

Factors influencing variation in investigations after a negative CT brain scan in suspected subarachnoid haemorrhage: A qualitative study

Chu, Kevin; Windsor, Carol; Fox, Jennifer; Howell, Tegwen; Keijzers, Gerben; Eley, Robert; Kinnear, Frances; Furyk, Jeremy; Thom, Ogilvie; Brown, Nathan J.; Brown, Anthony F.T.

Published in:
Emergency Medicine Journal

DOI:
[10.1136/emered-2018-207876](https://doi.org/10.1136/emered-2018-207876)

Published: 01/02/2019

Document Version:
Peer reviewed version

Licence:
CC BY-NC

[Link to publication in Bond University research repository.](#)

Recommended citation(APA):

Chu, K., Windsor, C., Fox, J., Howell, T., Keijzers, G., Eley, R., Kinnear, F., Furyk, J., Thom, O., Brown, N. J., & Brown, A. F. T. (2019). Factors influencing variation in investigations after a negative CT brain scan in suspected subarachnoid haemorrhage: A qualitative study. *Emergency Medicine Journal*, 36(2), 72-77. <https://doi.org/10.1136/emered-2018-207876>

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

For more information, or if you believe that this document breaches copyright, please contact the Bond University research repository coordinator.

**FACTORS INFLUENCING VARIATION IN INVESTIGATIONS AFTER A
NEGATIVE CT BRAIN SCAN IN SUSPECTED SUBARACHNOID
HAEMORRHAGE: A QUALITATIVE STUDY**

Kevin Chu^{1,2}, Carol Windsor³, Jennifer Fox³, Tegwen Howell¹, Gerben Keijzers⁴⁻⁶,
Robert Eley^{2,7}, Fran Kinnear^{2,8}, Jeremy Furyk⁹, Ogilvie Thom^{2,10}, Nathan J Brown^{1,2},
Anthony FT Brown^{1,2}

¹ Emergency and Trauma Centre, Royal Brisbane and Women's Hospital

² Faculty of Medicine, The University of Queensland

³ Faculty of Health, Queensland University of Technology

⁴ Department of Emergency Medicine, Gold Coast University Hospital

⁵ School of Medicine, Bond University

⁶ School of Medicine, Griffith University

⁷ Department of Emergency Medicine, The Princess Alexandra Hospital

⁸ Department of Emergency Medicine, The Prince Charles Hospital

⁹ Department of Emergency Medicine, University Hospital Geelong

¹⁰ Department of Emergency Medicine, Sunshine Coast University Hospital

Corresponding Author's Email: k.chu@uq.edu.au

Word count: 3,233

ABSTRACT

Introduction Variation in the approach to the patient with a possible subarachnoid haemorrhage (SAH) has been previously documented. The purpose of this study was to identify factors that influence emergency physicians' decisions about diagnostic testing after a normal computed tomography (CT) brain scan for emergency department (ED) patients with a headache suspicious of a SAH.

Methods We conducted an interview-based qualitative study informed by social constructionist theory. Fifteen emergency physicians from six EDs across Queensland, Australia, underwent individual face-to-face or telephone interviews. Content analysis was performed whereby transcripts were examined and coded independently by two co-investigators, who then jointly agreed upon the influencing factors.

Results Six categories of influencing factors were identified. Patient interaction was at the forefront of the identified factors. This shared decision-making process incorporated "what the patient wants" but may be biased by how the clinician communicates the benefits and harms of the diagnostic options to the patient. Patient risk profile, practice evidence and guidelines were also important. Other influencing factors included experiential factors of the clinician, consultation with colleagues, and external influences where practice location and work processes impose constraints on test ordering external to the preferences of the clinician or patient. The six categories were organised within a conceptual framework comprising four components: the context, the evidence, the experience, and the decision.

Conclusions When clinicians are faced with a diagnostic challenge, such as the workup of a patient with suspected SAH, there are a number of influencing factors

that can result in a variation in approach. These need to be considered in approaches to improve the appropriateness and consistency of medical care.

What is already known on this subject

- There is variation in investigations after a normal CT brain scan for the ED patient with a suspected subarachnoid haemorrhage.
- The factors that contribute to this variation in practice are not well understood.

What this study adds

- In this qualitative study among emergency physicians, decisions about investigations for patients with possible SAH are influenced by a number of factors, including patient interaction, patient risk profile, practice evidence, experiential factors, consultation, and external influences.
- These findings may help to explain variations in care for patients with suspected SAH and potentially for other diagnostic challenges.

