

# Acute Headache Management for Patients with Subarachnoid Hemorrhage: An International Survey of Healthcare Providers

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## Research Article

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# Abstract

**Background:** Severe headaches are common after subarachnoid hemorrhage (SAH). Guidelines recommend treatment with acetaminophen and opioids, but patient data show that headaches often persist despite multimodal treatment approaches. Considering an overall slim body of data for a common complaint affecting SAH patients during their intensive care stay, we set out to assess practice patterns in headache management among clinicians who treat patients with SAH.

**Methods:** We conducted an international cross-sectional study through a 37-question web-based survey distributed to members of 5 professional societies relevant to intensive and neurocritical care from 11/2021-1/2022. Responses were characterized through descriptive analyses; Fisher's exact test was used to test associations.

**Results:** Of 516 responses, 329/497 (66%) were from North America and 121/497 (24%) from Europe. 379/435 (87%) reported headache as major management concern for SAH patients. Intensive-care-teams were primarily responsible for analgesia during hospitalization (249/435, 57%), while responsibility shifted to neurosurgery at discharge (233/501, 47%). Most used medications were acetaminophen (90%), opioids (66%), corticosteroids (28%) and antiseizure medications (28%). Opioids or medication combinations including opioids were most frequently perceived as most effective, by 169/433 (39%, predominantly intensivists), followed by corticosteroids or combinations with corticosteroids (96/433, 22%, predominantly neurologists). Of medications prescribed at discharge, acetaminophen was most common (303/381, 80%), followed by opioids (175/381 [46%]), and antiseizure medications (173/381, 45%). Opioids during hospitalization were significantly more prescribed by intensivists, by providers managing higher numbers of SAH patients, and in Europe. At discharge, opioids were more frequently prescribed in North America. 299/435 (69%) indicated no change in prescription practice of opioids with the opioid crisis. Additional differences in prescription patterns between continents and providers, and inpatient versus discharge were found.

**Conclusions:** Post-SAH headache in the intensive care setting is a major clinical concern. Analgesia heavily relies on opioids both in utilization and in perception of efficacy, with no reported change in prescription patterns for opioids for most providers despite the significant drawbacks of opioids. Responsibility for analgesia shifts between hospitalization and discharge. International and provider-related differences are evident. Novel treatment strategies and alignment of prescription between providers are urgently needed.

## Introduction

Subarachnoid hemorrhage (SAH) classically presents with an excruciating headache of sudden onset that reaches maximal severity within seconds, known as "*thunderclap*" or described as "*worst headache of life*" [1, 2]. Nearly all SAH patients experience headaches, and in about 90%, headaches are

severe [3]. On average, SAH patients suffer from severe headaches for  $\geq 7$  days during their index hospitalization [4]. Moreover, headaches persist beyond hospitalization in  $>50\%$  of patients [5] and have been associated with reduced health-related quality of life [6]. The etiology of post-SAH headaches is multifactorial and includes meningeal irritation by blood in the subarachnoid space, inflammation, and sequela from treatment (i.e., craniotomy or endovascular intervention) and elevated intracranial pressure in some cases [7].

SAH can be a devastating life-event due to increased risk for ongoing structural brain injury and significant systemic complications. Hence, SAH patients are commonly managed in intensive care units with multidisciplinary collaboration, and guidelines largely focus on mitigation of secondary brain injury and systemic complications [8]. However, data and guidance on the optimal pharmacological and supportive management for post-SAH headaches are scarce. Current European guidelines recommend the use of acetaminophen (i.e., paracetamol) for mild-to-moderate headaches, with escalation to opioids (i.e., codeine, tramadol or piritramide) if symptoms are severe or resistant [9]. However, studies suggest that post-SAH headaches are only partially relieved and often persist despite provision of guideline-recommended treatment [3]. Importantly, opioid use is not without risks. Excess sedation from opioids can cloud neurologic examination, increase risk of delirium, and blunt chemosensitivity to hypercapnia, potentially contributing to respiratory suppression [10]. Furthermore, opioid prescriptions have been increasingly scrutinized due to their incurred risk for addiction [11]. However, due to the lack of alternative effective treatment options, opioids are commonly employed for post-SAH headache management [12]. More recently, multimodal pharmacotherapy with agents such as gabapentinoids, magnesium infusions, corticosteroids, and utilization of nerve blocks have been reported [13-16].

In the absence of data-proven effective headache management strategies, lack of updated guidelines for such management, and incomplete understanding of trajectories of post-SAH headache [17, 18], we hypothesized that significant practice variability exists in the management of acute post-SAH headaches in the critical care setting. The objective of this study is to examine the variety of different approaches to manage headaches in non-traumatic SAH patients during hospitalization and at discharge from the hospital with an emphasis on characterizing opioid administration and spanning international practice.

## Materials And Methods

### Study Design

The study was designed as a cross-sectional survey targeting healthcare providers who manage headaches in patients with non-traumatic (spontaneous, both aneurysmal and non-aneurysmal) SAH during the acute phase (index hospitalization and at discharge from index hospitalization).

To ensure proper reporting of results from an electronic survey, guidelines set by the Checklist of Reporting Results of Internet E-Surveys (CHERRIES) were followed. The survey study was approved by the University of Florida Institutional Review Board (IRB202100254) and electronic consent was obtained from all participants.

