal head movement” [1, 2]. Vertigo is a common symptom that considerably affects patients’ quality of life [3–6]. Previous epidemiological studies report a prevalence of 5% in the adult population (18 or older), while another study reports a prevalence >30% in the population aged 75 or older [3, 7]. The impact on patients is enormous: four out of five patients with vertigo report severely impairing symptoms, leading to medical consultation, interruption of daily activities, and/or avoidance of leaving the house which could lead to decreased productivity by work absenteeism [4, 8]. Since vestibular symptoms are strongly associated with age [3, 9], the personal and economic burden of vertigo will increase significantly in the future due to the ageing population [10].

Despite the fact that GPs treat the large majority of patients with vertigo, their ‘diagnostic toolkit’ to differentiate between vestibular diseases, such as vestibular neuritis, benign paroxysmal positional vertigo (BPPV), vestibular migraine and Meniere’s disease - as recommended by the Dutch GP guideline on vestibular symptoms [11], is seriously limited. There is no empirical evidence on the diagnostic value of history taking and physical examination for a patient with vertigo in general practice, because diagnostic accuracy studies on conditions that may cause vertigo have never been performed in a general practice setting [12]. Sufficient diagnostic test accuracy is crucial, because biased test results can lead to incorrect diagnosis and treatment [13]. Ultimately, we therefore aim to set up a large accuracy study for patients with vertigo in general practice [14]. To accomplish this, we need to start with a preselection in diagnostic tests. A Delphi procedure is a well-established approach to answer a research question by finding consensus when scientific evidence is absent or contradictory [15–18]. The aim of this Delphi procedure was to determine which tests should be investigated in a diagnostic accuracy study for patients with vertigo in general practice.

Methods

Sources of evidence

Prior to the Delphi procedure, we performed a comprehensive literature search in PubMed, Embase and Web of Science from January 2010 to March 2022. This time interval was chosen because Maarsingh et al. had already conducted an extensive search strategy prior to 2010 [19], in order to identify potentially relevant diagnostic tests for

dizziness/vertigo in general practice (query search strategy: see Appendix 1). We carried out the systematic screening of articles with the help of Covidence, an online platform for the management of systematic reviews [20]. Because of the number of studies identified, the title-abstract screening was conducted by nine screeners (six medical students and three researchers, i.e. AL, VV, OM). Title-abstract of each article was screened by two screeners. In case of disagreement, the article was discussed by AL, VV and OM to reach consensus. Full text screening was performed by two screeners (AL, VV or OM). The title-abstract screening of the original 13,737 articles resulted in the exclusion of 13,052 studies. We screened the remaining 671 for full text. Studies were excluded if the study did not concern a diagnostic accuracy study, the index test was not feasible in general practice, the index test was too expensive for general practice, the reference test was considered inappropriate (e.g. not relevant, not practical, inconsistency in the patient population), the study population did not include patients from a general practice or primary care setting, or the full text was not available in English, Dutch, German, or French. After full text screening, we included 119 relevant publications. Searching the reference lists of these publications did not yield additional relevant publication. The final 119 publications provided a total of 40 diagnostic tests of which 31 are also recommended by the Dutch GP guideline [11].

Study participants

We predefined that the relevant specialisms of general practice, neurology and otorhinolaryngology each had to be represented by at least five panellists with demonstrable expertise on vertigo and/or dizziness, i.e. contribution to at least one vestibular guideline or at least 5 international peer reviewed publications related to vertigo and/or dizziness. We used a combination of expert judgment and snowball sampling to select the panellists. Through the research team’s professional network, we invited individuals based on their recognized expertise and involvement in the field, who could in turn nominate other experts. This led to a total number of invitations for 26 national and international experts on vestibular symptoms such as vertigo and dizziness, including seven GPs, nine neurologists and ten otorhinolaryngologists. Out of these 26 experts, 20 decided to take part in our Delphi procedure. Reasons for non-participation were lack of time ($N=2$) or no response ($N=4$). Informed consent was obtained from all participants by e-mail.

Design

The Delphi method

A Delphi procedure concerns a series of sequential questionnaires presented in two or more rounds, interspersed with controlled feedback, in order to obtain the

most reliable consensus from an expert panel [21, 22]. An important characteristic of the procedure is to resolve disagreement in a structured, predefined way by giving repeated and controlled feedback. A Delphi procedure is performed anonymously (to avoid dominance of members of the expert panel) and consists of minimally two rounds. After the first round the results are summarized and presented as feedback in the second round.

The main goal of a Delphi procedure is to establish a level of consensus; however, there is not a universally agreed-upon consensus threshold [21]. In Delphi studies, consensus is typically considered to be achieved when there is a substantial level of agreement, such as 70% or higher [22].

Delphi survey rounds

In the first round, each panellist received a score form with 40 potential diagnostic tests that should be assessed. The score form was accompanied by two documents, one document providing background information on the Delphi procedure (Appendix II), and another document with empirical evidence and background information— including links to instruction videos, if applicable— of each test (Appendix III). This list of tests was based on a systematic review, see paragraph “source of evidence” and the Dutch DP guideline [11]. The panellists received a score form by email, on which they could indicate if a particular test should be evaluated in a diagnostic accuracy study in general practice (yes/no). Panellists had to motivate why a test should be excluded from the diagnostic accuracy study. The score form contained six predefined categories for motivation of exclusion. These categories

were derived from a framework often used to evaluate diagnostic technologies by categorizing studies into six hierarchical level: (1) technical feasibility, (2) diagnostic accuracy, (3) diagnostic thinking impact, (4) therapeutic choice impact, (5) patient outcome impact, and (6) societal impact [23].

If a panellist deemed that an important diagnostic test was missing, he or she could name this test on the score form with a brief description and motivation why it should be added. The researchers assessed each new test suggested by a panellist, examining whether the test was applicable in general practice, including considerations such as financial feasibility.

Each participant completed and returned the score form within six weeks by email. The researchers summarized the results. Tests on which at least 70% of the panellists agreed were either directly included in the diagnostic accuracy protocol or deleted from the list. The frequency of the responses per item was calculated and motivations were summarized per category per test. Tests on which no agreement had been reached (agreement level below 70%) were put on a new list, with a summary of motivations per test. A new score form for the second round was made for the panellists.