INTRODUCTION

Variation in medical practice is a global healthcare issue.^{1,2} Certain variation is expected given differences in the populations served. Nonetheless, some variation is unwarranted and reflects a “knowing-doing” gap, which needs addressing.³

Understanding variation in practice is an important step in improving patient outcomes through appropriate care.⁴

There is variation in the diagnostic approach to the emergency department (ED) patient presenting with a sudden, severe headache where subarachnoid haemorrhage (SAH) needs to be considered.^{5,6} The infrequent but catastrophic nature of SAH creates a diagnostic challenge.^{7,8} The diagnosis is missed in about 5% of cases.⁹ Identifying factors that influence variation in the diagnostic approach to SAH may help us understand variation in test ordering, particularly where there are diagnostic challenges.

The usual approach to SAH is a non-contrast computed tomography (CT) brain scan followed by a lumbar puncture (LP) if normal. A LP may not be necessary if the CT is normal within six hours of headache onset.¹⁰ A primary CT angiogram (CTA) has also been advocated as an alternative diagnostic option.¹¹ The optimal approach to SAH is debatable.

There is controversy over the timing of the LP and method of cerebrospinal fluid (CSF) examination.¹² National guidelines in the United Kingdom advocate delaying LP for 12 hours after headache onset and examining the CSF with spectrophotometry.¹³ There are no equivalent guidelines in Australia or the United

States. Physicians in North America typically do not delay LP and rely on a visual inspection of the CSF. Physicians in Australia show variation in practice such as using spectrophotometry of CSF, reflecting differences in practice on either side of the Atlantic.^{5,12}

Most emergency physicians will agree that a non-contrast CT brain scan is a reasonable first-line investigation. The optimal diagnostic approach after a negative CT scan is, however, uncertain and likely to follow local expert opinion.¹⁴ The objective of this interview-based qualitative study was to identify factors that influence emergency physicians' decisions about diagnostic testing for ED patients with a headache suspicious of a SAH.

METHODS

A qualitative approach to research generally involves interpretive practices that make visible what cannot be immediately grasped. Constructionism, which informed this research, is concerned with how human interaction contributes to the creation of a social reality.¹⁵ The assumption is that human practices are always contextual. Thus, in the clinical setting the ultimate objective of such research is to identify, interpret and explain clinical problems that are situationally variable. The problem investigated here was the variation in the diagnostic approach to SAH. Specifically, this study examined physician decision-making after a negative CT brain scan. The purpose was to explore the phenomenon rather than to seek associations between variables. Hence, a qualitative research design was an appropriate and innovative approach in addressing the purpose of this study. The study was approved by the local Human Research Ethics Committee.

Study data were generated through individual semi-structured interviews undertaken by the first author (KC), an experienced emergency physician and researcher in quantitative methods with an interest in headaches. Study participants were purposefully recruited as fellows of the Australasian College for Emergency Medicine. Recruitment was organised through the Queensland Emergency Research Collaborative, which is a state-wide network of emergency care researchers. Fifteen fellows ranging from a new fellow to a department director across six EDs in the state of Queensland, were invited to participate in the research. No one declined the invitation and formal agreement to participation was through an oral consent process at the commencement of the interview where participants were informed about its purpose and conduct. Ten of the fellows worked in referral hospitals with a neurosurgical unit onsite and five were from peripheral hospitals. The sample size was determined a priori with the view that it would adequately generate a conceptual depth of data for qualitative analysis.

The interviews were conducted via telephone in 11 cases and face-to-face in four. The face-to-face interviews took place in the ED. Each interview took approximately 20 to 30 minutes, was audio-recorded and subsequently transcribed. The interviews were organised around several key questions (Box 1).

Box 1. Semi-structured interview questions.

- Tell me about a time when you ordered (did not order) a lumbar puncture in a patient suspected of a subarachnoid haemorrhage?
- Tell me about a time when you ordered (did not order) a cerebral

angiogram in a patient suspected of a subarachnoid haemorrhage?

- How do you resolve the various approaches in the investigations of a patient suspected of a subarachnoid haemorrhage?