## **Instrument**

The study used an open web-based survey (Qualtrics®, Provo, UT) consisting of 37 questions (see Additional File) with skip-logic feature whenever applicable. All questions were designed by the authors (AG, BL, CBM, KMB, NAM, ZAM) to capture the demographics of the participants (including healthcare profession and subspecialty, region of practice, years of practice, specialized training, and the number of SAH patients managed per year by the individual provider and their affiliated institution) as well as the individual approaches to the management of headaches experienced by patients with non-traumatic SAH. Eight beta testers in two groups (four beta testers in each group) were selected by the authors to take and evaluate the survey prior to dissemination for content, usability and technical functionality. The ESICM Clinical Sensibility Testing Tool was used to assess the quality of the instrument. The first group of beta testers was invited to provide feedback on the survey (with the Clinical Sensibility Testing Tool in addition to unstructured narrative feedback), the survey was revised accordingly, and the process was repeated with the second group of beta testers prior to arriving at the final version of the survey. The survey's first question sought consent to participate by the individual respondent. Responses to questions were voluntary, and the back-button function allowed to change answers after initial response, and respondents were able to skip questions.

## **Dissemination of the survey**

Participants included in this study received the survey through professional networks or through distribution by the following societies:

- American Academy of Neurology (AAN)
- European Society of Intensive Care Medicine (ESICM)
- Neurocritical Care Society (NCS)
- Neuro Anesthesia and Critical Care Society (NACCS)
- Society of Critical Care Medicine (SCCM)

The survey was disseminated by the societies to their members via email or via posting on relevant forums with no incentives offered and advertised in social media platforms; these methods of dissemination precluded generation of response rates. The study was conducted from November 2, 2021, to January 26, 2022.

## **Statistical Analysis**

This was a cross-sectional study design with results reported as percentages based on study question. Participants were divided into five groups based on the frequency of medication prescription: (1) always, (2) often (>75%), (3) sometimes (25-75%), (4) rarely (<25%) and (5) never. We calculated the frequency table for each variable of interest by medication prescription. In the observation of small values in some cells of frequency tables, we used Fisher's exact test to test the association between each variable and the medication prescription at the significance level of 0.05 [19]. Data analysis was carried out using R Studio software v4.0.2 [20].

Participants had the opportunity to skip questions with resultant variability in total number of answers given per question; thus, the denominator varied according to each question. Percentages are rough estimates of prevalence with limitation of incomplete surveys. Missing data were excluded when calculating the percentage.

## Results

### Demographics

Of 521 total respondents who started the survey, four indicated that they did not consent to participate, and one indicated that they did not treat patients with non-traumatic SAH; these responses were excluded. Of the 516 returned surveys included in final analysis, 371 participants had completed the survey in its entirety.

Table 1 displays the demographics of respondents and characteristics of healthcare settings. Of respondents from six continents, 329/497 (66%) were from North America, and 121/497 (24%) from Europe. The majority were staff physicians, 359/491 (73%). Neurology and intensive care medicine were the most listed provider specialties (each 115/516, 22%). More than half of respondents (186/339, 55%) had completed medical training  $\geq 10$  years ago. The majority, 321/464 (69%), worked in academic centers and with a dedicated neurointensive care unit (361/464, 78%). Seventy-six percent (352/464) reported that their centers managed  $\geq 30$  SAH patients per year, and 242/464 (52%) responded that they personally manage >20 SAH patients per year.

Factors determining admission to the intensive care unit included clinical grade of SAH in 311/461 (68%), need for cerebrospinal fluid diversion in 235/461 (51%), requirement of mechanical ventilation in 288/461 (63%), and "other" in 170/461 (37%). In the category "other", the most listed factor was a protocol for admission of *all* SAH patients to the intensive care unit (126/170, 27%).

### Headache Management for SAH

Headache post-SAH was named a major clinical concern by 379/435 (87%) respondents. In most practice settings (249/435, 57%), the intensive care team was primarily responsible for management of post-SAH headache during the hospital admission (see Figure 1).

The most frequently used medications to treat post-SAH headaches are shown in Figure 2.

Acetaminophen was most commonly used, with 378/421 (90%) indicating prescription “always” or “often”. Opioids followed as second most used medication, with 276/421 (66%) indicating use “always” or “often”. Corticosteroids and antiseizure medications were mostly “sometimes” prescribed by 32% and 30% respondents, respectively. While non-steroidal anti-inflammatory drugs (NSAIDs) and magnesium were mostly indicated as “never” employed, with half of the providers would order those medications rarely or sometimes.

Anesthetic blocks, antihistamines, barbiturates, botulinum toxin, caffeine, continuous infusions, muscle relaxants, topical medications and vitamin supplements were predominantly “never” used (see Supplemental Table 1).

Of the 433 individual responses to the question of which medication(s) they perceived as most effective treatment for headache post-SAH (see Figure 3), 169 (39%) indicated opioids or medication combinations containing opioids, followed by corticosteroids or medication combination regimens with corticosteroids as part of the combination (96/433, 22%) and multimodal therapy not further specified (32/433, 7%). Six percent (27/433) indicated either that *no* medication therapy is helpful or that the most helpful management approach is to focus on supportive and nursing care.

Nine percent (31/371) of respondents indicated that their institution had an established protocol or guidelines for headache management post-SAH.

