Thunderclap headache syndrome presenting to the emergency department: an international multicentre observational cohort study

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ABSTRACT

Background Most headache presentations to emergency departments (ED) have benign causes; however, approximately 10% will have serious pathology. International guidelines recommend that patients describing the onset of headache as 'thunderclap' undergo neuroimaging and further investigation. The association of this feature with serious headache cause is unclear. The objective of this study was to determine if patients presenting with thunderclap headache are significantly more likely to have serious underlying pathology than patients with more gradual onset and to determine compliance with guidelines for investigation.

Methods This was a planned secondary analysis of an international, multicentre, observational study of adult ED patients presenting with a main complaint of headache. Data regarding demographics, investigation strategies and final ED diagnoses were collected. Thunderclap headache was defined as severe headache of immediate or almost immediate onset and peak intensity. Proportion of patients with serious pathology in thunderclap and non-thunderclap groups were compared by χ^2 test.

Results 644 of 4536 patients presented with thunderclap headache (14.2%). CT brain imaging and lumbar puncture were performed in 62.7% and 10.6% of cases, respectively. Among patients with thunderclap headache, serious pathology was identified in 10.9% (95%CI 8.7% to 13.5%) of cases—significantly higher than the proportion found in patients with a different headache onset (6.6% (95% CI 5.9% to 7.4%), p<0.001.). The incidence of subarachnoid haemorrhage (SAH) was 3.6% (95% CI 2.4% to 5.3%) in those with thunderclap headache vs 0.3% (95% CI 0.2% to 0.5%) in those without (p<0.001). All cases of SAH were diagnosed on CT imaging. Non-serious intracranial pathology was diagnosed in 87.7% of patients with thunderclap headache.

Conclusions Thunderclap headache presenting to the ED appears be associated with higher risk for serious intracranial pathology, including SAH, although most patients with this type of headache had a benign cause. Neuroimaging rates did not align with international guidelines, suggesting potential need for further work on standardisation.

Key messages

What is already known on this subject

- Thunderclap headache is regarded as a 'red flag' symptom for acute headache presentations to the emergency department (ED), potentially signifying a serious aetiology, requiring urgent identification and management.
- The majority of patients who present with headache have a 'primary headache' disorder as their ED discharge diagnosis.

What this study adds

- In this planned secondary analysis of an international, multicentre, observational study of adult ED patients with main complaint of headache, we found that serious pathology was more common among those describing their headache as thunderclap versus those with more gradual onset (10.9% (95% CI 8.7% to 13.5%) vs 6.6% (95% CI 5.9% to 7.4%)).

How this study might affect research, practice or policy

- A large number of patients with thunderclap headache had benign aetiologies, suggesting further work is needed to distinguish the high-risk group.
- Neuroimaging rates were not consistent with international guidelines, suggesting potential for further work on standardisation.

INTRODUCTION

Acute headache accounts for between 1% and 2% of all emergency department (ED) attendances.[1] Over half of these presentations will have a final ED diagnosis of primary (benign) headache.[2 3] However, up to 10% will have serious and potentially treatable pathology as the precipitant cause of the headache.[4 5] Although diagnostic testing can identify such cases, the tests themselves are not without harm and opportunity cost. Additionally, advanced neuroimaging leads to incidental findings requiring further investigation in about 2% of patients.[6] Particularly in the frequent situation

where there are no neurologic examination findings, emergency clinicians are therefore faced with the challenge of deciding which patients should undergo testing based on the subjective description of the headache.

One feature commonly thought to be predictive of serious pathology is a so-called 'thunderclap' onset of headache symptoms which is described in approximately 15% of acute headache presentations to ED.[7] Thunderclap has variable definitions, but essentially describes a severe headache of instantaneous onset, reaching peak intensity within a short period (60 s to 5 min).[3 8] It has been associated with subarachnoid haemorrhage (SAH) (11%–25%) and other serious disorders such as stroke, tumour or meningitis in 10%–12% of cases.[9 10] Early identification of these conditions through timely investigation and intervention can be lifesaving. Recently, papers have questioned both the interobserver agreement and the diagnostic utility of subjective headache features for the diagnosis of serious pathology, such as SAH.[11 12]

International guidelines, including those from the Australasian College for Emergency Medicine, the United Kingdom (UK) National Institute for Health and Care Excellence (NICE) and the American College of Emergency Physicians recommend neuroimaging for all patients with 'thunderclap' headache.[3 13 14] To what extent this recommendation is followed in practice is unclear.

The objective of this study was to determine if patients presenting with thunderclap headache are significantly more likely to have a serious underlying pathology than patients with more gradual onset and to determine compliance with guidelines for investigation.

METHODS

Design, setting and participants

This study was a planned substudy of a multicentre, international, observational cohort study.[5] The methodology of that study is described in detail elsewhere.[5] In brief, for one calendar month in 2019 (for most sites March, last site October), adult patients presenting to EDs at 67 health services in 10 countries with headache as a chief complaint were identified prospectively. Data collected included demographics, clinical features, investigations, ED diagnosis and final diagnosis. The requirements for patient consent varied by country and institution and complied with local research ethics requirements. At the majority of sites, written informed consent for data collection was not required. While eligible patients were identified prospectively, data could be collected retrospectively, dependent on site resource and research infrastructure.

Inclusion and exclusion criteria

This secondary analysis included patients who reported a so-called 'thunderclap' onset of headache. Thunderclap headache was defined as severe headache of immediate or almost immediate onset and peak intensity.

Data collection

Data fields included demographics, clinical assessment, investigation, treatment, ED diagnosis and outcome (online supplemental material). The time between headache onset and neuroimaging was not collected. Data were collected by local researchers and entered as non-identifiable data to a predesigned on-line database (REDCap). The only included identifiers were region and hospital, with the latter used for verification processes only. A data integrity exercise was not undertaken.

Classification as thunderclap headache was made by the researcher collecting data. In the vast majority of cases, this was a physician but at some sites research nurses collected data. Where that was done retrospectively, it was reliant on clinical records and based on patients' recorded history.

Outcomes of interest

The primary outcome of interest was to describe the distribution of final diagnoses and rate of serious pathology in patients presenting with 'thunderclap' headache.

Secondary outcomes were to:

- compare the rate of the diagnosis of serious diagnosis and SAH between the group of patients presenting with thunderclap headache and those with a different headache onset,
- describe investigative strategies by modality (CT vs CT angiography (CTA) versus magnetic resonance imaging (MRI) versus lumbar puncture (LP)) and
- describe variation in practice across countries and within countries.

We defined serious cause of headache as the composite of headache due to SAH, intracranial haemorrhage (ICH), meningitis, encephalitis, cerebral abscess, neoplasm, hydrocephalus, vascular dissection, stroke, hypertensive crisis or pregnancy-related hypertension, temporal arteritis, idiopathic intracranial hypertension or ventriculoperitoneal shunt complications. We defined primary (benign) headache as the composite of coded diagnosis of 'migraine' and 'benign headache not otherwise specified'.