Panellists received information on [a] the percentage agreement per item in the first round, [b] the frequency of motivation categories, [c] a brief summary of comments and [d] an overview of their own scores compared to the group scores. In the second round each participant had to indicate for each remaining test if and why the test should be incorporated in the diagnostic accuracy protocol. This round offered the opportunity for panellists to change their score in view of the group’s response. The panel received a summary of the results. Again, tests on which at least 70% of the panellists agreed were either included in the protocol or deleted from the list. If there were tests on which no agreement had been reached (threshold 70%), additional rounds could be held if necessary.

Sensitivity analysis

In order to assess the potential consequences of the Dutch majority in our Delphi study (see Table 1), we performed a secondary sensitivity analysis of the first Delphi round using an expert subpanel consisting of non-Dutch international experts. Herein we compared the included and excluded tests after the first round between the expert subpanel and the full expert panel.

Results

Expert panel

We included 20 experts from five different countries with an average of 22 years of working experience (see

Table 1 Characteristics of the Delphi panellists ($n = 20$)

Characteristic	N
<i>Sex</i>	
Female	7
Male	13
Age in years	Mean = 50 [range: 34–72]
<i>Occupation</i>	
General practitioner	7
ENT specialist	7
Neurologist	6
<i>Location of panellists</i>	
The Netherlands	11
United Kingdom	4
United States of America	3
Belgium	1
Australia	1
Years of working experience	Mean = 22.4 [range: 5–45]
Numbers of international publications on vertigo	Mean = 19 [range: 0–70]

Table 1). The response rate of participating panellists throughout the subsequent Delphi rounds was 100%.

Delphi rounds

The final results of the Delphi procedure are shown in Tables 2 and 3. After the first round, 15 out of 40 tests were included, 11 tests were excluded and 14 tests did not reach agreement. The most mentioned reasons for exclusion were technical feasibility, (lack of) diagnostic accuracy and diagnostic thinking impact. During this round the panel suggested 10 additional tests to assess during the next round. Four of these tests were not included in the second round, i.e. portable video-oculography (VOG), was deemed too expensive for use in general practice, while the other three tests were already on the list.

Round two started with 20 tests to be assessed, i.e. 14 tests remaining from the first round and six tests added by the panel. After round two, one test was included and 11 were excluded. The panel could not reach consensus on eight tests, namely Head Impulse-Nystagmus-Test of Skew (HINTS), HINTS Plus, Past Pointing Test, Frenzel glasses, Questionnaire Vestibular Migraine, Dynamic Visual Acuity, Tuning forks and ECG.

In total 16 test were included after two rounds.

Given the test scores of round two (33–58%) and the respective comments, it was unlikely that one of the remaining eight tests would reach the threshold of $\geq 70\%$ during another Delphi round. Despite not reaching the threshold, the research group decided to add the HINTS Plus (not structural, but on indication) to the set of 16 index tests, because: (1) the high level of empirical evidence for the application of the HINTS [120] is incomparable to the evidence for other tests that did not reach the inclusion threshold; (2) the HIT (not structural, but on indication) is already recommended in the Dutch GP guideline, which warrants verification of its accuracy in a general practice setting; (3) some panellists disputed the ability of non-experts or GPs to perform and interpret the HINTS, but this was never verified.

During a 7-day timeframe, panellists were invited to raise objections to the draft protocol, including the inclusion of the HINTS test. No objections were raised during this period.

Table 3 describes the final list of 17 diagnostic tests to be investigated in a diagnostic accuracy study for patients with vertigo in general practice.

At the end of this Delphi procedure, the expert panel selected 17 tests to be investigated in a diagnostic accuracy study. The panel endorsed 15 tests as recommended by the Dutch GP guideline on vestibular symptoms [11], supplemented by the Tandem walking test [26, 53, 77, 78] and the Romberg test [77, 78, 87, 88].

Sensitivity analysis

Using the subpanel consisting of our 9 international experts, we found quite similar results to those of the full expert panel after the first round (see Table 4). More specifically, within the subpanel 14 tests were included after the first round, all of which were also in the 15 tests included after the first round within the full panel (93%). In particular, only one test, the Head-roll/Supine Roll test, scored insufficiently (56%) within the subpanel and so would go on to the second round instead of directly being included as it did after the first round in the full panel.

For the tests excluded in the first round of the subpanel we also find a substantial degree of agreement with the tests excluded after the first round of the full analysis. In particular, we find that of the 12 tests excluded after the first round in the subpanel, 9 of these were also excluded in the 11 tests excluded after the first round of the full panel (81%). In particular, within the subpanel, the Sideways Stepping test and PCI scoring were now outright excluded, while laboratory testing went onto the second round. There were no other discrepancies.

Discussion

Summary

We conducted a Delphi procedure to determine which tests should be investigated in a diagnostic accuracy study for patients with vertigo in general practice. Through the Delphi method, a structured and iterative approach for building consensus among experts from different specializations, we combined empirical evidence with expert opinion to formulate a definitive protocol for a diagnostic accuracy study. After the completion of the Delphi procedure, the international experts reached consensus on 17 tests for vertigo in general practice that should be further investigated in a diagnostic accuracy study [14]. The final test battery agreed upon contains 15 tests that were already recommended by the Dutch GP Guideline, supplemented by the non-recommended Tandem walking Test and the Romberg Test.

Our sensitivity analysis demonstrated substantial agreement between the subpanel and the full panel on both included (14 out of 15, i.e. 93%) and excluded tests (9 out of 11, i.e. 81%), suggesting that the majority of Dutch experts did not influence the study results in an important manner. A more likely explanation for the significant overlap between the included test battery by our panel and the Dutch guideline may therefore be that the guideline adequately reflects the international consensus on diagnosing vertigo in general practice.