### **Opioid-based therapy for Post-SAH Headaches**

The duration for opioid therapy was noted to be determined on a case-by-case basis in 233/304 (77%); 45/304 (15%) would prescribe for a limited number of days only, and 26/304 (9%) for the duration of hospitalization, with prescription mode on an “as needed” basis when utilized, as opposed to scheduled dosing for all indicated durations. Choice of duration and daily dose of opioid was based on individual patient characteristics (211/304, 69%), pain intensity scores (210/304, 69%), concern for or presence of side effects (142/304, 47%), and institutionally specified dosing and duration (25/304, 8%) as shown in Figure 4.

Table 3 shows demographic differences in opioid prescribing practices during index hospitalization. Opioids were significantly more prescribed by providers practicing in Europe compared to North America and other world regions (81% vs. 61% vs. 59% for “often” or “always”, respectively;  $p=0.029$ ). Anesthesiologists and intensive care medicine specialists rely on opioids more when compared to neurology providers (71% vs 70% vs 51%, respectively;  $p = 0.006$ ). Professional role, years in practice, type

of healthcare facility, presence of a dedicated neurocritical care unit, and number of the institution's SAH admissions per year were not significantly associated with practitioner's reported opioid prescription practice. Providers who manage more SAH patients per year indicated a higher rate of opioid prescriptions than those who manage fewer SAH patients ( $p = 0.007$ ).

Of the 435 participants who answered whether the opioid crisis has changed their approach to managing post-SAH headaches, 299 (69%) answered "no"; providers who indicated their prescription practice had changed were predominantly from North America as opposed to Europe (109/293 or 37% vs. 15/86 or 17%;  $p < 0.001$ ). Providers who indicated that they changed prescription patterns in light of the opioid crisis indicated less frequent (i.e., less "often" or "always") prescription of opioids during the hospital stay (72/132 or 55% vs. 204/289 or 71%;  $p = 0.007$ ), and more frequent use of antiseizure medications (100/132 or 76% vs. 146/289 or 51%;  $p < 0.001$ , for use at least "sometimes"). We found no significant difference in use of steroids (88/132 or 67% vs. 165/289;  $p = 0.206$ , for use at least "sometimes") or NSAIDs (62/132 or 47% vs. 128/289 or 44%;  $p = 0.092$ , for use at least "sometimes").

Opioid prescription at discharge (either indicated as "often" or "always") was significantly more common among North American compared to European and other providers (21% vs. 8% vs. 11%; respectively;  $p = 0.033$ ). Neurosurgeons prescribed opioids more often than neurologists, intensivists, anesthesiologists, or other specialty providers (7/17 or 41% vs. 18/106 or 17% vs. 12/91 or 13% vs. 8/60 or 13% vs. 20/107 or 19%, respectively;  $p = 0.002$ ).

### **Non-pharmacologic Management of Post-SAH Headaches**

Of 418 respondents who answered whether cerebrospinal fluid (CSF) diversion was adjusted to headache severity, 278 (67%) respondents answered "yes" or "sometimes". The use of alternative treatment options (e.g., acupuncture, herbal medicine, massage therapy, Reiki therapy, music therapy, etc.) was reported by 77/418 (18.4%).

### **Management of Post-SAH Headaches at Hospital Discharge**

Different to inpatient management for post-SAH headaches, prescriptions at discharge were largely provided by neurosurgery team members (233/501, 47%) as shown in Figure 1. The majority (297/403 or 74%) indicated that they do not prescribe analgesics for headaches upon discharge. Of medications prescribed at discharge, acetaminophen was the most common (i.e., prescription "always", "often" or "sometimes") medication (303/381, 80%), followed by opioids (175/381, 46%), and antiseizure medications (173/381, 45%).

### **Differences in Practice Patterns by Demographic Characteristics**

Several differences in practice patterns were noted for demographic variables (see Supplemental Table 2 for details). Use of antiseizure medication differed between continents, specialties and years in practice for both in-hospital and at-discharge prescriptions. Antiseizure medications were used more commonly (i.e., prescribed "often" or "always") in North America as compared to Europe and other continents both in-

hospital (35% vs. 9% vs.19%, respectively;  $p<0.001$ ) and at discharge (22% vs. 10% vs. 16%, respectively;  $p=0.020$ ). They were also significantly prescribed more commonly by neurologists than other providers both during hospitalization and at discharge and were prescribed more frequently by providers with fewer years of practice.

Corticosteroids during hospitalization were significantly prescribed more commonly by neurologists or neurosurgeons when compared to other providers, and were co-prescribed with antiseizure medications, NSAIDs and opioids more often than individually.

Perceived effectiveness of therapies significantly varied across providers' specialty (details shown in Supplemental Table 3). Opioids and opioid combinations were perceived as the best analgesic nearly twice as commonly by anesthesiologists and intensivists, as compared to neurologists and neurosurgeons (46% and 46% vs. 24% and 27%, respectively;  $p=0.0005$ ). By contrast, steroid and steroid combinations were perceived as the best analgesic strategy much more commonly by neurologists and neurosurgeons when compared to anesthesiologists and intensive care specialists (33% and 23% vs. 8% and 6%, respectively;  $P=0.0005$ ).

Providers considering alternative treatment options (e.g., acupuncture, herbal medicine, massage therapy, Reiki therapy, music therapy etc.) were more likely from North America compared to Europe and other continents (62/269 or 23% vs. 15/114 or 13%;  $p=0.029$ ) and were more likely to be practicing in a setting where the intensive care team is responsible for analgesia as compared to neurosurgery/neurology/other team's responsibility (57/231 or 25% vs. 20/167 or 12%;  $p=0.016$ ). No differences were found for professional role, background, years in practice, hospital setting and number of yearly patients with SAH.