We defined important findings on neuroimaging as SAH, ICH/haematoma (acute or chronic), signs suggestive of intracranial hypertension, venous thrombosis, stroke, neoplasm (benign or malignant), vascular abnormality without bleeding (aneurysm, arteriovenous malformation and so on), hydrocephalus and signs suggestive of intracranial infection, irrespective of their relationship to final diagnosis.

Sample size

No formal sample size calculation was undertaken.

Data analysis

Data were analysed using Stata 16 (College Station, Texas, USA). Demographics, investigative strategies and final diagnosis are reported descriptively. Groups were compared using the χ^2 and t-test as appropriate. $P<0.05$ was considered statistically significant. The overall mean proportion and variance of investigative strategies between hospitals and countries were calculated using a hierarchical binary logistic regression analysis with hospital and country modelled as random effects. In those patients who received no investigations, demographics were reported descriptively. Patients with missing data were excluded from relevant analyses.

Oversight and ethical approval

Full details of the ethical approvals are provided in the parent paper.[5] Primary approval was by the Melbourne Health Human Research Ethics Committee (HREC/43148/MH-2018). Ethics approval was subsequently obtained for each participating site according to local institutional requirements. In most jurisdictions, the study was conducted under waiver of consent. Patient consent was required in 15.6% of sites, including verbal consent in France and Queensland (Australia), and approved opt-out consent in the UK (Ethics reference 19/SW/0089). The study was

Table 1 Demographics of patients presenting with thunderclap headache vs general acute headache cohort

Variable	Category	Thunderclap headache n=644 n (%)	General acute headache n=4536 n (%)
Gender	Male	245 (38.1%)	1627 (35.9%)
	Female	399 (61.9%)	2908 (64.1%)
	Missing	*0 (0.0%)*	*1 (0.02%)*
Age (median, IQR)		44 (32–57)	41 (29–55)
Age distribution	18–40	275 (42.7%)	2265
	41–60	239 (37.1%)	1469
	61–75	90 (14.0%)	538
	>75	40 (6.2%)	264 (5.8%)
	Missing	*0 (0.0%)*	*0 (0.0%)*
Country	Australia	227 (35.3%)	1777, 39.2%
	New Zealand	98 (15.2%)	593 (13.1%)
	Singapore	36 (5.6%)	578 (12.7%)
	France	30 (4.7%)	115 (2.5%)
	UK	64 (10.0%)	276 (6.1%)
	Israel	4 (0.6%)	12 (0.3%)
	Belgium	14 (2.2%)	70 (1.5%)
	Turkey	155 (24.1%)	982 (21.6%)
	Romania	16 (2.5%)	69 (1.5%)
	Hong Kong	0 (0.0%)	64 (1.4%)
	Missing	*0 (0.0%)*	*0 (0.0%)*
Mode of arrival	Private Transport/ Self	440 (68.4%)	3636 (80.2%)
	Ambulance	181 (28.1%)	790 (17.4%)
	Other	23 (3.6%)	110 (2.4%)
	Missing	*0 (0.0%)*	*0 (0.0%)*
GCS score	15	499 (77.6%)	3921 (72.1%)
	8–14	24 (3.7%)	72 (1.6%)
	Less than 8	5 (0.8%)	5 (0.1%)
	Missing	*116 (18.0%)*	*537 (11.8%)*
Systolic BP	80<	0 (0.0%)	6 (0.1%)
	80–100	25 (3.9%)	185 (4.1%)
	181–200	30 (4.7%)	158 (3.5%)
	201–220	13 (2.0%)	54 (1.2%)
	>220	3 (0.5%)	21 (0.5%)
	Missing	*5 (0.8%)*	*60 (1.3%)*

BP, Blood pressure; GCS, Glasgow Coma Scale.

registered with the Australia and New Zealand Clinical Trials Register (trial number 376695).

Patient and public involvement

Patients or public representatives were not involved in the design of this study but did contribute to a previous research priority setting partnership exercise for UK Emergency Medicine, where this research question was identified as a priority.[15]

RESULTS

Primary outcome and demographics

The parent study enrolled 4536 patients from 67 health services in 10 countries. Of these, 14.2% (644/4536) were categorised as presenting with thunderclap headache. Median age was 44 years (IQR 32–57). The median proportional presentation within national cohorts was 18.2% (IQR 12.8%–23.2%), with only Hong Kong reporting no thunderclap headache presentations.

Table 2 Investigative strategy and results

Variable	Category	Total (n=644)
CT	Performed	404 (62.7%)
CT result	Normal	343 (85.1%)
	SAH	23 (5.7%)
	Other bleed	13 (3.2%)
	Neoplasm	4 (1.0%)
	Other	20 (5.0%)
LP	Performed	68 (10.6%)
LP result	Normal	51 (75.0%)
	Infection	7 (10.3%)
	SAH	1 1.5%
	Raised ICP	1 (1.5%)
	Inconclusive	8 (11.8%)
MRI	Performed	29 (4.5%)
MRI result	Normal	23 (79.3%)
	Bleed	0 (0.0%)
	Abscess	0 (0.0%)
	Neoplasm	1 (3%)
	Other	5 (17.2%)
CTA	Performed	86 (13.4%)
CTA result	Normal	59 (68.6%)
	Aneurysm with bleed	14 (16.3%)
	Aneurysm without bleed	3 (3.5%)
	No aneurysm	3 (3.5%)
	Other	7 (8.1%)
No neuroimaging or LP		225 (34.9%)

CTA, CT angiography; ICP, Intracranial Pressure; LP, lumbar puncture.

The demographics of the thunderclap cohort and their comparison to the overall cohort are outlined in table 1. A regional breakdown is provided in the online supplemental material. Patients from Australia (35.3%) and New Zealand (15.2%) made up 50.5% of the cohort.

Investigation strategies by modality

CT brain was the most common form of initial neuroimaging for patients with thunderclap headache, with 62.7% (404/644) of this group undergoing CT brain imaging in the ED (table 2). There was substantial international variation by country ranging from 78.4% in New Zealand vs 25.0% in Romania. The median overall investigation rate with CT brain was 71.4% (IQR 40.5%–74.5%). Breakdown by country and demographics of the 225 patients who did not undergo investigation are shown in the online supplemental material.

Initial CT brain imaging found serious acute pathology in 7.8% (49/644) of the thunderclap cohort. The most common aetiology was SAH (5.7%, 23/404), followed by 'other ICH' (3.2%, 13/404). All 23 patients with a final diagnosis of SAH and 13 patients with ICH were diagnosed on initial CT brain scans.