The key questions were open-ended and intended to create room for exploring new and unexpected phenomena.¹⁶ Each interview was focused and intentional but allowed for flexibility in conversation. Study participants were encouraged to provide narratives that reflected their experiences. They were informed about the study objective and were explicitly informed that there were no right or wrong answers. Follow up questions allowed the interviewer to prompt, probe and delve deeper into what the participant was saying. During the interview, one of the authors (TH), took notes which were used at the end of a session to seek, if needed, further clarification from a participant. No other person was present in the interview. The 15 interviews generated a conceptual depth of data that allowed for an exploration of the concept of variation in the diagnosis of SAH in the ED. There were no follow-up or repeat interviews. Transcripts were not provided to the participant nor were feedback requested on the findings. Interview data were subjected to content analysis where the interview question was the unit of analysis. The analysis was performed by two authors (CW, JF) with extensive expertise in qualitative research. In the initial analysis codes were generated. Codes are labels that are applied to data. Each code corresponded to an idea or concept that was judged to be analytically significant. From the codes, data were reduced to 16 influencing factors. The two raters independently developed initial codes and jointly agreed upon the influencing factors which were prioritised to reflect their frequency of mention. The next step involved abstraction where factors were grouped into six broader categories each of

which consisted of sub-categories. Importantly and methodologically, it was assumed that both the participants and researchers engaged in filtered interpretations of social reality.¹⁷ Thus, at this stage, a dialogue was conducted between relevant literature and conceptual outcomes to strengthen the analytical process. The final level of abstraction devised a general description of the diagnostic process around SAH with the formulation of a conceptual framework.

RESULTS

We identified 16 factors that influenced the ordering of diagnostic tests for suspected SAH following a negative CT brain scan. These factors and their frequency of mentions are summarised in Figure 1. The factors were grouped into six categories: patient interaction, practice evidence, patient profile, consulting, external influences, and experiential factors. The categories were then organised within a conceptual framework generated from the study findings. The framework consisted of four components: the context, the evidence, the experience and the decision. The six categories of influencing factors and the four components of the conceptual framework are depicted in Figure 2. The results and discussion are organised around the key categories.

Patient interaction

Almost all (13/15) clinician participants reported that they provided the patient with information about the choice of investigations, discussed their benefits and harms, and arrived at a joint decision after considering all options including “wait and watch”.

...it is share decision making...I say (to the patient) that this is what the guidelines suggest we might do, this is what I think we should do, and then ask the patient, what do you think we should do?(P11)

...having a discussion with the patient, so that it is a shared decision making...most of them aren't keen on the test (LP) and would like to avoid it...that seems to be heavily influenced by how they feel now...if they feel fine, they are more likely to be reluctant to have the LP. But...I think you have to be careful not to influence too much because it is easy to convince someone it is not a good idea if you the clinician don't think it is a good idea. It is our responsibility to make the discussion reasonably balanced.(P2)

The participant clinicians felt responsible for guiding this process.

I don't know of too many patients who would want a LP rather than a CT angio....It is our responsibility...patients need our support and experience. We should share this with the patient and guide them.(P3)

They highly valued this shared decision-making process.

I think that is very important...don't be afraid of including patients in your discussions, particularly where you are conflicted as to what is the right thing to do....It is our interactions with the patient that makes a lot of difference.(P1)

I think it is a fantastic idea to have the patient involved in the decision-making process...(P9)

Clinicians also expressed that their preferences for one or the other investigation can impact on the interaction.

...you formulate your decision about what you want to do first and then you have the conversation with the patient...but more importantly, you are having that conversation...(P4)

... they (patients) are influenced by what you say and the way that you say it.(P7)

Practice evidence

Physicians reported that the results of recent research strongly contributed to their management approach. A 2011 Canadian report by Perry et al, on the sensitivity of CT performed within six hours of headache onset (100%, 95%CI:97-100%), was frequently quoted by the participants.¹⁸ As one participant noted:

My practice has become based on the BMJ article from Canada.(P1)

Social media was perceived to have an increasing presence as an information source although not as a substitute for a protocol.

Social media has a big influence on emergency medicine and certainly makes me think but I won't change my behaviour until the department has guidelines/policies on the topic.(P6)

Participants acknowledged that social media content on SAH and other ED diagnostic practices informed both formal and informal conversations in ED and may have been a mediating factor in the evolution of protocols.

They (the College) acknowledge that social media sources, blogs, podcasts etc. can be useful and they have done a filtering process and recommended some resources.(P2)

Speaking for the department rather than myself, I think that social media and blogs have a big influence...Personally I do not use them. Not

because I don't think they are of value but because I have no time.(P8)

Patient profile

The extent to which a diagnosis was pursued was also reported to be driven by risk assessment and the condition of the patient.