Moreover, while checking the agreement between this guideline and the general international expert consensus was not a primary aim of this study, it is nonetheless an interesting finding and raises two natural questions. First,

Table 2 Results Delphi procedure: included tests

Diagnostic Test N=40+6	Round one			Round two			Consensus round Result, Ω
	Inclusion	Exclusion	No Expertise	Inclusion	Exclusion	No Expertise	
I. Patient history [11]							
1. Present Vertigo Symptoms	19	1	0				I
2. Accompanying symptoms	19	1	0				b, c, d, e, f
3. Timing of symptoms	20	0	0				-
4. Triggers of symptoms	19	1	0				-
5. Medication	18	2	0				b, c
6. Past medical history	20	0	0				-
7. Cardiovascular risk factors	17	2	0				b, c, d, e
II. Physical examination							
8. Pulse and blood pressure [24–26]	18	2	0				b, c
9. Otoscopy [11, 27, 28]	18	2	0				a, b
10. Audiometry [29–31]	10	14	0	Round two	5	15	0
11. Motor and Sensory function (Global neurological exam) [13, 32, 33]	19	1	0				I
12. Nystagmus, general observed [11, 34–37]	18	2	0				I
13. Head-shaking nystagmus [31, 36, 38–40]	4	16	0				E
14. Head Impulse-Nystagmus-Test of Skew (HINTS) [41–52]	10	10	0	Round two	7	12	1
Alternative HINTS Plus							Consensus round I
15. Sideways stepping/Fukuda Stepping/Unterberger test [40, 53–59]	6	14	0	Round two	7	12	1
16. Dix-Hallpike test [40, 60–67]	20	0	0				I
17. Head-roll/Supine-roll test [11, 68–70]	14	6	0				I
18. STANDING algorithm (SponT)Aneous Nystagmus, Direction, head Impulse test, standing) [48, 71–73]	9	10	1	Round two	5	15	0
19. Gait disorientation test [74–76]	1	19	0				E
20. Tandem walking test [53, 77–81]	16	4	0				I
21. Bucket test [37, 82–86]	2	17	0				E
22. Romberg test [39, 77, 78, 81, 87, 88]	15	5	0				I
23. Single leg stance test [77]	4	16	0				E
24. Timed up & Go test [59, 77]	5	15	0				E

Table 2 (continued)

Diagnostic Test N = 40 + 6	Round one			Round two			Consensus round Result, Ω
	Inclusion	Exclusion	No Expertise	Inclusion	Exclusion	No Expertise	
25. Past pointing test [59]	11	8	1	7	13	0	Consensus round E
26. Five Times Sit to Stand test [59, 89]	2	18	0				E
27. Pull test [59]	2	18	0				E
28. Frenzel glasses [90]	9	11	0	9	11	0	Consensus round E
III. Additional tests							
29. Laboratory testing [91–104]	5	14	0				E
IV. Questionnaires							
30. PCI Score System [105]	6	12	2	5	13	1	E
31. Essen Score System [105, 106]	2	14	0				E
32. ABCD ² Score System [37, 43, 44, 48, 52, 105, 107, 108]	3	14	0				E
33. TriAge + Score System [107]	4	12	0				E
34. Questionnaires Benign Paroxysmal Positional Vertigo	10	9	1				Round two
Chen et al. [109]				5	15	0	E
Kim et al. [110]				5	15	0	E
Lapena et al. [111]				2	18	0	E
35. Questionnaire Vestibular Migraine [112]	9	10	1	8	12	0	Consensus round E
36. Questionnaires Vestibular Disorders	6	13	1				Round two
Steward et al. [113]				3	17	0	E
Bayer et al. [114]				2	18	0	E
V. Additional tests suggested by Delphi Panel							
I. Romberg with Jendrasik [77]				5	18	2	E
II. Orthostatic blood pressure [115]				17	2	1	I
III. Dynamic Visual Acuity [116, 117]				4	14	2	E
IV. Carmona Gait Ataxia Severity Score [45]				6	12	2	Consensus round E
V. Tuning Forks [118]				11	8	1	Consensus round E
VI. Electrocardiogram (ECG) [119]				9	8	2	Consensus round E

a: Technical feasibility; b: Diagnostic accuracy; c: Diagnostic thinking impact; d: Therapeutic choice impact; e: Patient outcome impact; f: Societal impact

= I: Inclusion, E: Exclusion

Table 3 Final selection of diagnostic tests which should be investigated in a diagnostic accuracy study^a

I. Patient history	Description
1. Present vertigo symptoms	What kind of vertigo symptoms does the patient experience?
2. Accompanying symptoms	Does the patient experience other symptoms associated with vertigo symptoms (e.g. nausea, vomiting, tinnitus)?
3. Timing of symptoms	When does the patient experience his/her complaints of vertigo? Is it a constant feeling or are there attacks of vertigo? What is the duration of attacks (e.g. seconds, minutes, hours)? How often does it occur (daily, weekly, monthly)?
4. Triggers of Symptoms	Does the patient describe activities/factors that provoke the vertigo (e.g. bending over, looking up, loud noises)?
5. Medication	Does the patient use medication? Does he/she smoke or use alcohol or drugs?
6. Past medical history	Does the patient have a medical history of cardiovascular diseases, internal diseases, ENT diseases, neurological diseases, musculoskeletal diseases, and/or visual diseases?
7. Cardiovascular risk	Does the patient have known cardiovascular risk factors (e.g. smoking, obesity, high blood pressure)?
II. Physical examination	
8. Pulse and blood pressure	Pulse measurement and blood pressure measurements can be performed to assess the hemodynamic condition of a patient. Hemodynamic abnormalities can be associated with vestibular symptoms.
9. Otoscopy	Otoscopy can be used to diagnose inflammation/infection of the inner ear, perforation of the tympanic membrane, perilymphatic fistula or cholesteatoma. These diagnoses can be associated with vestibular symptoms.
10. Global neurological exam	The standard neurological clinical assessment is used to evaluate the nervous system. This exam is used to diagnose disorders affecting the brain, nerves and spinal cord that may cause vestibular symptoms.
11. Nystagmus, general observed	A nystagmus is an involuntary eye movement, that is directly followed by a compensatory rapid eye movement in the contradictory direction. The occurrence of nystagmus can be associated with vestibular symptoms and problems within the vestibular system.
12. HINTS (Head Impulse-Nystagmus-Test of Skew)	The HINTS exam consists of the Head Impulse Test (HIT), Nystagmus examination and Test of Skew. The HIT is also known as the Head Thrust Test (HTT). The HINTS is a clinical bedside test that is used to differentiate peripheral vestibular disease from stroke in patients with an acute vestibular syndrome (AVS).
13. Dix-Hallpike	The Dix-Hallpike manoeuvre is a clinical test for benign paroxysmal positional vertigo (BPPV) of the posterior semicircular canal.
14. Head-roll/Supine-roll test	The Head-roll test is a clinical test for benign paroxysmal positional vertigo (BPPV) of the lateral (horizontal) semicircular canal.
15. Tandem walking test	The Tandem walking Test is a clinical test used to screen patients for neurologic and vestibular disorders.
16. Romberg test	The Romberg test is a clinical test used to assess the dorsal columns of the spinal cord and the general balance of the patient. Vestibular dysfunction could be accompanied by balance problems.
17. Orthostatic blood pressure test	An abnormal fall in blood pressure on standing from a supine or sitting position has been described as orthostatic hypotension. Orthostatic blood pressure measurement could be performed for patients who complains of dizziness or syncope.