The combined investigation modalities used for the thunderclap cohort are described in the online supplemental material. CTA was performed during the initial work up in six of nine participating countries. Overall, 13.4% (86/644) of the thunderclap cohort received a CTA during the initial admission; 0.8% (5/644) underwent a CTA as their primary investigation and 17.3% (70/404) underwent a CTA after a CT brain scan. Aneurysmal bleeds were identified in 16.3% (14/86) of CTAs. There

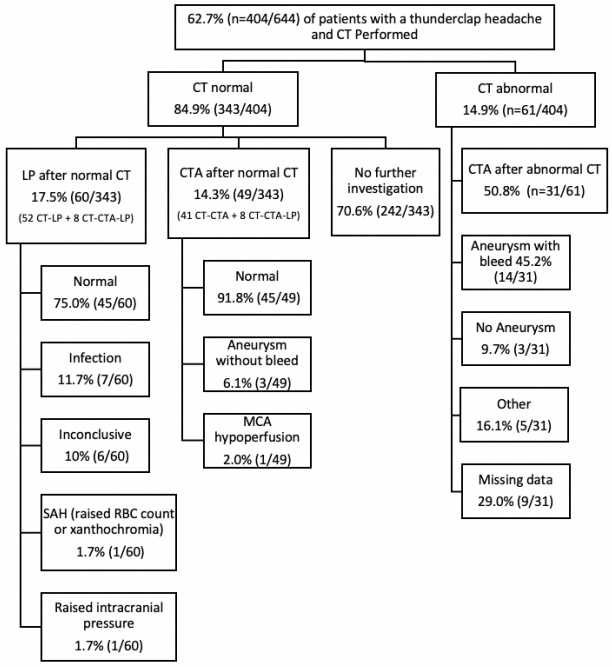

Figure 1 The diagnostic flow of patients presenting with thunderclap headache. CTA, CT angiography; LP, lumbar puncture; SAH, subarachnoid haemorrhage.

was a 3.5% (3/86) rate of incidental aneurysm without evidence of bleed.

Diagnostic LP was undertaken in 10.6% (68/644), with rates of LP varying from 14.3% to 17.5% in the five countries who reported LP results. LP was normal (75.0%, 51/68) or inconclusive (11.8%, 8/68) in 86.8% of tests undertaken.

Magnetic resonance (MR) neuroimaging was performed in 4.5% (29/644) of patients with thunderclap headache, of which a large proportion were reported as normal (79.3%, 23/29).

Diagnostic process

The diagnostic process for patients is detailed in figure 1. Of the 62.7% of patients (404/644) who had a CT brain, 84.9% (343/404) had a 'normal' report. In those with a 'normal' report, 15.2% (52/343) had an LP, 12.0% (41/343) had a CTA and 2.3% (8/343) had both an LP and CTA. None of these were diagnosed with SAH. Diagnostic strategy by country is shown in the online supplemental material.

Final diagnosis

Findings on final diagnosis are presented in table 3. The most common ED diagnosis was of primary headache syndrome (benign headache not otherwise specified 42.6% (n=274/644) and migraine 22.9% (n=147/644)). SAH was coded in the ED in 4.5% (n=29/644) of cases. Six of these patients had their ED diagnosis changed from SAH to another diagnosis in the final hospital diagnosis (four migraine, one primary headache, one other). The remaining 23 patients with SAH were admitted to their local hospital (n=15/23), transferred to tertiary hospitals (n=7/23) or directly to interventional radiology (n=1/23). In total, 3.6% (n=23/644) of patients had a final confirmed hospital discharge diagnosis of SAH.

Thirteen patients (2.0%, 13/644) were diagnosed with ICH (other than SAH), all of which were identified by CT brain. There were no reported acute diagnoses of vascular dissection or bacterial meningitis in the thunderclap cohort. When compared with the patients without thunderclap headache, the thunderclap headache group had a significantly higher rate of serious intracranial pathology (10.9% (95% CI 8.7% to 13.5%) vs 6.6% (95% CI 5.9% to 7.4%), p<0.001) and final diagnosis of SAH (3.6% (95% CI 2.4% to 5.3%) vs 0.3% (95% CI 0.2% to 0.5%), p<0.001).

DISCUSSION

In this study, thunderclap headache accounted for 14.2% of headaches attending ED. Serious intracranial pathology was identified in 10.9% of these cases, a significantly higher proportion than in patients without this clinical feature. The proportion of patients with confirmed SAH (3.6% (95% CI 2.4% to 5.3%)) was consistent with previous estimates.[11] These findings support the widely held perception that thunderclap headache is a high-risk feature. Notwithstanding, primary headache disorders were still the most common diagnosis made.

In this cohort, the diagnosis of SAH was entirely confirmed by neuroimaging. There was wide international variation in diagnostic workup strategies, including neuroimaging. This suggests potential for further standardisation of practice internationally.

The finding that about 30% of patients reporting thunderclap headache did not undergo neuroimaging is surprising. Our study was not designed to explore decision-making regarding neuroimaging but clearly identifies this as an area requiring further research. In particular, this is not consistent with the Ottawa SAH Clinical Decision Rule (CDR). This rule was derived to identify patients who could have SAH ruled out without neuroimaging.[16] The CDR defines thunderclap headache as a high-risk feature requiring neuroimaging.

The ideal diagnostic pathway for a patient presenting with thunderclap headache and ongoing clinical concern after a normal CT brain, remains unclear. Guidance from the American College of Physicians advocates the 'use of shared decision making to select the best diagnostic testing modality after weighing potential pros and cons of LP vs CTA'.[14] An Australasian guideline advocates LP after a normal CT brain.[13] This guideline however was written in 2012, so it may not include more recent research. Draft UK guidance released in March 2021, from NICE, advises that no further investigation be undertaken if CT brain imaging conducted within 6 hours of headache onset is normal. If the CT brain is conducted greater than 6 hours from onset, an LP performed at least 12 hours after onset is advised. No current role for emergency CTA during the initial investigation of thunderclap headache in ED is identified.[17]

This differing guidance highlights that the clinical value of LP in this context is a matter of ongoing debate. It appears to be being performed less frequently and so infrequently contributes to patient outcome.[18] This is likely due to the opportunity cost, complications, low diagnostic yield and high rates of inconclusive results.[11 18–20] Additionally, a number of patients may decline LP. The number-needed-to-LP to identify an additional SAH in those with negative CT brain has been reported to be as high as 250.[18]

The use of CTA raises specific challenges. Most prominent among these is the onward management of incidental asymptomatic cerebral aneurysms which are present in around 2% of the general population.[21] Future research should compare the test characteristics and risks of LP vs CTA in this cohort, and the post-test probability of SAH after a normal CT brain by interval presentation time (6–12 hours). This work would support future

Table 3 Final diagnosis in thunderclap cohort compared with general headache cohort