## Discussion

In this cross-sectional analysis, we captured current practice patterns in the management of post-SAH headache among an international cohort. Post-SAH headache is widely recognized as a major clinical concern by 87% of providers. Our findings unveil a nearly ubiquitous reliance on acetaminophen (i.e., paracetamol) and heavy reliance on opioids and corticosteroids, in addition to multimodal analgesic approaches.. Importantly, opioid-based strategies predominate as the analgesic modality perceived as the most effective—by 2 of 5 providers—and are at least sometimes prescribed at discharge by nearly half of providers. We further documented a shift in primary responsibility in headache management between hospitalization and discharge, as well as regional and provider-related differences in management practices. Additionally, providers indicated a widespread lack of institutional guidance for analgesia in post-SAH headache with only 9% of respondents indicating the presence of a standardized approach to pain management at their institution.

### Opioids in Post-SAH Headache Management

The recognition of post-SAH headache as a major clinical concern aligns with the near universal occurrence of post-SAH headache in up to 90% of patients during the acute phase [3, 4, 21]. Our data

confirm heavy utilization of acetaminophen and opioids—aligning with the guideline-recommended mainstay of acute therapy for severe headache [9] and prior cohort-based reports [3-5, 22]. Many centers have reported daily oral morphine equivalent ranging from 22mg to 63mg and commonly exceeding 400mg over the hospital stay even after introduction of opioid-sparing initiatives [4, 5, 22]. While our survey indicates that opioids were also perceived as the most effective analgesic strategy, prior data have shown that opioid analgesia is suboptimal and oftentimes fails to alleviate pain on the standard assessments in a meaningful way (i.e., reduction of pain scores by at least 2 points on the 11-point numeric rating scale) [4, 14, 23]. This finding of opioids performing suboptimally as an analgesic has also been found in migraine, where hydromorphone was inferior to prochlorperazine in a randomized clinical trial [24]. This might explain why the perception of opioids and opioid-based combinations as the best analgesic was only half as common by neurologists and neurosurgeons when compared with anesthesiologists and intensivists. A similarity of some features of post-SAH headaches may also have been reflected in the listing of an approach to analgesia akin to migraine by several respondents.

In addition to the documented failure of opioids to adequately manage post-SAH pain, early opioid administration can also impair adequate neurologic exams for SAH patients and impede effective initiation of care [25]. Specifically in the critically ill population, inadequate pain control and opioid use are both associated with delirium [26]. Furthermore, opioid-related depressed consciousness and respiratory drive, nausea, ileus, urinary retention, and hypotension are common [27]. Of relevance for patients in the acute phase of SAH, any sedative effect of analgesics can cloud neurologic assessments, thereby interfering with timely diagnosis of rebleeding and vasospasm. These drawbacks of opioids—albeit used for their perceived analgesic potency—are reflected in our survey’s finding of selecting opioid dosing by the concern for side effects by nearly half of providers.

## **Impact of Opioid Crisis**

Our data in this international survey capturing worldwide practice patterns confirm the frequent continuation of opioid prescriptions beyond hospitalization, despite the well characterized drawbacks of prescription opioid therapy. Approximately 40% of all opioid overdose deaths in the U.S. involve a prescription by healthcare professionals [28, 29]. Nearly 5% of patients with opioid prescriptions misuse them or develop dependence, according to a pooled analysis of 12 studies with over 300,000 patients [30]. Additionally, as known from other headache disorders, the use of around-the-clock analgesics also renders patients with poor headache control susceptible to medication-overuse headache—a vicious cycle that perpetuates the long-term use of opioids [31, 32]. When considering the opioid crisis, however, it is important to understand international differences. The opioid crisis is a phenomenon with variable impact based on geographic location. Although prescription opioid use increased in Europe by almost 40% between 2005 and 2015, it still only reached about half of the U.S. volume in 2015, with almost 10 times less opioid related deaths in western Europe compared to the U.S. [33]. Several differences, including different drug and prescription regulations, pharmaceutical advertising, and a different approach to medical use of opioids have been proposed as contributory to this steep difference [34, 35]. With this differential understanding of the opioid crisis in mind, it is not surprising that

a perceived change in prescription pattern was mostly indicated by North American providers with decreased utilization of opioids, and increased use of antiseizure medications. On the contrary, despite the recognition of the opioid crisis in North America, opioid prescription at discharge was significantly more common in North America compared to Europe—a finding supporting explanations of the considerable difference in embedding opioids as one among many possible analgesic strategies.

### **Alternative Analgesic Strategies**

Investigated analgesic strategies alternative to opioids for post-SAH headache include gabapentin, pregabalin, and magnesium. While these provide only modest pain relief [13, 36, 37] and also carry a risk of sedation and hypotension, our survey data show that these medications are used, with both regional—more use of antiseizure medications in North America compared to Europe—and specialty-driven (more commonly prescribed by neurologists compared to other specialty providers) differences. Interestingly, corticosteroids were both commonly used—preferentially by neurologists and neurosurgeons—and were second to opioids in perceived effectiveness, albeit data to support its effectiveness for headache management after SAH are lacking. There are, however, data on dexamethasone use after SAH—based on the premise of disturbed corticoid homeostasis after SAH, and possible benefits of antiedematous and anti-inflammatory effects of steroids—showing that 5-day-or-longer courses of dexamethasone after SAH were independently associated with adverse events, such as infection and hyperglycemia, and unfavorable outcomes at discharge [38, 39]. Based on our finding of frequent use of corticosteroids in the management of post-SAH headaches, further study is required to identify optimal analgesics to inform guidelines and improve consensus on management. Similarly, albeit used less frequently, data on effectiveness and safety of NSAIDs post-SAH are lacking.