^aFor background information see Appendix III

it might be interesting to see whether the large degree of consensus between the subpanel and the full panel holds with the addition of more international experts. If it does, then the applied Delphi method could in general be utilized as a novel kind of accuracy study methodology in order to gauge agreement between a country's national guideline(s) and the international expert consensus on particular topics within primary care and secondary/tertiary care, or agreement between different specialties within secondary/tertiary care.

Strengths and limitations

A strength of this study is the use of an extensive systematic literature search to identify potentially relevant diagnostic tests for vertigo in general practice. These tests were supplemented by a comprehensive appendix (see Appendix III), that explained each test, provided links to instructional videos, and references to supporting literature. Several experts commented that they found this appendix to be very valuable, as it facilitated completing

of the scoring form during the Delphi procedure. Another strength of this study is the 100% response rate among the expert panel during the Delphi rounds [116]. A final strength was that our panel demonstrated substantial confidence in their own knowledge and expertise regarding tests for vertigo in general practice. They only stated 'insufficient expertise' in 2.6% of all judgements were stated as 'insufficient expertise', whereas this percentage was much higher during a previous, similar Delphi procedure (14.4%) [19]. One panellist suggested to add portable video-oculography (VOG) to the test selection [121, 122]. Unfortunately, this was not possible, because VOG is currently still too expensive and therefore not yet feasible for use in general practice.

A possible limitation of our study is that our strategy for the purposive sampling of experts based on expert judgement and snowball sampling might be too stringent. A less stringent threshold for judging expertise, i.e. less heavily relying on relevant academic or guideline

Table 4 Sensitivity analysis: comparison of the full expert panel results to the expert subpanel results after the first round

Tests	Full panel (n = 20)			Subpanel (n = 9)		
	Inclusion: yes > 70%	Exclusion: yes < 30%	Round 2: yes = 30 to 70%	Inclusion: yes > 70%	Exclusion: yes < 30%	Round 2: yes = 30 to 70%
I. Patient history						
1. Present vertigo symptoms	95%			89%		
2. Accompanying symptoms	95%			89%		
3. Timing of symptoms	100%			100%		
4. Triggers of symptoms	95%			89%		
5. Medication	90%			78%		
6. Past medical history	100%			100%		
7. Cardiovascular risk	85%			89%		
II. Physical examination						
8. Pulse and blood pressure	90%			89%		
9. Otoscopy	90%			89%		
10. Audiometry			30%		22%	
11. Motor and sensory function (global neurological exam)	95%			89%		
12. Nystagmus, general observed	90%			100%		
13. Head-shaking nystagmys		20%			22%	
14. HINTS (Head Impuls, Nystagmus, Test of Skew)			50%			44%
15. Sideways Stepping/Fukuda Stepping/Unterberger Test			30%		22%	
16. Dix-Hallpike	100%			100%		
17. Head-roll/Supine-roll Test	70%					56%
18. STANDING algorithm (SponTaneous Nystagmus, Direction, head Impuls test, standiNG)			45%			44%
19. Gait Disorientation Test		5%			0%	
20. Tandem Walking Test	80%			100%		
21. Bucket Test		10%			0%	
22. Romberg Test	75%			100%		
23. Single Leg Stance Test		20%			22%	
24. Timed up & Go Test		25%				33%
25. Past Pointing Test			55%			56%
26. Five Times Sit to Stand Test		10%			0%	
27. Pull Test		10%			0%	
28. Frenzel glasses			45%			44%
III. Additional Tests						
29. Laboratory testing		25%				56%
IV. Questionnaires						
30. PCI Score System			30%		22%	
31. Essen Score System		10%			11%	
32. ABCD ² Score System		15%			22%	
33. TriAGe + Score System		20%			11%	
34. Questionnaires Benign Proxysmal Positional Vertigo			50%			44%
35. Questionnaire Vestibular Migraine			45%			56%
36. Questionnaire Vesstibular disorders			30%			33%
TOTALS:	Yes: N = 15	No: N = 11	R2:N = 10	Yes: N = 14	No: N = 12	R2:N = 10

publications, might result in a larger pool of experts to choose from.

Another possible limitation is that we have prematurely excluded non-academic clinical experts, e.g. experienced GPs and/or neurologists/ENT-specialists who in practice may have a generally recognized degree of clinical expertise on these topics, while not necessarily having

any documented publications on these topics [123]. Trying to incorporate such non-academic clinical experts with undocumented specialized knowledge into a Delphi study poses significant challenges. Exactly due to lack of proper documentation, searching by random or using registry-based sampling would be problematic, where one is forced to rely on word-of-mouth and folk wisdom.

Choosing to include such non-academic clinical experts would likely result in a larger pool of panellists, but with the trade-off of an unintended probable increase in the frequency of ‘insufficient expertise’ getting reported (or not) by the panellists with respect to the tests.

Comparison with existing literature

We conducted a PubMed search to identify comparable studies. This search yielded a total of 13 articles, eight of which were identified as Delphi studies; one specifically addressed diagnostic tests for patients with dizziness. Maarsingh et al. [19] focused on tests for evaluating dizziness in older patients, while we focused on adults with vertigo. Despite similarities in history-taking importance and physical examination components, their study had a higher uncertainty rate (14.4%) compared to ours (2.6%), likely due to differing expert compositions. Maarsingh included additional tests like ECGs and questionnaires, not considered in our study, possibly due to differences in target populations and intended scope.