...if the headache is still severe and the patient is unwell then clearly, they aren't going home and so I would consider doing further tests.(P14)
...patients with a high body mass index are more likely to be sent for CT angio because of the challenges of doing a LP.(P7)

Consulting

Consultation with in-patient specialists regarding next steps occurred frequently, and was more common if the patient needed to be admitted for further investigations.

I will discuss with the (neurosurgery) consultant if I have a patient who presents with sudden onset (headache) and the LP is negative but I still have some concerns...(P14)

First, we speak with the radiologist on call and it depends who you speak to. It's not just the emergency physicians who decide.(P6)

...a patient that challenges me around the decision-making process...I tend to talk to my colleagues and ask them how they would deal with...(P3)

Decision outcomes depended on the result of the consultation and discussions.

Many physicians reported that unwarranted variations in practice would be reduced where there was prior agreement in the form of a hospital-wide guideline developed from prior collaboration with the pertinent specialties.

External influences

Decisions may also be based on the availability of investigations in a particular setting. The different business models of public and private practices along with access to CT scans contributed to significant practice variation. One clinician reported requesting a CTA immediately following a normal brain CT when working at a private hospital. The same clinician working in a public hospital, operating within departmental guidelines, requested a LP 12 hours after headache onset following a normal brain CT.

When I work in the private, the small number of neurosurgeons are happy for CT/CTA!(P1)

Requesting a CTA was said to be quicker than arranging and performing a LP some 12 hours after headache onset. Moreover, spectrophotometry for the detection of xanthochromia was not locally available at some hospitals, necessitating visual inspection of the CSF or transport of the specimen to a referral laboratory.

Increases in radiology services and availability of CTA has encouraged some people to use it more.(P6)

Experiential factors

Participants reported that their previous experience, including past outcomes, influenced their decisions about diagnostic procedures

...people (patients) don't like LP. It is a very low yield procedure...I have never found anyone with a negative scan and a positive xanthochromia.(P13)

Conversely, missing a serious diagnosis in the past will lower a clinician's threshold for further investigations.

... you will alter your practice and practise differently if you have had an adverse event in the past.(P1)

The decision might also be influenced by differential diagnoses under consideration by experienced clinicians. If meningitis had to be ruled out in addition to a SAH, a LP was essential. Furthermore, the skill level of the clinician was pertinent. A clinician skilled at performing a LP did not see it as a time-consuming difficult procedure fraught with complications.

And the thing is that LP really is a pretty benign procedure if you think about it because I have done so many of them.(P14)

Non-influencing factors

Medicolegal concerns were raised with the participants. Concerns about litigation appeared to have been “self-managed” and considered as non-influential.

You want to minimise your risk but nothing is without risk. ... I don't allow medico-legal factors to govern how I do medicine.(P6)

... towing the department line and following their protocol, and never get into hot water which is obviously attractive from a medico-legal perspective.(P2)

I want to make sure that the next of kin understand the risk. By doing this, it decreases the chance of litigation in the future.(P7)

DISCUSSION

Patient interaction, practice evidence, patient profile, consulting, external influences, and experiential factors identified in this study reasonably explained variations in diagnostic testing after a normal CT in suspected SAH. The identified influencing

factors do allow us to better understand variation in practice particularly in diagnostically challenging cases. When evidence arises to inform practice, modifying the factors that influence variation can be expected improve patient care.

Patient interaction

In this study, the patient's values, preferences and circumstances, or "what the patient wants", was at the forefront of the identified influencing factors. Clinician-patient interaction resulting in shared decision-making is a well-recognised and accepted clinical practice.¹⁹ However, the physicians were aware that they could influence that decision making. How the clinician communicates the benefits and harms of each diagnostic option will no doubt reflect their biases and agenda, and this can influence the negotiation of the joint-decision making process.^{20,21} Patients also have their biases. Many were averse to invasive diagnostic procedures such a LP.

Practice evidence

Despite the lack of a formalised protocol, physicians will rely on seminal research papers to guide practice, particularly when it matches their own experience. In this study, the findings by Perry¹⁸ were frequently cited in this study. This paper empowered clinicians to forego investigations, which they knew from experience nearly always produced normal results.