Another frequent consideration in headache management was the adjustment of CSF diversion to headache severity: two thirds of respondents indicated considering this as a therapeutic strategy. There are, however, no data to guide the clinician on the subtype of patient who might have hydrocephalus-related headaches, and detailed phenotypic description of headache types that might be CSF-responsive are also lacking.

Further alternative strategies, including nerve-blocks, acupuncture, herbal medicine etc. were utilized at least occasionally by nearly one of five respondents. While most published data on any of these treatments are based on case reports or smaller case series, experience with pterygopalatine fossa blocks, occipital nerve blocks and acupuncture have been reported with potentially promising results [15, 16, 40, 41] and may offer potential additions to the multi-drug regimens that are most commonly employed. Providers considering such alternative strategies were more likely based in North America—likely a reflection of the regional shift from opioid-based analgesia—and were more likely to be considered in a setting where the intensive care team was responsible for analgesia.

### **Headache Management in the Transition from Intensive Care to Hospital Discharge**

Several important findings were retrieved from this survey concerning the prescription of medications for post-SAH at discharge. First, despite up to 47% of SAH patients having headaches in the months and year after discharge [5, 6], 74% of respondents indicated that they do not prescribe any medications at discharge. With post-SAH headache constituting the 4<sup>th</sup> most common cause for 30- and 90-day readmissions, surpassed only by stroke, hydrocephalus, and sepsis [42], this practice constitutes a gap that may be worthwhile for a systematic and multidisciplinary approach. Second, the most commonly prescribed medication was acetaminophen, a medication likely not sufficient in many instances [14], and opioids, with the drawbacks as discussed above. Last, there is a common shift in the prescribing provider from intensive care team during the inpatient stay to neurosurgical team at discharge. With 91% of respondents reporting no availability of an institutional protocol for managing headaches in this population, scarce data available to guide such management, and the shift in responsibility on transition to outpatient management, it is not surprising that overall dissatisfaction with headache management has been reported by patients during both inpatient and outpatient care [21]. Specifically, SAH survivors with persistent headache face more anxiety and stress, cognitive dysfunction, weariness, and impaired sleep— all factors that negatively impact quality of life [6, 43].

## **Limitations**

Our study is the first to characterize a broad spectrum of analgesic practices to post-SAH headache across disciplines and world regions; however, it has important limitations. The method of survey dissemination precluded an exact summary of all recipients to be ascertained and consequently, the evaluation of response rates. We mitigated this impact by obtaining additional granular data characterizing respondents to better clarify the source of answers, including practice settings. Most participants who responded were based in academic hospitals, which could potentially limit the generalizability of the findings to the larger community setting. Additionally, not all participants answered all questions, limiting interpretation of the questions with fewer respondents and hampering more granular subgroup analysis due to smaller sample size. The data were not stratified by geographic region to account for potential regional variance across the world. Clustering due to several responses from the same hospital system is also a possibility. Considering that most responses were from North America, the data are most consistent with practice patterns from this region. Provided that the survey was only distributed in English language, language barrier might also have played a role in response patterns. Finally, as data were collected at a single point in time regarding generalized practice patterns, no individual determination about specific patient-focused metrics can be made.

## **Conclusion**

This large cross-sectional study evaluated practice patterns for post-SAH headache management throughout the world. Current treatment heavily relies on systemic therapy including opioids despite recognized drawbacks and lack of sufficient pain control. Provider-specific differences in approach to analgesia are evident. The need for a multidisciplinary approach, novel treatment strategies and data

guiding optimal approach to post-SAH headache is apparent and should be undertaken in a rigorous scientific manner.

## Abbreviations

AAN	American Academy of Neurology
CHERRIES	Checklist of Reporting Results of Internet E-Surveys
CSF	Cerebrospinal fluid
ESICM	European Society of Intensive Care Medicine
NACCS	Neuro Anesthesia and Critical Care Society
NCS	Neurocritical Care Society
NSAIDs	Non-steroidal anti-inflammatory drugs
SAH	Subarachnoid Hemorrhage
SCCM	Society of Critical Care Medicine
U.S.	United States of America

## Declarations

### Availability of Data and Materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

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Authors confirm the following:

1. We confirm that manuscript complies with all instructions provided to the authors.

2. We confirm that authorship requirements have been met and the final manuscript was approved by all authors.
3. We confirm that this manuscript has not been published elsewhere and is not under consideration by another journal.
4. We confirm adherence to ethical guidelines. IRB approval was obtained through the University of Florida (IRB202100254), and individual consent was obtained as part of the survey by all participants.
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## Tables