Implications for research and practice

The 17 tests that were recommended in this Delphi procedure are currently being tested in a large diagnostic accuracy study called the Vertigo Diagnosis (VERDI) study (start recruitment March 2023; Trial registration number: ISRCTN97250704; Registration date: March 16th 2023; <https://doi.org/10.1186/ISRCTN97250704>) [14]. Currently, GPs have to diagnose patients with vertigo using a diagnostic toolkit that lacks scientific justification. By conducting this diagnostic accuracy study, a diagnostic algorithm can be developed to help GPs more accurately and efficiently identify an underlying cause in patients with vertigo, which may lead to faster efficient treatment, and an improvement of the overall outcome for patients with vertigo in general practice.

Conclusion

Based on an international Delphi procedure, experts recommended 17 diagnostic tests for patients with vertigo in general practice to be evaluated in a diagnostic accuracy study, of which 15 tests were already recommended by the Dutch GP guideline, supplemented by the non-recommended Tandem Walking Tests and the Romberg Test.

Abbreviations

ECG	Electrocardiogram
GP	General Practitioner
HIT/HTT	Head Impulse Test / Head Thrust Test
HINTS	Head Impulse-Nystagmus-Test of Skew
ICVD	International Classification of Vestibular Disorders
BPPV	Benign Paroxysmal Positional Vertigo
VERDI study	Vertigo Diagnosis Study
VOG	Vestibular Oculography

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

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Authors' contributions

OM is the coordinator of the study. OM, VV, AL, AR, RvL, TB, JC and BLW were involved in the design of the study. AL wrote the original draft of the study. All authors contributed, read and approved the final manuscript.

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Data availability

The dataset(s) supporting the conclusions of this article, including the individually completed score forms, are not publicly available due to confidentiality agreements with the participating experts. However, they are available from the corresponding author upon reasonable request, subject to maintaining the anonymity and confidentiality of the experts.

Declarations

Ethics approval and consent to participate

Ethics approval for this study was obtained from the Medical Ethics Review Committee of the Amsterdam UMC, VU University Medical Center (reference number: 2022.0390, approval date: 28 June 2022).

Consent for publication

Informed consent was obtained from all experts by e-mail. The experts agreed to give their professional opinion

Competing interests

The authors declare no competing interests.