Patient profile

Patients assessed as high risk for a serious headache influenced the decision of clinicians in this study to obtain additional investigations following a negative CT and

LP. This is consistent with an expert review¹⁴ where its diagnostic algorithm provided scope for advanced imaging when there are clues for other important vascular conditions such as cerebral venous sinus thrombosis and reversible cerebral vasoconstriction syndrome. In a Bayesian framework, the higher the pre-test probability for a serious condition the more needs to be done to reduce the post-test probability to an acceptable level.¹²

Consulting

Consultation with inpatient specialists and colleagues in the ED influenced the management decisions of the participants. Consultations were common, in keeping with the 20% to 40% reported for ED patients in North America.²² Consultations were requested for opinions regarding further investigations and admissions of high-risk patients, and for specific procedures such as a CT angiogram. Participants reported variation in the advice provided even from consultants in the same specialty. They believed that consistency in practice can be achieved with a hospital-wide guideline.

External influences

Although the literature may support a particular management strategy, this way of working may not always be practical and decisions may be made on available resources and logistics, external to the preferences of the clinician or patient.

Contemporary EDs are characterised by crowding and there is pressure to complete the diagnostic work up expeditiously. Although the gold standard for SAH is the LP, logistics can favour the use of CT angiography over a LP.

Experiential factors

Clinicians in this study knew from practice that SAH is unlikely after a normal brain CT, even if performed more than six hours after headache onset. This will influence their decision to pursue further investigations. This can be further influenced by how well the patient looks, and the perceived difficulty of performing the procedure.

Non-influencing factors

In general, given the study scenario, participants did not consider that fear of litigation influenced their practice. The above contrasts with participants in an Australian national survey who reported practice change because of medicolegal concerns.²³ In that study, medicolegal concerns expressed by a diverse group of doctors were of a general nature, which contrasts with the SAH specific focus for the emergency physicians of our study.

Our findings can be compared to a prior study on physician decision making in minor head injury. Non-clinical and human factors that promote or inhibit appropriate use of CT in minor head injury were described by Melnick et al in a qualitative study with clinician and patient participants.²⁴ Five domains emerged: establishing trust, anxiety (patient and clinician), constraints related to ED practice, influence of others, and patient expectations. These domains are similar to the categories that we independently identified. Establishing trust, managing anxiety and meeting patient expectations can be incorporated into our patient interaction category; ED practice constraints into the external influences category; and influence of others into the consulting category. Our findings are thus consistent with the limited literature available.

Limitations

The study examined variations in diagnostic testing following a negative CT scan but not the selection of patients for a CT in the first instance. We did not quantify the magnitude of the variation in practice nor distinguish between warranted and unwarranted variations. A given influencing factor can cause unwarranted variation in one context and warrant variation in another.²⁵

Interviewees produced situated accounts and were from one state in one country. The sample size was small, but was typical for qualitative studies and able to generate a conceptual depth of data that allowed for an exploration of the concept of variation. Furthermore, the group of emergency physician participants was diverse, varying in seniority, experience and work locations across the state.

Conclusions

An identification of factors that underpin variation in medical practice is essential before the appropriateness of care can be improved. The factors can be structured around a context, evidence, experience, and decision framework. Six categories of influencing factors were identified for the diagnostic approach to SAH. Patient interaction appears to be the most important when the best approach is uncertain. Besides patient profile, practice evidence and guidelines, other influencing factors include external influences, experiential factors, and consultation. While context may appropriately demand variation, influencing factors need to be considered when variation in practice is investigated to improve the appropriateness of medical care and in this case around SAH diagnosis.

REFERENCES

1. National Health Service Improvement. Atlas of variation in health and care. 2017. <https://improvement.nhs.uk/resources/atlas-variation-health-and-care/> (accessed 25 November 2018).
2. Australian Commission on Safety and Quality in Health Care. The Australian atlas of healthcare variation. 2017. <https://www.safetyandquality.gov.au/atlas/> (accessed: 25 November 2018).
3. DaSilva P, Mello M, Aitkinhead S. Exploring unwarranted variation through the RightCare programme. *Nursing Times* [online]; 2018;114:28-30.
4. Duggan A, Koff E, Marshall V. Clinical variation: why it matters. *Med J Aust.* 2016;205 (10 Suppl): S3-S4.
5. Rogers A, Furyk J, Banks C, et al. Diagnosis of subarachnoid haemorrhage: a survey of Australasian emergency physicians and trainees. *Emerg Med Australas.* 2014;26:468-473.
6. Kas P. There is no consensus in the way we investigate potential subarachnoid haemorrhage. 17 Feb 2017. <https://www.resus.com.au/2017/02/17/no-consensus-way-diagnose-subarachnoid-haemorrhage> (accessed 25 November 2018).
7. Chu KH, Mahmoud I, Hou XY, et al. Incidence and outcome of subarachnoid haemorrhage in the general and emergency department populations in Queensland from 2010 to 2014. *Emerg Med Australas.* 2018;20:503-510.
8. Chu KH, Howell TE, Keijzers G, et al. Acute headache presentations to the emergency department: a statewide cross-sectional study. *Acad Emerg Med.* 2017;24:53-62.