	Thunderclap (n=644)				Non-thunderclap (n=3892)			
	ED diagnosis		Final hospital diagnosis if admitted		ED Diagnosis		Final hospital diagnosis if admitted	
	n	%	n	%	n	%	n	%
Serious intracranial pathology Total	70	10.9	32	5.0	257	6.6	131	3.4
Confirmed SAH	23*	3.57	15	11.63	12	0.30	7	1.3
Confirmed other intracranial haemorrhage	13†	2.01	5	3.88	37	0.95	24	4.47
Stroke	11	1.71	4	3.1	39	1	20	3.72
Meningitis—viral	8	1.24	5	3.88	32	0.82	26	4.84
TIA	7	1.09	T/D	T/D	11	0.28	T/D	T/D
Neoplasm	2	0.31	2	1.55	41	1.05	26	4.84
Intracranial hypertension	2	0.31	1	0.78	25	0.64	11	2.05
Meningitis unknown	2	0.31	0	0	3	0.08	2	0.37
Hydrocephalus	1	0.16	T/D	T/D	3	0.08	T/D	T/D
Hypertension crisis/urgency	1	0.16	T/D	T/D	10	0.26	T/D	T/D
Other	0	0	0	0	44	1.1		
Non-serious intracranial pathology Total	565	87.7	97	15.1	3628	93.2	406	10.4
Benign headache (not otherwise specified)	274	42.55	22	17.05	1324	34.02	48	8.94
Migraine	147	22.83	26	20.16	954	24.51	96	17.88
Unclear	34	5.28	2	1.55	206	5.29	20	3.72
Tension headache	24	3.73	3	2.33	293	7.53	24	4.47
Cluster headache	14	2.17	0	0	57	1.46	5	0.93
Other	11	1.71	36	27.91	146	3.75	168	31.28
Sinusitis	10	1.55	3	2.33	131	3.37	9	1.68
Viral illness without meningitis	9	1.4	3	2.33	195	5.01	17	3.17
Post traumatic headache	9	1.4	0	0	67	1.72	4	0.74
Post coital headache	7	1.09	1	0.78	1	0.03	0	0
Vertigo/BPPV	6	0.93	T/D	T/D	17	0.44	T/D	T/D
Musculoskeletal	5	0.78	0	0	67	1.72	7	1.3
Non-cerebral infection (eg, pneumonia)	4	0.62	T/D	T/D	2	0.05	T/D	T/D
Trigeminal/cranial neuralgias	3	0.47	1	0.78	31	0.8	5	0.93
Alcohol-related hangover	2	0.31	0	0	6	0.15	0	0
Aneurysm/vascular malformation	2	0.31	T/D	T/D	6	0.15	T/D	T/D
Seizure	2	0.31	T/D	T/D	27	0.69	T/D	T/D
Hypertension other	1	0.16	T/D	T/D	47	1.21	T/D	T/D
Toxicity (eg, carbon monoxide)	1	0.16	0	0	5	0.13	0	0
Other	0	0	0	0	46	1.2	3	0.56

*29 patients had SAH coded in ED, only 23 of these ED SAH had confirmed SAH.
†16 patients had other ICH coded in ED, only 13 of these confirmed ICH.
BPPV, benign paroxysmal positional vertigo; ED, emergency department; ICH, intracranial haemorrhage; LP, lumbar puncture; SAH, subarachnoid haemorrhage; T/D, patient discharged or transferred from the ED; TIA, transient ischaemic attack; VP, ventriculoperitoneal.

guidance to facilitate shared decision making as advised by the American College of Physicians.[14]

The guidelines referred to above focus on the of exclusion of SAH. It is important to note the wide range of pathologies identified by neuroimaging and LP in our cohort. Our data identified more than 10 pathological causes for thunderclap headache. This is consistent with a previous systematic review that found over 100 causes.[22] This demonstrates that not all thunderclap headache is aneurysmal SAH. It also raises questions about the specificity of this presenting feature for key diagnoses and highlights the importance of considering a broad differential diagnosis.

Strengths and limitations

As a multisite, international study, our work provides a robust overview of current practice for patients presenting to ED with thunderclap headache. This project was a pragmatic, real world evaluation with central data control and analysis. This work also provides insight into the geographical variation in practice. Our study was entirely observational and data collection was performed independent of the acute care team. As such, the impact of Hawthorne effect should be negligible. Our results represent current practice, rather than expert management, protocolised care within a trial or biased assessment. As such, it forms a solid basis for improvement in practice.

Given the observational nature and lack of long-term follow-up, this study has several limitations. We did not have the resource to insist on mandatory reporting fields or source data verification for all patients; this may have resulted in incomplete or inaccurate data. There was variability of data collection across sites and no representation from North or South America. There

was over-representation of patients from Australasia (50.5%), which should be considered in any discussions on the generalisability of the findings. As some data were collected retrospectively, selection bias is a risk. There is also a risk of classification bias. It is possible that the treating doctor did not consider the headache onset to meet the definition of thunderclap but that the data collector interpreted the record differently. However, rates of thunderclap headache and SAH are consistent with the wider literature, suggesting that this risk is low. Finally, we relied on efficient data methods and coding process for hospital discharge diagnoses. While this process is universal, mandatory and well resourced, it can potentially be inaccurate with regard to complex diagnoses.

Implications

This study confirms that thunderclap headache is an important clinical feature due to the higher incidence of serious pathology overall and the higher incidence of SAH. However, despite a higher incidence of pathology, the vast majority of patients presenting with thunderclap had primary headache or migraine as their final diagnosis. The variation in investigation rates suggests poor guideline adherence, significant interobserver variation in the definition of thunderclap headache (also present in the academic literature), imprecise use of the term among clinicians or an awareness by clinicians that this feature alone may not be sufficient to direct imaging.[14] Our findings also confirm the need for holistic care of patients presenting with thunderclap headache. Ruleout pathways for a single pathological entity are likely to focus only on exclusion, rather than consideration of the wider differential diagnosis and appropriate management.

Finally, for patients with normal neuroimaging, we found no cases of SAH diagnosed by LP, a finding which supports current evidence questioning the incremental diagnostic benefit of LP to exclude SAH.[16] This information can further inform shared decision making with patients.

The direction of future research

Our results do not address the performance of recently proposed clinical decision rules for exclusion of SAH. They do not examine how patients should be managed after a negative CT brain in the context of thunderclap headache or the incidence and downstream healthcare burden of reversible cerebral vasoconstriction syndrome. Addressing these three questions will allow for the identification of those patients requiring minimal investigation, the most appropriate investigations for those with higher risk and a developed understanding of management options for thunderclap headache of uncertain cause.

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Contributors A-MK conceived the idea for the study. A-MK was responsible for the initial study design, which was refined with the help of the steering committee. KC provided the statistical plan. TR led the dissemination of the study in UK. KC provided the statistics. TR, DEH, A-MK and KC critically revised successive drafts of the manuscript and approved the final version. The study management group is responsible for the conduct of the study. TR is responsible for the content this manuscript.

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Online supplementary

Comparison between patients who had a non-contrast computed tomography (NCCT) brain scan versus patients without a NCCT.