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References

1. Bisdorff A. Vestibular symptoms and history taking. *Handb Clin Neurol*. 2016;137:83–90.
2. Bisdorff AR, Staab JP, Newman-Toker DE. Overview of the international classification of vestibular disorders. *Neurol Clin*. 2015;33(3):541–50. vii.
3. Jönsson R, et al. Prevalence of Dizziness and vertigo in an urban elderly population. *J Vestib Res*. 2004;14(1):47–52.
4. Neuhauser HK, et al. Burden of Dizziness and vertigo in the community. *Arch Intern Med*. 2008;168(19):2118–24.
5. Newman-Toker DE, et al. Spectrum of Dizziness visits to US emergency departments: cross-sectional analysis from a nationally representative sample. *Mayo Clin Proc*. 2008;83(7):765–75.
6. Kruschinski C, et al. Diagnosing Dizziness in the emergency and primary care settings. *Mayo Clin Proc*. 2008;83(11):1297–8. author reply 1298–9.
7. Neuhauser HK, et al. Epidemiology of vestibular vertigo: a neurotologic survey of the general population. *Neurology*. 2005;65(6):898–904.
8. Kovacs E, Wang X, Grill E. Economic burden of vertigo: a systematic review. *Health Econ Rev*. 2019;9(1):37.
9. Colledge NR, et al. The prevalence and characteristics of Dizziness in an elderly community. *Age Ageing*. 1994;23(2):117–20.
10. *World Population Ageing 2020*, United Nations, Department of Economic and Social Affairs, Population Division: New York. 2020; Available from: <https://www.un.org/en/development/desa/population/publications/pdf/ageing/WorldPopulationAgeing2013.pdf>
11. Bouma M, et al. Dutch college of gp's guideline Dizziness (first revision). *Huisarts En Wetenschap*. 2017;60(7):348–56.
12. Dros J, et al. Tests used to evaluate Dizziness in primary care. *CMAJ*. 2010;182(13):E621–31.
13. Levin MC. *Neurologic Examination*. 2021; Available from: <https://www.merckmanuals.com/home/brain,-spinal-cord,-and-nerve-disorders/diagnosis-of-brain,-spinal-cord,-and-nerve-disorders/neurologic-examination>
14. Ross A, et al. Prospective diagnostic accuracy study of history taking and physical examination for adults with vertigo in general practice: study protocol. *BMJ Open*. 2024;14(4):e085715.
15. Sourani A, Sohail M. The Delphi method: review and use in construction management research. *Int J Constr Educ Res*. 2015;11(1):54–76.
16. de Villiers MR, de Villiers PJT, Kent AP. The Delphi technique in health sciences education research. *Med Teach*. 2005;27(7):639–43.
17. Jones J, Hunter D. Consensus methods for medical and health services research. *BMJ*. 1995;311(7001):376–80.
18. Meijer R, et al. The use of a modified Delphi procedure for the determination of 26 prognostic factors in the sub-acute stage of stroke. *Int J Rehabil Res*. 2003;26(4):265–70.
19. Maarsingh OR, et al. Development of a diagnostic protocol for Dizziness in elderly patients in general practice: a Delphi procedure. *BMC Fam Pract*. 2009;10:12.
20. Veritas Health Innovation. Covidence systematic review software [Internet]. Melbourne: Veritas Health Innovation. Available from: <https://www.covidence.org/>. [cited 2025 Jul 6].
21. Keeney S, Hasson F, McKenna H. Consulting the oracle: ten lessons from using the Delphi technique in nursing research. *J Adv Nurs*. 2006;53(2):205–12.
22. Keeney S, Hasson F, McKenna HP. A critical review of the Delphi technique as a research methodology for nursing. *Int J Nurs Stud*. 2001;38(2):195–200.
23. Tatsioni A, et al. Challenges in systematic reviews of diagnostic technologies. *Ann Intern Med*. 2005;142(12 Pt 2):1048–55.
24. Spodick DH. Normal sinus heart rate: sinus tachycardia and sinus bradycardia redefined. *Am Heart J*. 1992;124(4):1119–21.
25. Brignole M, et al. Guidelines on management (diagnosis and treatment) of syncope-update 2004. Executive summary. *Eur Heart J*. 2004;25(22):2054–72.
26. Thomas G. Hypertension in adults: Blood pressure measurement and diagnosis. UpToDate [Internet]. Waltham, MA: UpToDate, Inc.; 2023. Available from: <https://www.uptodate.com/contents/hypertension-in-adults-blood-pressure-measurement-and-diagnosis>. [cited 2025 Jul 6].
27. Karma PH, et al. Otoscopy diagnosis of middle ear effusion in acute and non-acute otitis media. I. The value of different otoscopic findings. *Int J Pediatr Otorhinolaryngol*. 1989;17(1):37–49.
28. Rothman R, Owens T, Simel DL. Does this child have acute otitis media? *JAMA*. 2003;290(12):1633–40.
29. Paul BC, Roland JT Jr. An abnormal audiogram. *JAMA*. 2015;313(1):85–6.
30. Foster MF, Backous DD. Clinical evaluation of the patient with otosclerosis. *Otolaryngol Clin North Am*. 2018;51(2):319–26.
31. Di Giustino F, Pecci R, Vannucchi P. Vestibular Schwannoma diagnosis: evaluation of a neuro-otological test battery. *Hear Balance Communication*. 2016;14(4):157–62.
32. Shahrokhi M, Asuncion RMD. Neurologic Exam. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK557589/>. [cited 2025 Jul 6].
33. Hafiz S, De Jesus O. Ataxia. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK562284/>. [cited 2025 Jul 6].
34. Barton JJ. Overview of nystagmus. 2022 2023; Available from: Post TW, ed. UpToDate. Waltham, MA: UpToDate Inc. <http://www.uptodate.com>. Accessed [July 2022]. <https://www.uptodate.com/contents/overview-of-nystagmus#:~:text=Nystagmus%20is%20a%20rhythmic%20regular,more%20common%20than%20pendular%20nystagmus>.
35. Thurtell MJ, Leigh RJ. Chapter 13 - *Nystagmus and saccadic intrusions*. Handbook of clinical neurology. Elsevier; 2011, pages 333–378.
36. Califano L, et al. Sensitivity and specificity of vestibular bedside examination in detecting VIII cranial nerve Schwannoma with sensorineural sudden unilateral hearing loss as presenting symptom. *Acta Otorhinolaryngol Ital*. 2017;37(4):336–40.
37. Chang T-P, et al. The bucket test differentiates patients with MRI confirmed brainstem/cerebellar lesions from patients having migraine and Dizziness alone. *BMC Neurol*. 2019;19(1):219.
38. Angeli SI, Velandia S, Snapp H. Head-shaking nystagmus predicts greater disability in unilateral peripheral vestibulopathy. *Am J Otolaryngol*. 2011;32(6):522–7.
39. Gofrit SG, et al. The association between vestibular physical examination, Vertigo questionnaires, and the electronystagmography in patients with vestibular symptoms. *Ann Otol Rhinol Laryngol*. 2017;126(4):315–21.
40. Kamal N, Taha H, Galal E. Office vestibular tests: A battery approach to guide the diagnosis of dizzy patients. *Audiol Med*. 2011;9(2):79–84.
41. Kattah JC, et al. 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(11):3504–10.
42. Nham B, et al. Capturing vertigo in the emergency room: three tools to double the rate of diagnosis. *J Neurol*. 2022;269(1):294–306.
43. Kerber KA, et al. Stroke risk stratification in acute Dizziness presentations: A prospective imaging-based study. *Neurology*. 2015;85(21):1869–78.
44. Newman-Toker DE, et al. HINTS outperforms ABCD2 to screen for stroke in acute continuous vertigo and Dizziness. *Acad Emerg Med*. 2013;20(10):986–96.
45. Carmona S, et al. The diagnostic accuracy of truncal Ataxia and HINTS as Cardinal signs for acute vestibular syndrome. *Front Neurol*. 2016;7:125.
46. Choi JH, et al. Early MRI-negative posterior circulation stroke presenting as acute Dizziness. *J Neurol*. 2018;265(12):2993–3000.
47. Dmitriev C, et al. Diagnostic accuracy of the HINTS exam in an emergency department: A retrospective chart review. *Acad Emerg Med*. 2021;28(4):387–93.
48. Gerlier C, et al. Differentiating central from peripheral causes of acute vertigo in an emergency setting with the HINTS, STANDING, and ABCD2 tests: A diagnostic cohort study. *Acad Emerg Med*. 2021;28(12):1368–78.
49. Korda A, et al. Acute vestibular syndrome: is skew deviation a central sign? *J Neurol*. 2022;269(3):1396–403.
50. Saber Tehrani AS, et al. Small strokes causing severe vertigo: frequency of false-negative MRIs and nonlacunar mechanisms. *Neurology*. 2014;83(2):169–73.
51. Sankalia D, Kothari S, Phalgune DS. Diagnosing stroke in acute vertigo: sensitivity and specificity of HINTS battery in Indian population. *Neurol India*. 2021;69(1):97–101.
52. Wang W, et al. Central nystagmus plus ABCD(2) identifying stroke in acute Dizziness presentations. *Acad Emerg Med*. 2021;28(10):1118–23.
53. Cohen HS, et al. Utility of stepping, walking, and head impulses for screening patients for vestibular impairments. *Otolaryngol Head Neck Surg*. 2014;151(1):131–6.
54. Hornibrook J. A balance test for chronic Perilymph fistula. *Int J Otolaryngol*. 2012;2012:163691.
55. Honaker JA, et al. Fukuda stepping test: sensitivity and specificity. *J Am Acad Audiol*. 2009;20(5):311–4. quiz 335.
56. Fukuda T. The stepping test: two phases of the labyrinthine reflex. *Acta Otolaryngol*. 1959;50(2):95–108.
57. Al Saif AA, Alsenany S. The efficiency of the sideways stepping test in detecting unilateral vestibular hypofunction. *J Phys Ther Sci*. 2014;26(11):1719–22.