9. Vermeulen MJ, Schull MJ. Missed diagnosis of subarachnoid hemorrhage in the emergency department. *Stroke*. 2007;38:1216-1221.
10. Dubosh NM, Bellolio MF, Rabinstein AA, et al. Sensitivity of early brain computed tomography to exclude aneurysmal subarachnoid hemorrhage: a systematic review and meta-analysis. *Stroke*. 2016;47:750-755.
11. Westerlaan HE, van Dijk JM, Jansen-van der Weide MC, et al. Intracranial aneurysms in patients with subarachnoid hemorrhage: CT angiography as a primary examination tool for diagnosis – systematic review and meta-analysis. *Radiology*. 2011;258:134-145.
12. Chu KH, Bishop RO, Brown AF. Spectrophotometry, not visual inspection for the detection of xanthochromia in suspected subarachnoid haemorrhage: a debate. *Emerg Med Australas*. 2015;27:267-272.
13. Cruickshank A, Auld P, Beetham R, et al. Revised national guidelines for analysis of cerebrospinal fluid for bilirubin in suspected subarachnoid haemorrhage. *Ann Clin Biochem*. 2008;45:238-44.
14. Edlow JA. Managing patients with nontraumatic, severe, rapid-onset headache. *Ann Emerg Med*. 2018;71:400-408. [Review]
15. Marvasti A. Qualitative research in sociology. Thousand Oaks, CA: Sage; 2004. <http://methods.sagepub.com/book/qualitative-research-in-sociology> (accessed 25 November 2018).
16. Ranney ML, Meisel ZF, Choo EK, et al. Interview-based qualitative research in emergency care Part II: data collection, analysis and results reporting. *Acad Emerg Med*. 2015;22:1103-1112.
17. Alvesson M, Kärreman D. Qualitative research and theory development: Mystery as Methods. Los Angeles, CA. Sage; 2011.

<http://methods.sagepub.com/book/qualitative-research-and-theory-development> (accessed 25 November 2018).

18. Perry JJ, Stiell IG, Sivilotti ML, et al. Sensitivity of computed tomography performed within six hours of onset of headache for diagnosis of subarachnoid haemorrhage: prospective cohort study. *BMJ*. 2011;343:d4277.
19. National Health Service England. Shared decision making. <https://www.england.nhs.uk/shared-decision-making/> (accessed 25 November 2018).
20. Henriquez AR. Bias control in shared decision making: still too many loose ends. *BMJ*. 2012;345:e8291.
21. Schoenfeld EM, Goff SL, Elia TR, et al. The physician as stakeholder: an exploratory qualitative analysis of physicians' motivations for using shared decision making in the emergency department. *Acad Emerg Med*. 2016;23:1417-1427.
22. Woods RA, Lee R, Ospina MB, et al. Consultation outcomes in the emergency department: exploring rates and complexity. *CJEM*. 2008;10:25-31.
23. Nash LM, Walton MM, Daly MG, et al. Perceived practice change in Australian doctors as a result of medicolegal concerns. *Med J Aust*. 2010;193:579-583.
24. Melnick ER, Shafer K, Rodulfo N, et al. Understanding overuse of computed tomography for minor head injury in the emergency department: a triangulated qualitative study. *Acad Emerg Med*. 2015;22:1474-1483.
25. Mercuri M, Gafni A. Medical practice variations: what the literature tells us (or does not) about what are warranted and unwarranted variations. *JEval Clin Pract*. 2011;17:671-677.

ETHICS APPROVAL

The study was approved by the Human Research Ethics Committee, Royal Brisbane and Women's Hospital, Brisbane, Australia.

CLINICAL TRIAL REGISTRATION

Not applicable.

FUNDING

This work was supported by the Emergency Medicine Foundation, Australia, grant number EMPG200R19.

COMPETING INTEREST

None declared.

FIGURE LEGENDS

Figure 1. Factors influencing a clinician's diagnostic approach to subarachnoid haemorrhage.

Figure 2. A conceptual framework along with categories and sub-categories of factors influencing a clinician's diagnostic approach to subarachnoid haemorrhage.