Demographics and presentation

	All	No NCCT	NCCT	P‡
	n = 629†	n = 225	n = 404	
Age, median (IQR), yr	44 (32-57)	41 (29-52)	47 (33-59)	< 0.001
Female, n (%)	388 (62)	145 (64)	243 (60)	0.288
Pregnant/Female, n (%)	13 (3.4)	7/145 (4.8)	6/243 (2.5)	0.212
Triage category, n (%)				
Immediate	19 (3.0)	2 (0.9)	17 (4.2)	< 0.001
Urgent	400 (64)	115 (51)	285 (71)	
Non-urgent	210 (33)	108 (48)	102 (25)	
Referred by, n (%)				
Self	509 (81)	187 (83)	322 (80)	0.297
Doctor	120 (19)	38 (17)	82 (20)	
Mode of arrival, n (%)				
Private	433 (69)	174 (77)	259 (64)	< 0.001
Ambulance	173 (28)	35 (16)	138 (34)	
Others	23 (3.7)	16 (7.1)	7 (1.7)	

NCCT, non-contrast computed tomography; LP, lumbar puncture; MR, magnetic resonance

†Excluded patients who had CTA only (5), LP only (3), CTA + LP only (1), and MR only (6)
‡No imaging or LP vs CT

Clinical history

	All n = 629[†]	No NCCT n = 225	CT n = 404	P[‡]
Headache				
Duration of symptoms, n (%) hr				
< 24 hr	456 (73)	167 (74)	289 (72)	0.718
1-3 hr	93 (15)	32 (14)	61 (15)	
> 3 d	77 (12)	26 (12)	51 (13)	
unknown	3 (0.5)	0	3 (0.7)	
Worst ever, n (%)	199 (32)	20 (9.9)	179 (44)	< 0.001
Severity, n (%)				
Mild	99 (16)	61 (27)	38 (9.4)	< 0.001
Moderate	178 (28)	92 (41)	86 (21)	
Severe	307 (49)	54 (24)	253 (63)	
Unclear	45 (7.2)	18 (8.0)	27 (6.7)	
Location, n (%)				
Generalised	359 (57)	129 (57)	230 (57)	0.784
Unilateral	187 (30)	69 (31)	118 (29)	
Unclear	83 (13)	27 (12)	56 (14)	
Relationship with				
Exertion, n (%)	58 (9.2)	24 (11)	34 (8.4)	0.350
Sexual activity, n (%)	24 (3.8)	2 (0.9)	22 (5.5)	0.004
Associated symptoms				
Syncope, n (%)	37 (5.9)	7 (3.1)	30 (7.4)	0.027
Neck pain or stiffness, n (%)	100 (16)	23 (10)	77 (19)	0.004
Nausea or vomiting, n (%)	277 (44)	79 (35)	198 (49)	0.001
Subjective fever	31 (4.9)	10 (4.4)	21 (5.2)	0.676
Rash	6 (1.0)	2 (0.9)	4 (1.0)	0.900
Neurological symptoms				
Speech difficulty, n (%)	34 (5.4)	3 (1.3)	31 (7.7)	< 0.001
Limb weakness, n (%)	47 (7.5)	13 (5.8)	34 (8.4)	0.228
Limb paraesthesia, n (%)	43 (6.8)	11 (4.9)	32 (7.9)	0.149
Visual disturbance, n (%)	91 (14)	28 (12)	63 (16)	0.282
Photophobia, n (%)	145 (23)	39 (17)	106 (26)	0.013
Past history				
Benign headache	186 (30)	74 (33)	112 (28)	0.174
SAH, intracranial aneurysm without SAH, intracranial vascular abnormality	12 (1.9)	3 (1.3)	9 (2.2)	0.432
Serious intracranial injury	5 (0.8)	0	5 (1.2)	0.094
VP shunt	3 (0.5)	0	3 (0.7)	0.195
Any intracranial tumour	8 (1.3)	1 (0.4)	7 (1.7)	0.167
Non intracranial malignancy	9 (1.4)	1 (0.4)	8 (2.0)	0.120
Others				
Head trauma within last week, n (%)	13 (2.1)	4 (1.8)	9 (2.2)	0.704
Recent intravenous drug use	10 (1.6)	5 (2.2)	5 (1.2)	0.344

NCCT, non-contrast computed tomography; LP, lumbar puncture

†Excluded patients who had CTA only (5), LP only (3)), CTA + LP only (1), and MR only (6)
‡No imaging or LP vs CT

Online supplementary

Overall probability of CT and any imaging of the brain derived from a hierarchical binary logistic regression analysis of patients with thunderclap headaches

Outcome = CT/any imaging: yes/no
Null model i.e. intercept only
Random effects: hospital and country
n = 644

	Probability (95% CI)	Variance (95% CI)		Intraclass Correlation (95% CI)	
	Overall	Country	Hospital	Country	Hospital
CT (with/without another test)	0.635 (0.518-0.751)	0.500 (0.139 - 1.796)	0.133 (0.022-0.820)	0.128 (0.039-0.347)	0.161 (0.065-0.347)
Any imaging: CT (with/without another test) + MR only + CTA (+/- LP) only	0.657 (0.542-0.773)	0.522 (0.151-1.802)	0.154 (0.027-0.870)	0.132 (0.042-0.347)	0.170 (0.072-0.354)

CT, computed tomography; CTA, computed tomography; MR, magnetic resonance; LP, lumbar puncture

The overall average CT rate is 63.5%. The overall any imaging rate is 65.7% There is greater variation between countries (higher variance) than between hospitals. There is greater correlation within hospitals (higher intraclass correlation) than with countries.

Online Supplement. Demographics of patients presenting with thunderclap headache by country

Variable	Category	Country									
		Australia	New Zealand	Singapore	France	United Kingdom	Israel	Belgium	Turkey	Romania	**Total**
Gender	Male	77	38	21	6	29	0	5	62	7	**245**
	Female	150	60	15	24	35	4	9	93	9	**399**
Age	18-25	34	12	6	9	8	0	2	21	1	**93**
	26-30	18	9	4	3	7	1	2	9	1	**54**
	31-35	19	7	4	4	7	1	2	14	4	**62**
	36-40	17	10	3	4	4	1	4	23	0	**66**
	41-45	18	8	2	3	6	0	1	24	3	**65**
	46-50	20	8	4	1	7	1	0	17	1	**59**
	51-55	18	9	4	3	7	0	0	20	2	**63**
	56-60	27	8	1	2	3	0	3	7	1	**52**
	61-65	16	10	3	0	4	0	0	6	1	**40**
	66-70	6	3	2	1	1	0	0	5	1	**19**
	71-75	12	4	2	0	7	0	0	5	1	**31**
	>75	22	10	1	0	3	0	0	4	0	**40**
Mode of Arrival	Private Transport/Self	133	53	33	18	41	4	13	134	11	**440**
	Ambulance	91	44	3	10	23	0	1	4	5	**181**
	Other	3	1	0	2	0	0	0	17	0	**23**
GCS	15	203	82	25	29	53	4	14	73	16	**499**
	8-14	12	6	0	1	3	0	0	2	0	**24**
	less than 8	1	3	1	0	0	0	0	0	0	**5**
Systolic BP	80-100	10	1	0	2	5	0	0	8	0	**26**
	101-120	45	16	8	6	11	3	4	35	3	**131**
	121-140	69	28	11	12	16	0	6	105	8	**255**
	141-160	64	28	6	6	19	1	3	4	4	**135**
	161-180	22	7	8	1	5	0	1	1	1	**47**
	181-200	9	12	1	1	6	0	0	1	0	**30**
	201-220	4	4	2	0	2	0	0	1	0	**13**
	>220	0	2	0	1	0	0	0	0	0	**3**