58. Honaker JA, Shepard NT. Performance of Fukuda stepping test as a function of the severity of caloric weakness in chronic dizzy patients. *J Am Acad Audiol*. 2012;23(8):616–22.
59. Maranhão ET, et al. Migraine patients consistently show abnormal vestibular bedside tests. *Arq Neuropsiquiatr*. 2016;74(1):22–8.
60. Andera L, et al. Optimizing testing for BPPV - The loaded Dix-Hallpike. *J Int Adv Otol*. 2020;16(2):171–5.
61. Evren C, et al. Diagnostic value of repeated Dix-Hallpike and roll maneuvers in benign paroxysmal positional vertigo. *Braz J Otorhinolaryngol*. 2017;83(3):243–8.
62. Shah MU, et al. Smartphone telemedical emergency department consults for screening of nonacute Dizziness. *Laryngoscope*. 2019;129(2):466–9.
63. Zainun Z, et al. Determination of sensitivity & specificity of dix hallpike test (DHT) in peripheral vestibular disordered subjects. *Int Med J* (1994). 2013;20:1–2.
64. Jeon EJ, et al. The efficacy of a modified Dix-Hallpike test with a pillow under shoulders. *J Vestib Res*. 2019;29(4):197–203.
65. Ling X, et al. Diagnostic value of straight head hanging in posterior Canal benign paroxysmal positional Vertigo. *J Clin Neurol*. 2021;17(4):558–62.
66. Noda K, et al. Predictors for benign paroxysmal positional vertigo with positive Dix-Hallpike test. *Int J Gen Med*. 2011;4:809–14.
67. Burston A, Mossman S, Weatherall M. Are there diurnal variations in the results of the Dix-Hallpike manoeuvre? *J Clin Neurosci*. 2012;19(3):415–7.
68. Asprella-Libonati G. Pseudo-spontaneous nystagmus: a new sign to diagnose the affected side in lateral semicircular Canal benign paroxysmal positional vertigo. *Acta Otorhinolaryngol Ital*. 2008;28(2):73–8.
69. Bhattacharyya N, et al. Clinical practice guideline: benign paroxysmal positional Vertigo (Update). *Otolaryngol Head Neck Surg*. 2017;156(3suppl):S1–47.
70. Martellucci S, Malara P, Castellucci A, Pecci R, Giannoni B, Marcelli V, Scarpa A, Cassandro E, Quagliari S, Manfrin ML, Rebecchi E, Armato E, Comacchio F, Mion M, Attanasio G, Ralli M, Greco A, de Vincentiis M, Botti C, Savoldi L, Califano L, Ghidini A, Pagliuca G, Clemenzi V, Stolfi A, Gallo A, Asprella Libonati G. Upright BPPV Protocol: Feasibility of a New Diagnostic Paradigm for Lateral Semicircular Canal Benign Paroxysmal Positional Vertigo Compared to Standard Diagnostic Maneuvers. *Front Neurol*. 2020;11:1–12. <https://doi.org/10.3389/fneur.2020.578305>.
71. Vanni S, et al. Can emergency physicians accurately and reliably assess acute vertigo in the emergency department? *Emerg Med Australas*. 2015;27(2):126–31.
72. Vanni S, et al. STANDING, a four-step bedside algorithm for differential diagnosis of acute vertigo in the emergency department. *Acta Otorhinolaryngol Ital*. 2014;34(6):419–26.
73. Vanni S, et al. Differential diagnosis of Vertigo in the emergency department: A prospective validation study of the STANDING algorithm. *Front Neurol*. 2017;8:590.
74. Chen L, et al. Diagnostic accuracy of acute vestibular syndrome at the bedside in a stroke unit. *J Neurol*. 2011;258(5):855–61.
75. Grove CR, et al. The gait disorientation test: A new method for screening adults with Dizziness and imbalance. *Arch Phys Med Rehabil*. 2021;102(4):582–90.
76. Wrisley DM, et al. Reliability, internal consistency, and validity of data obtained with the functional gait assessment. *Phys Ther*. 2004;84(10):906–18.
77. Salah M, et al. Clinical balance testing to screen for patients with vestibular disorders: A retrospective Case-control study. *Otol Neurotol*. 2020;41(9):1258–65.
78. Cohen HS, et al. Screening for vestibular disorders using the modified clinical test of sensory interaction and balance and tandem walking with eyes closed. *Otol Neurotol*. 2019;40(5):658–65.
79. Cohen HS, et al. Tandem walking as a quick screening test for vestibular disorders. *Laryngoscope*. 2018;128(7):1687–91.
80. Cohen HS, et al. Tests of walking balance for screening vestibular disorders. *J Vestib Res*. 2012;22(2):95–104.
81. Longridge NS, Mallinson AI. Clinical Romberg testing does not detect vestibular disease. *Otol Neurotol*. 2010;31(5):803–6.
82. Cohen HS, Sangi-Haghpeykar H. Subjective visual vertical in vestibular disorders measured with the bucket test. *Acta Otolaryngol*. 2012;132(8):850–4.
83. Wengier A, et al. Subjective visual vertical evaluation by a Smartphone-based Test-Taking the phone out of the bucket. *Otol Neurotol*. 2021;42(3):455–60.
84. Sun DQ, et al. Evaluation of a bedside test of utricular function - the bucket test - in older individuals. *Acta Otolaryngol*. 2014;134(4):382–9.
85. Shaban A, et al. The bucket test improves detection of stroke in patients with acute Dizziness. *J Emerg Med*. 2021;60(4):485–94.
86. Riera-Tur L, et al. Efficacy of the subjective visual vertical test performed using a mobile application to detect vestibular pathology. *J Vestib Res*. 2022;32(1):21–7.
87. Hong SK, et al. Clinical efficacy of the Romberg test using a foam pad to identify balance problems: a comparative study with the sensory organization test. *Eur Arch Otorhinolaryngol*. 2015;272(10):2741–7.
88. Zamysłowska-Szmytko E, Szostek-Rogula S, Śliwińska-Kowalska M. Bedside examination for vestibular screening in occupational medicine. *Int J Occup Med Environ Health*. 2015;28(2):379–87.
89. Guralnik JM, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol*. 1994;49(2):M85–94.
90. Yeolekar AM, Shinde KJ, Qadri H. Innovative use of Google cardboard in clinical examination of patients of Vertigo. *Clin Med Insights Ear Nose Throat*. 2019;12:1179550619882012.
91. Celikbilek A, et al. Serum uric acid levels correlate with benign paroxysmal positional vertigo. *Eur J Neurol*. 2014;21(1):79–85.
92. Evrin T, Katipoglu B. Predictive values of serum uric acid, mean platelet volume and plateletcrit on benign paroxysmal positional Vertigo. *Eurasian J Emerg Med*. 2019;18:95–8.
93. Lan W, Ai P, Xu Q. Deep-learning-based MRI in the diagnosis of cerebral infarction and its correlation with the neutrophil to lymphocyte ratio. *Ann Palliat Med*. 2021;10(11):11370–81.
94. Yuan J, et al. Factors associated with benign paroxysmal positional vertigo: A Chinese Case-Control study. *Med Sci Monit*. 2017;23:3885–9.
95. Hong SI, et al. C-reactive protein for stroke detection in the emergency department in patients with Dizziness without neurological deficits. *Front Neurol*. 2021;12:662510.
96. Lee SH, et al. Utility of Neutrophil-to-Lymphocyte ratio (NLR) as a predictor of acute infarction in New-Onset acute Vertigo patients without neurologic and computed tomography abnormalities. *J Emerg Med*. 2018;54(5):607–14.
97. Zhang Y, Jiang L, Yang P, Zhang Y. Diagnostic Values of Neutrophil and Neutrophil to Lymphocyte Ratio in Distinguishing between Acute Cerebral Infarction and Vertigo. *Clin Lab*. 2019;65(8). <https://doi.org/10.7754/Clin.Lab.2019.190208>.
98. Kijpaisalratana N, et al. Serum miRNA125a-5p, miR-125b-5p, and miR-433-5p as biomarkers to differentiate between posterior circulation stroke and peripheral vertigo. *BMC Neurol*. 2020;20(1):372.
99. Kartal AG, et al. Diagnostic value of S100B protein in the differential diagnosis of acute vertigo in the emergency department. *Acad Emerg Med*. 2014;21(7):736–41.
100. Mozafari J, et al. Characteristics of S100B and neuron specific enolase in differentiating acute Vertigo cases with central cause; a diagnostic accuracy study. *Arch Acad Emerg Med*. 2020;8(1):e3.
101. Sohn JH, et al. Diagnostic value of serum biomarkers for differentiating central and peripheral causes of acute Vertigo. *Front Med (Lausanne)*. 2020;7:84.
102. Şener A, Erel Ö. Evaluation of thiol / disulfide homeostasis and ischemia modified albumin levels in the differential diagnosis of central and peripheral vertigo. *Annals Clin Anal Med*. 2021;12:1218–22.
103. Purrucker JC, et al. Serum protein S100β is a diagnostic biomarker for distinguishing posterior circulation stroke from vertigo of nonvascular causes. *Eur Neurol*. 2014;72(5–6):278–84.
104. Zhou C, et al. A novel diagnostic prediction model for vestibular migraine. *Neuropsychiatr Dis Treat*. 2020;16:1845–52.
105. Chen R, et al. A posterior circulation ischemia risk score system to assist the diagnosis of Dizziness. *J Stroke Cerebrovasc Dis*. 2018;27(2):506–12.
106. Boulanger M, et al. Essen risk score in prediction of myocardial infarction after transient ischemic attack or ischemic stroke without prior coronary artery disease. *Stroke*. 2019;50(12):3393–9.
107. Kuroda R, et al. The TriAge + Score for Vertigo or dizziness: A diagnostic model for stroke in the emergency department. *J Stroke Cerebrovasc Dis*. 2017;26(5):1144–53.
108. Navi BB, et al. Application of the ABCD2 score to identify cerebrovascular causes of Dizziness in the emergency department. *Stroke*. 2012;43(6):1484–9.
109. Chen W, et al. Validation of 5-item and 2-item questionnaires in Chinese version of Dizziness handicap inventory for screening objective benign paroxysmal positional vertigo. *Neurol Sci*. 2016;37(8):1241–6.
110. Kim HJ, et al. Questionnaire-based diagnosis of benign paroxysmal positional vertigo. *Neurology*. 2020;94(9):e942–9.
111. Lapenna R, et al. Reliability of an anamnesic questionnaire for the diagnosis of benign paroxysmal positional vertigo in the elderly. *Aging Clin Exp Res*. 2016;28(5):881–8.