**Table 1. Demographic characteristics of survey respondents and their institutions**

Demographics	Responses	Frequency	Percent
Primary country of practice (n = 497)	North America	329	66.2
	Europe	121	24.3
	South America	19	3.8
	Australia	1	0.2
	Africa	9	1.8
	Asia	18	3.6
Professional role (n = 491)	Advanced Practice Provider (Nurse Practitioner, Physician Assistant, CRNA, etc.)	67	13.6
	Staff Physician (MD or DO)	359	73.1
	Physician Trainee	26	5.3
	Pharmacist	32	6.5
	others	7	1.4
Specialty (n = 516)	Neurology	115	22.3
	Neurosurgery	20	3.9
	Anesthesiology	69	13.4
	Intensive Care Medicine	115	22.3
	Other/not answered	197	38.2
Fellowship specialty (n = 312)	Neurocritical care	120	38.5
	Surgical Critical Care	20	6.4
	Internal Medicine Critical Care	26	8.3
	Anesthesia Critical Care	20	6.4
	Additional Certification	17	5.4
	I have not completed a fellowship	109	34.9
Number of years in practice post training (n = 339)	<5	78	23
	5 to 9	75	22.1
	10 to 14	59	17.4
	>15	127	37.5
Dedicated Neurointensive care unit (n = 464)	Yes	361	77.8
	No	103	22.2
SAH admissions to institution per year (n = 464)	1 to 29	112	24.1
	>=30	352	75.9

SAH, subarachnoid hemorrhage

**Table 2. Association of Opioid prescription during hospitalization with respondent characteristics**

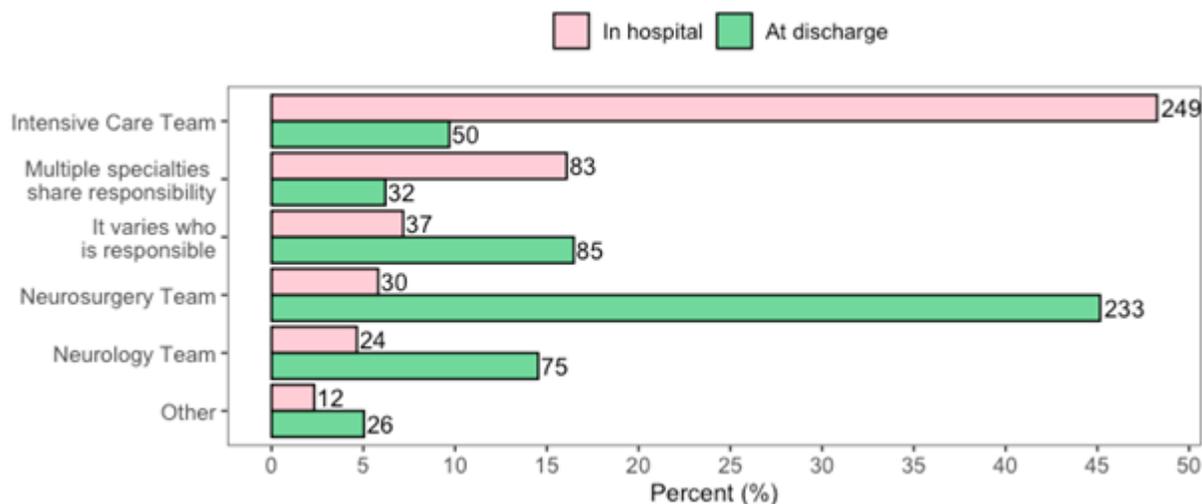
Question	Category	Opioid use in hospital [n (%)]					P value
		Never	Rarely	Sometimes	Often	Always	
Primary country of practice	North America	9 (3.2)	33 (11.6)	68 (23.9)	120 (42.3)	54 (19.0)	<b>0.020*</b>
	Europe	0 (0)	6 (6.2)	12 (12.5)	52 (54.2)	26 (27.1)	
	Other	1 (2.4)	5 (12.2)	11 (26.8)	20 (48.8)	4 (9.8)	
Professional role	Advanced Practice Provider	0 (0)	7 (12.7)	8 (14.5)	27 (49.1)	13 (23.6)	0.696
	Pharmacist	0 (0)	0 (0)	6 (25.0)	13 (54.2)	5 (20.8)	
	Staff Physician	10 (3.2)	34 (10.9)	68 (21.8)	141 (45.2)	59 (18.9)	
	Physician Trainee	0 (0)	2 (11.1)	6 (33.3)	5 (27.8)	5 (27.8)	
	Other	0 (0)	1 (14.3)	1 (14.3)	3 (42.9)	2 (28.6)	
Primary specialty	Neurology	6 (5.4)	13 (11.6)	36 (32.1)	42 (37.5)	15 (13.4)	<b>0.002*</b>
	Neurosurgery	0 (0)	2 (11.1)	5 (27.8)	4 (22.2)	7 (38.9)	
	Intensive Care Medicine	3 (2.9)	9 (8.8)	19 (18.6)	53 (52.0)	18 (17.6)	
	Anesthesiology	1 (1.5)	10 (15.2)	8 (12.1)	29 (43.9)	18 (27.3)	
	Other	0 (0.0)	12 (8.5)	28 (19.9)	68 (48.2)	33 (23.4)	
Years in practice after completing training	<5	3 (4.2)	7 (9.7)	21 (29.2)	31 (43.1)	10 (13.9)	0.496
	5 to 9	4 (5.7)	11 (15.7)	14 (20.0)	28 (40.0)	13 (18.6)	
	10 to 14	1 (1.8)	8 (14.3)	14 (25.0)	24 (42.9)	9 (16.1)	
	>=15	2 (1.7)	10 (8.5)	21 (17.9)	57 (48.7)	27 (23.1)	
Type of practice setting	University/Academic	7 (2.2)	31 (9.6)	71 (22.0)	143 (44.4)	70 (21.7)	0.383
	Other	3 (3.0)	13 (13.1)	20 (20.2)	49 (49.5)	14 (14.1)	
Dedicated neuroICU	Yes	6 (1.8)	35 (10.7)	73 (22.3)	146 (44.6)	67 (20.5)	0.591
	No	4 (4.3)	9 (9.6)	18 (19.1)	46 (48.9)	17 (18.1)	
SAH patients admitted per year	1 to 29	4 (4.0)	11 (11.0)	23 (23.0)	49 (49.0)	13 (13.0)	0.221
	≥30	6 (1.9)	33 (10.3)	68 (21.2)	143 (44.5)	71 (22.1)	
SAH patients managed personally per year	<5	2 (3.6)	8 (14.5)	10 (18.2)	28 (50.9)	7 (12.7)	<b>0.007*</b>