Online Supplement - Investigative strategies in patients who were further tested following a normal CT Brain

	Australia	New Zealand	Singapore	France	United Kingdom	Israel	Belgium	Turkey	Romania	Total
	n=61	n=21	n=0	n=3	n=11	n=0	n=2	n=10	n=0	n=108
CT-LP, n (%)	24 (39)	14 (67)	-	3 (100)	9 (82)	-	2 (100)	0	-	52 (48)
CT-CTA, n (%)	26 (43)	5 (24)	-	0	1 (9.0)	-	0	9 (90)	-	41 (38)
CT-CTA-LP, n (%)	6 (9.8)	1 (4.8)	-	0	1 (9.0)	-	0	0	-	8 (7.4)
CT-MRI, n (%)	5 (8.2)	1 (4.8)	-	0	0	-	0	1 (10)	-	7 (6.5)

CT – Computerised Tomography, LP – Lumbar Puncture, MRI – Magnetic Resonance Imaging, CTA - Computerised Tomography Angiography

Investigative strategy and results by country

Variable	Category	Country									
	Total	**Australia (n=227)**	**New Zealand (n=98)**	**Singapore (n=36)**	**France (n=30)**	**United Kingdom (n=64)**	**Israel (n=4)**	**Belgium (n=14)**	**Turkey (n=155)**	**Romania (n=16)**	**Total (n=644)**
CT	Yes (% of total)	168 (74.0%)	77 (78.6%)	27 (75.0%)	21 (70.0%)	47 (73.4%)	2 (50.0%)	10 (71.4%)	48 (31.0%)	4 (25.0%)	**404 (62.7%)**
CT result	Normal	146 (86.9%)	60 (77.9%)	24 (88.9%)	16 (76.2%)	40 (85.1%)	2 (100%)	9 (90.0%)	43 (89.6%)	3 (75.0%)	**343 (85.1%)**
	SAH	10 (6.0%)	5 (6.5%)	1 (3.7%)	0	5 (10.6%)	0	0	1 (2.1%)	0	**23 (5.7%)**
	Other bleed	3 (1.8%)	6 (7.8%)	0	2 (9.5%)	0	0	0	2 (4.2%)	0 (	**13 (3.2%)**
	Neoplasm	1 (0.6%)	1 (1.3%)	0	0	0	0	0	2 (4.2%)	0	**4 (1.0%)**
	Other	8 (4.8%)	5 (6.5%)	2 (7.4%)	3 (14.3%)	2 (4.3%)	0	1 (10.0%)	0	1 (25.0%)	**20 (5.0%)**
LP	Yes (% of total)	33 (14.5%)	17 (17.4%)	0	5 (16.7%)	11 (17.2%)	0	2 (14.3%)	0	0	**68 (10.6%)**
LP result	Normal	18 (54.6%)	16 (94.1%)	N/A	5 (100%)	11 100.0%	N/A	1 (50.0%)	N/A	N/A	**51 (75.0%)**
	Infection	7 (21.2%)	0	N/A	0	0	N/A	0	N/A	N/A	**7 (10.3%)**
	SAH	1 (3.0%)	0	N/A	0	0	N/A	0	N/A	N/A	**1 1.5%**
	Raised ICP	1 (3.0%)	0	N/A	0	0	N/A	0	N/A	N/A	**1 (1.5%)**
	Inconclusive	6 (18.2%)	1 (5.9%)	N/A	0	0	N/A	1 (50.0%)	N/A	N/A	**8 (11.8%)**
MRI	Yes (% of total)	21 (9.3%)	2 (2.0%)	1 (2.8%)	2 (6.7%)	1 (1.6%)	0	0	2 (1.3%)	0	**29 (4.5%)**
MRI result	Normal	18 (85.7%)	2 (100%)	1 (100%)	1 (50.0%)	0	N/A	N/A	1 (50.0%)	N/A	**23 (79.3%)**
	Bleed	0	0	0	0	0	N/A	N/A	0	N/A	**0 (0.0%)**
	Abscess	0	0	0	0	0	N/A	N/A	0	N/A	**0 (0.0%)**
	Neoplasm	0	0	0	0	0	N/A	N/A	1 50%	N/A	**1 3%**
	Other	3 (14.3%)	0	0	1 (50%)	1 (100%)	N/A	N/A	0	N/A	**5 17.2%**
CTA	Yes (% of total)	50 (22.0%)	19 (19.4%)	0	1 (3.3%)	6 (9.4%)	0	0	9 (5.8%)	1 (6.3%)	**86 (13.4%)**
CTA result	Normal	36 (72.0%)	10 (52.6%)	N/A	0	3 (50.0%)	N/A	N/A	9	1 (100%)	**59 (68.6%)**
	Aneurysm with bleed	8 (16.0%)	3 (15.8%)	N/A	1 (100%)	2 (33.3%)	N/A	N/A	0	0	**14 (16.3%)**
	Aneurysm without bleed	3 (6.0%)	0	N/A	0	0	N/A	N/A	0	0	**3 (3.5%)**
	No aneurysm	0	3 (15.8%)	N/A	0	0	N/A	N/A	0	0	**3 (3.5%)**
	Other	3 (6.0%)	3 (15.8%)	N/A	0	1 (16.7%)	N/A	N/A	0	0 (0.0%)	**7 (8.1%)**

CT – Computerised Tomography, LP – Lumbar Puncture, MRI – Magnetic Resonance Imaging, CTA - Computerised Tomography Angiography

Online Supplement - Investigation modality for thunderclap headache		
Investigation(s)	n = 644	%
CT with/without another test (see subset below)	404	62.7
No neuroimaging or LP	225	34.9
MRI only	6	0.93
CTA only	5	0.78
LP only	3	0.47
CTA & LP only*	1	0.16
Subset of patients who received CT brain	n = 404	%
CT only	261	64.6
CT-CTA	70	17.3
CT-LP*	54	13.4
CT-CTA-LP*	10	2.4
CT-MR	9	2.23

*The order of investigations is not known.

CT – Computed Tomography, LP – Lumbar Puncture, MRI – Magnetic Resonance Imaging, CTA - Compute Tomography Angiography

Online Supplement – Study Questions		
Item	**Definition**	**Comment**
Age	Numerical Unknown =9999	
Gender	Male =1 Female =2 Unknown =3	
Known current pregnancy	No=1 Yes=2 Not applicable =3	
Ethnicity (NZ only; required under NZ national ethics approval guidelines)	NZ European =1 Australian =2 European NFD =3 Maori =4 Samoan =5 Tongan =6 Cook Island Maori =7 Pacific Islander NFD =8 African =9 American =10 Asian NFD =11 Chinese =12 Dutch =13 Fijian =14 Fijian Indian =15 Indian =16 Iranian = 17 Latin American =18 Malay =19 Middle Eastern =20 Niuean =21 Southeast Asian =22 Tokeluan =23 Other =24 Unknown=25	
Referred by	Self =1 GP/ other doctor =2	
Arrival by	Private transport/ self = 1 Ambulance-=2 Other=3	
Triage category	1= immediate 2= urgent (2 and 3 on a five point scale) 3 = non-urgent (4 and 5 on a 5 point scale)	
Past medical history		
History of recurrent headache (migraine excluded)	No=1 Yes=2	If not documented, assumed to be No
Previous migraine diagnosis	No=1 Yes=2	If not documented, assumed to be No
Previous cluster headache diagnosis	No=1 Yes=2	If not documented, assume to be No