112. Celebisoy N, et al. Establishing a vestibular migraine diagnosis questionnaire and testing its validity. *Neurologist*. 2016;21(4):51–4.
113. Stewart V, et al. Construction and validation of the vestibular screening tool for use in the emergency department and acute hospital setting. *Arch Phys Med Rehabil*. 2015;96(12):2153–60.
114. Bayer O, Warninghoff JC, Straube A. Diagnostic indices for vertiginous diseases. *BMC Neurol*. 2010;10:98.
115. Jang K, Park M, Kim HL. Time point of blood pressure drop in patients with orthostatic hypotension in the emergency department. *J Hypertens*. 2020;38(11):2169–75.
116. Avella JR. Delphi panels: research design, procedures, advantages, and challenges. *Int J Doctoral Stud*. 2016;11:305–21.
117. Petersen JA, Straumann D, Weber KP. Clinical diagnosis of bilateral vestibular loss: three simple bedside tests. *Ther Adv Neurol Disord*. 2013;6(1):41–5.
118. Lustig LR. *Hearing Loss*. 2022; Available from: <https://www.merckmanuals.com/home/ear-nose-and-throat-disorders/hearing-loss-and-deafness/hearing-loss>
119. Brignole M, et al. Practical instructions for the 2018 ESC guidelines for the diagnosis and management of syncope. *Eur Heart J*. 2018;39(21):e43–80.
120. Gottlieb M, Peksa GD, Carlson JN. Head impulse, nystagmus, and test of skew examination for diagnosing central causes of acute vestibular syndrome. *Cochrane Database Syst Rev*. 2023;11(11):pCd015089.
121. Mantokoudis G, Otero-Millan J, Gold DR. Current concepts in acute vestibular syndrome and video-oculography. *Curr Opin Neurol*. 2022;35(1):75–83.
122. Kattah JC, Newman-Toker DE. Video-Oculography to guide neuroimaging for Dizziness and Vertigo. *JAMA Otolaryngol Head Neck Surg*. 2022;148(5):474–5.
123. Wieringa S, Greenhalgh T. 10 years of mindlines: a systematic review and commentary. *Implement Sci*. 2015;10:1–11.

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