	6 to 10	3 (4.9)	7 (11.5)	18 (29.5)	28 (45.9)	5 (8.2)	
	11 to 20	3 (3.4)	7 (8.0)	20 (23.0)	46 (52.9)	11 (12.6)	
	>20	2 (0.9)	22 (10.1)	43 (19.7)	90 (41.3)	61 (28.0)	
Team prescribing pain medications in the hospital	Neurosurgery Team	0 (0)	5 (17.9)	4 (14.3)	14 (50.0)	5 (17.9)	0.684
	Neurology Team	0 (0)	1 (4.3)	8 (34.8)	9 (39.1)	5 (21.7)	
	Intensive Care Team	4 (1.7)	26 (10.7)	49 (20.2)	114 (47.1)	49 (20.2)	
	Other	6 (4.7)	12 (9.4)	30 (23.4)	55 (43.0)	25 (19.5)	

\* Indicates statistical significance at the 0.05 level

Abbreviations: ICU - intensive care unit; SAH - non-traumatic subarachnoid hemorrhage

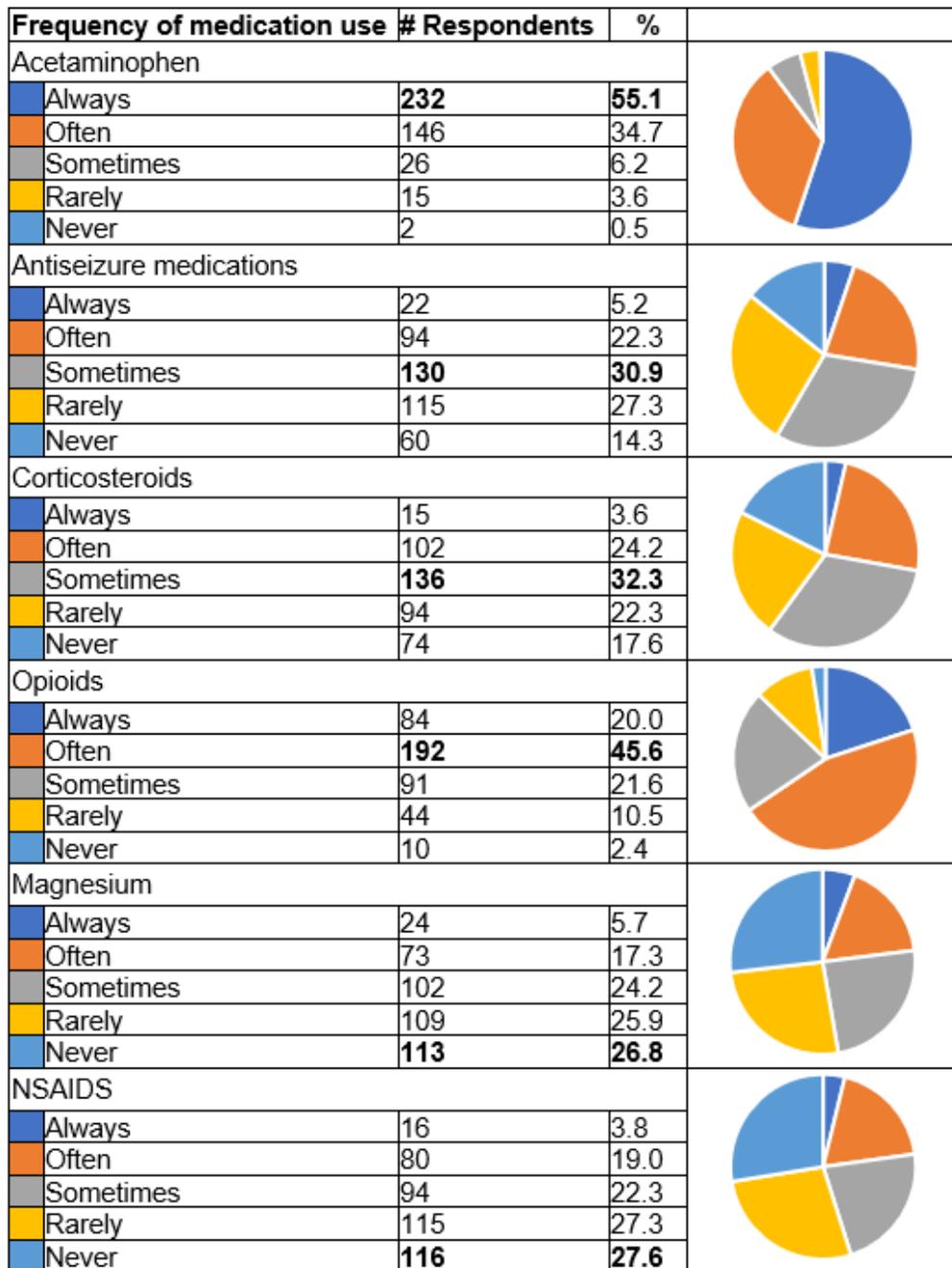
## Figures



**Figure 1**

Team primarily responsible for prescribing treatment for post-SAH headache during hospitalization and at discharge (n = 435)