Previous tension headache diagnosis	No=1 Yes=2	If not documented, assume to be No
Previous stroke/ TIA	No=1 Yes=2	If not documented, assumed to be No
Serious intracranial injury – extradural, subdural, traumatic subarachnoid, cerebral contusion requiring hospital admission/ neurosurgery	No=1 Yes=2	If not documented, assumed to be No
Presence of a ventriculo-peritoneal shunt	No=1 Yes=2	If not documented, assumed to be No
Intracranial neoplasm - primary	No=1 Yes=2	If not documented, assumed to be No
Intracranial neoplasm - secondary	No=1 Yes=2	If not documented, assumed to be No
Non-cerebral malignancy without known intracranial secondary neoplasm	No=1 Yes=2	If not documented, assumed to be No
Subarachnoid haemorrhage	No=1 Yes=2	If not documented, assumed to be No
Intracranial aneurysm without SAH	No=1 Yes=2	If not documented, assumed to be No
Intracranial hypertension	No=1 Yes=2	If not documented, assumed to be No
Regular medications		
Triptan	No=1 Yes=2	If not documented, assumed to be No
Beta-blockers – propranolol, metoprolol, atenolol, bisoprolol, timolol, etc	No=1 Yes=2	If not documented, assumed to be No
Pizotifen (Sandomigran)	No=1 Yes=2	If not documented, assumed to be No
Topiramate (Topamax)	No=1 Yes=2	If not documented, assumed to be No
Tricyclic antidepressants – amitriptyline, nortriptyline, etc	No=1 Yes=2	If not documented, assumed to be No
Sodium valproate	No=1 Yes=2	If not documented, assumed to be No
Candesartan	No=1 Yes=2	If not documented, assumed to be No
Verapamil	No=1 Yes=2	If not documented, assumed to be No
Botulinum toxin	No=1 Yes=2	If not documented, assumed to be No
Anticoagulants – Novel Oral Anticoagulants (NOAC), warfarin, Vit K antagonist	No=1 Yes=2	If not documented, assumed to be No
Long term codeine preparations	No =1 Yes=2	If not documented, assume to be No
Other opioids	No=1 Yes=2	If not documented, assumed to be No

Mode of arrival		
Mode of arrival	Self =1 Ambulance =2 Unknown =3	
Clinical history		
Duration	>24 hours =1 1-3 days =2 >3 days =3	
Onset	Gradual =1 Sudden/ thunderclap =2 (peaking instantly or almost) Peak within 1 hour but not instant =3 Unknown =4	
Location	General =1 Unilateral =2 Unclear =3	
Severity	Mild (pain score up to 3/10) =1 Moderate (pain score 4-7/10) =2 Severe (pain score 8 or more/10) =3 Unclear =4	
Worst headache ever?	No =1 Yes =2	If not documented, assumed to be No
Relationship to exertion	No =1 Yes=2	If not documented, assumed to be No
Relationship to exertion/ sexual activity	No =1 Yes=2	If not documented, assumed to be No
Reported neck pain or stiffness	No =1 Yes=2	If not documented, assumed to be No
Nausea or vomiting	No =1 Yes=2	If not documented, assumed to be No
Photophobia	No =1 Yes=2	If not documented, assumed to be No
Syncope/ loss of consciousness	No =1 Yes=2	If not documented, assumed to be No
New limb weakness – transient or current	No =1 Yes=2	If not documented, assumed to be No
New limb paraesthesia – transient or current	No =1 Yes=2	If not documented, assumed to be No
New speech difficulty – including slurred speech, inability to speak, etc.	No =1 Yes=2	If not documented, assumed to be No
New reported visual disturbance – transient or ongoing	No =1 Yes=2	If not documented, assumed to be No
Subjective fever or rigors	No =1 Yes=2	If not documented, assumed to be No
Rash	No =1 Yes=2	If not documented, assumed to be No
Intravenous drug use	No =1	If not documented, assumed

	Yes=2	to be No
Pre-ED medications for this episode (if known – patient)		
Paracetamol	No =1 Yes=2	If not documented, assumed to be No
Aspirin	No =1 Yes=2	If not documented, assumed to be No
NSAID, excluding aspirin	No =1 Yes=2	If not documented, assumed to be No
Codeine containing preparation	No =1 Yes=2	If not documented, assumed to be No
Triptan	No =1 Yes=2	If not documented, assumed to be No
Oxycodone (e.g. endone, oxycontin, oxynorm, targin)	No =1 Yes=2	If not documented, assumed to be No
Tramadol	No =1 Yes=2	If not documented, assumed to be No
Other opiate	No =1 Yes=2	If not documented, assumed to be No
Antiemetic – metoclopramide, prochlorperazine. ondanstron	No =1 Yes=2	If not documented, assumed to be No
Other	Specify	
No medications taken	No =1 Yes =2	If no medications documented assume to be Yes
AMBULANCE PATIENTS ONLY Pre-ED medications for this episode (if known – ambulance)		
Paracetamol	No =1 Yes=2	If not documented, assumed to be No
Aspirin	No =1 Yes=2	If not documented, assumed to be No
NSAID, excluding aspirin	No =1 Yes=2	If not documented, assumed to be No
Codeine containing preparation	No =1 Yes=2	If not documented, assumed to be No
Triptan	No =1 Yes=2	If not documented, assumed to be No
Oxycodone (e.g. endone, oxycontin, oxynorm, targin)	No =1 Yes=2	If not documented, assumed to be No
Tramadol	No =1 Yes=2	If not documented, assumed to be No
Fentanyl	No =1 Yes=2	If not documented, assumed to be No
Other opiate	No =1 Yes=2	If not documented, assumed to be No
Antiemetic – metoclopramide, prochlorperazine. ondanstron	No =1 Yes=2	If not documented, assumed to be No
Methoxyflurane	No =1	If not documented, assumed

	Yes=2	to be No
Other	Specify	
No medications taken	No =1 Yes =2	If no medications documented assume to be Yes
Clinical exam		
Pulse rate	Numerical Unknown =9999	
Systolic BP	Numerical Unknown =9999	
Temperature (Celsius)	Numerical Unknown =9999	
GCS (overall)	Numerical Unknown = 9999	
GCS -eye	Numerical	
GCS-verbal	Numerical	
GCS- motor	Numerical	
Rash	No =1 Yes=2	If not documented, assumed to be No
Confusion	No =1 Yes=2	If not documented, assumed to be No
Meningism	No =1 Yes=2	If not documented, assumed to be No
Limited neck flexion	No =1 Yes=2	If not documented, assumed to be No
New focal neurological signs	No =1 Yes=2	If not documented, assumed to be No
New vision defect	No =1 Yes=2	If not documented, assumed to be No
Ophthalmoscopy findings	Not done =1 Normal = 2 Papilloedema = 3 Other =4 (specify)	If not documented, assume not done
Blood tests		
White cell count	Numerical	Leave blank if not done
C reactive protein	Numerical	Leave blank if not done
Other tests		
Lumbar puncture	Normal =1 Indicative of infection on microscopy=2 Indicative of SAH (Red cell count or xanthochromia)=3 Indicative of raised intracranial pressure =4 Inconclusive =5	Leave blank if not done
Imaging		
CT scan	Normal =1 Abnormal =2	Leave blank if not done
CT abnormality	SAH =1 Other bleed =2 Abscess =3 Neoplasm =4 Other = 5 (free text describe)	Leave blank if not done