**Figure 2. Most frequently used medications for SAH headache during hospital stay (n = 421)**

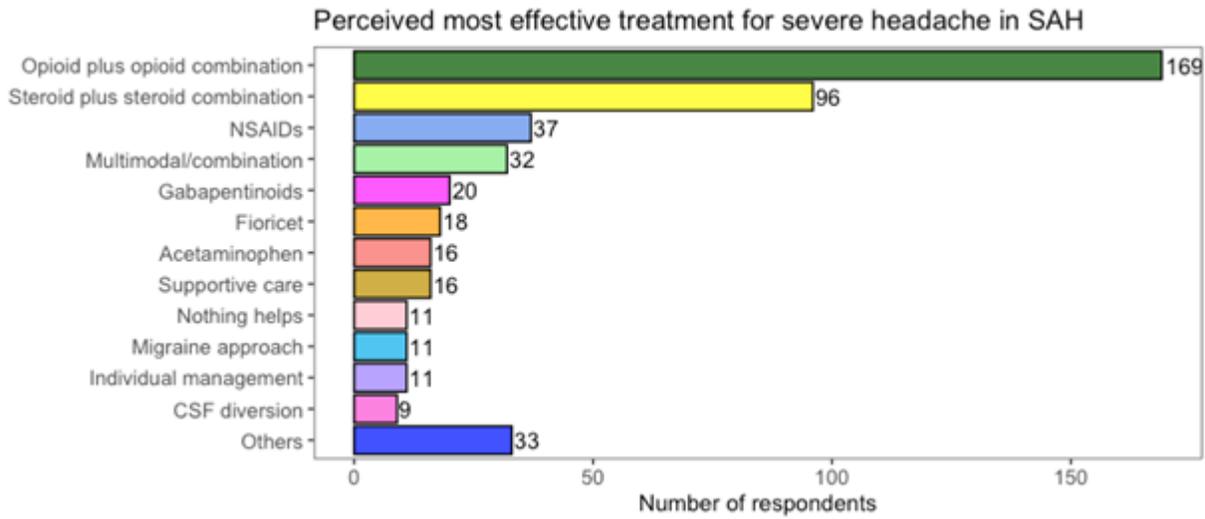


Legend: Always, 100%; often, >75%; sometimes, 25-75%; rarely, <25%; never, 0%.

NSAIDs, non-steroidal anti-inflammatory drugs

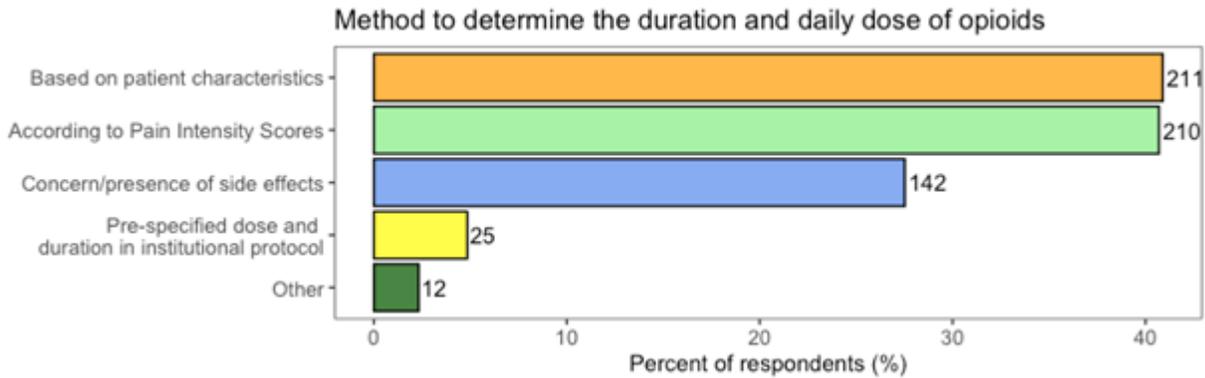
**Figure 2**

Most frequently used medications for post-SAH headache during hospitalization (n = 421)



**Figure 3**

Perceived most effective treatment for severe post-SAH headache during hospitalization (n = 433); NSAIDs, nonsteroidal anti-inflammatory drugs; CSF, cerebrospinal fluid



**Figure 4**

Factors determining duration and dose of opioid prescription during hospitalization (number of respondents, n = 304; multiselect allowed)

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SuplTable1.docx](#)
- [SupplementalTable2.docx](#)
- [SupplementalTable3.docx](#)