MRI	Normal =1 Abnormal =2	Leave blank if not done
MRI abnormality	Bleed =1 Abscess =2 Neoplasm =3 Other = 4 (free text describe)	Leave blank if not done
CT angiography	Normal =1 Abnormal =2	Leave blank if not done
CT angiography abnormality	Aneurysm with bleed =1 Aneurysm without bleed =2 No aneurysm =3 Other = 4 (free text describe)	Leave blank if not done
Other imaging	Specify, with result	Leave blank if not done
Final ED diagnosis		
ED diagnosis	Primary headache (benign headache not otherwise specified) =1 Migraine = 2 Cluster headache =3 Musculoskeletal =4 Tension headache =5 Subarachnoid haemorrhage =6 Other intracranial haemorrhage = 7 Post coital headache =8 Neoplasm = 9 Viral illness without meningitis = 10 Sinusitis =11 Meningitis (viral) =12 Meningitis (bacterial) =13 Meningitis (Fungal) =14 Encephalitis =15 Stroke =16 Post-traumatic headache =17 Cerebral abscess =18 Toxicity e.g. CO =19 (specify) Trigeminal neuralgia/ cranial neuralgias =20 Glaucoma =21 Alcohol-related hangover =22 Analgesia overuse =23 Temporal arteritis = 24 Intracranial hypertension =25 Vascular dissection =26 Shingles of head/ neck =27 Other (specify) =28 Unclear =29	
Treatment in ED (Primary)		
Paracetamol	1=No	If not documented, assume

	2=Oral 3=Parenteral	No
Aspirin	1=No 2=Yes	
Codeine containing compounds	1=No 2=Yes	
NSAID (other than aspirin)	1=No 2=Oral 3=Parenteral	
Triptan	1=No 2=Yes	
Oxycodone	1=No 2=Yes	
Pethidine/ meperidine	1=No 2=Yes	
Other opioid	1=No 2=oral 3=parenteral	
Chlorpromazine infusion	1=No 2=Yes	
Metoclopramide	1=No 2=Yes	
Prochlorperazine	1=No 2=Oral 3=Parenteral	
Ondansetron	1=No 2=Oral 3=Parenteral	
Droperidol/ haloperidol	1=No 2=Yes	
Ergot alkaloids	1=No 2=Yes	
Antibiotic/ antiviral agent	1=No 2=Yes	
Acupuncture	1=No 2=Yes	
Corticosteroid	1=No 2=Yes	
Oxygen	1=No 2=Yes	
Intravenous fluids (not part of drug infusion)	1=No 2=Yes	
Other	1= No 2= Yes (specify)	
Treatment in ED (secondary) – more than 30 mins after primary treatment		
Paracetamol	1=No 2=Oral 3=Parenteral	If not documented, assume No
Aspirin	1=No 2=Yes	
Codeine containing	1=No	

compounds	2=Yes	
NSAID (other than aspirin)	1=No 2=Oral 3=Parenteral	
Triptan	1=No 2=Yes	
Oxycodone	1=No 2=Yes	
Other opioid	1=No 2=oral 3=parenteral	
Chlorpromazine infusion	1=No 2=Yes	
Metoclopramide	1=No 2=Yes	
Prochlorperazine	1=No 2=Oral 3=Parenteral	
Ondansetron	1=No 2=Oral 3=Parenteral	
Droperidol/ haloperidol	1=No 2=Yes	
Ergot alkaloids	1=No 2=Yes	
Antibiotic/ antiviral agent	1=No 2=Yes	
Acupuncture	1=No 2=Yes	
Corticosteroid	1=No 2=Yes	
Oxygen	1=No 2=Yes	
Intravenous fluids (not part of drug infusion)	1=No 2=Yes	
Other	1= No 2= Yes (specify)	
Interventions		
Intubation and mechanical ventilation	1=No 2=Yes	
Intracranial surgery	1=No 2=within 24 hours 3= within 1 week	
Endovascular intervention	1=No 2=within 24 hours 3= within 1 week	
Other surgery/ major intervention during hospital stay	specify	
Disposition	1= Home from ED 2 = Home from ED observation unit 3= Admit ward 4= Admit critical care	

	5= Transfer 6= Unknown 7= died in ED	
For patients discharged from ED or ED observation unit ONLY		
Paracetamol	1=No 2=Yes	If not documented, assume No
Aspirin	1=No 2=Yes	
Codeine containing compounds	1=No 2=Yes	
NSAID (other than aspirin)	1=No 2=Yes	
Triptan	1=No 2=Yes	
Oxycodone	1=No 2=Yes	
Tramadol	1=No 2=Yes	
Other opioid	1=No 2=Yes	
Metoclopramide	1=No 2=Yes	
Prochlorperazine	1=No 2=Yes	
Ondansetron	1=No 2=Yes	
Ergot alkaloids	1=No 2=Yes	
Antibiotic/ antiviral agent	1=No 2=Yes	
Corticosteroid	1=No 2=Yes	
Other	1= No 2= Yes (specify)	
Post discharge – patients discharged from ED only		
Representation within 72 hours	1=No 2=Yes	
If represented, ED diagnosis at re-attendance	(Text)	If did not represent, leave blank
If re-presented, was patient admitted/ transferred for admission	1=No 2=Yes	If did not represent, leave blank
For admitted patients ONLY		
Final hospital diagnosis	Primary headache (benign headache) =1 Migraine = 2 Cluster headache =3 Musculoskeletal =4 Tension headache =5 Subarachnoid haemorrhage	

	=6 Other intracranial haemorrhage = 7 Post coital headache =8 Neoplasm = 9 Viral illness without meningitis = 10 Sinusitis =11 Meningitis (viral) =12 Meningitis (bacterial) =13 Meningitis (Fungal) =14 Encephalitis =15 Stroke =16 Post-traumatic headache =17 Cerebral abscess =18 Toxicity e.g. CO =19 (specify) Trigeminal neuralgia/ cranial neuralgias =20 Glaucoma =21 Alcohol-related hangover =22 Analgesia overuse =23 Temporal arteritis = 24 Intracranial hypertension =25 Vascular dissection =26 Shingles of head/ neck =27 Other (specify) =28 Unclear =29	
In-patient outcome	1= discharged alive 2= died 3=unknown	
Length of stay (include day of admission and day of discharge)	(Number)	