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Migraine Screening Among A Non-Clinical Sample

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MIGRAINE SCREENING AMONG A NON-CLINICAL SAMPLE

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ABSTRACT

Migraine is a commonly-occurring primary headache disorder that can be extremely disabling. Despite its prevalence and impact, migraine remains under-recognized and under-treated. The US Headache Consortium recommended validated screening measures as one way to improve headache diagnosis. Previous studies have sought to determine optimal symptom algorithms for differentiating migraine from other types of headache or to validate migraine screening measures, but few studies have attempted to do both.

The current study attempted to statistically determine the most sensitive and specific symptoms for differentiating between migraine and other headache and validate the resulting symptom algorithm as a screening measure. Young adults who suffered from migraine (Group 1) and other headache (Group 2), based on their responses on a computerized diagnostic interview, served as participants. The total sample consisted of 1,829 participants (71.5% female; 74.4% white; mean age = 19.09 years [*SD* = 2.05]) who suffered from some type of headache, which was split randomly into experimental and validation samples. One hundred fifty-eight (8.6%) individuals met diagnostic criteria for migraine and 1,104 (60.3%) met for another type of headache.

Headache duration of 4-72 hours (100%), severity ≥ 5 (91%), photophobia (90%), and phonophobia (90%) showed the highest sensitivity, while vomiting (98%), duration of 4-72 hours (92%), nausea (89%), and headache-related disability (88%) showed the highest specificity. Symptoms that did not show either a positive likelihood ratio > 4.5 or negative likelihood ratio < 0.25 were eliminated. A backward stepwise logistic regression analysis was

performed on the remaining symptoms and resulted in an optimal model of duration of 4-72 hours, nausea, photophobia, and phonophobia. ROC curve analyses showed that these items had an optimal operating point (OOP) of 3 out of 4 symptom endorsements, showing a sensitivity of 94%, a specificity of 92%, and an AUC of 93% (+LR = 12.37, -LR = 0.06, PPV = 67%, NPV = 99%).

The current migraine screener performed much better than previous screening measures and has utility in identifying migraine among non-clinical and young adult samples. Potential uses of this screening measure are discussed, as are limitations of the current study and possible future directions.

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CHAPTER 1

INTRODUCTION

Migraine Diagnosis and Burden

Migraine is a commonly-occurring primary headache disorder that can be extremely disabling and can have a major impact on many areas of an individual's life. The diagnostic criteria for migraine are outlined in the 2004 International Headache Society's (IHS) *International Classification of Headache Disorders, Second Edition* (ICHD-II; Headache Classification Subcommittee of the IHS, 2004). Migraine is defined as "a recurrent headache disorder manifesting in attacks lasting 4-72 hours" either untreated or unsuccessfully treated (IHS, 2004, p. 24). Typical characteristics of migraine include unilateral location, pulsating/throbbing quality, moderate or severe intensity, aggravation by or avoidance of routine physical activity, and association with nausea and/or vomiting and/or photophobia and phonophobia (IHS, 2004). Migraine can be divided into two major sub-types: migraine without aura (1.1) and migraine with aura (1.2). Though less common than migraine without aura, migraine with aura is characterized by neurological symptoms (i.e., aura) that are usually visual in nature and typically precede the other features of migraine. (See Appendix B for full criteria for migraine with and without aura).

In the United States, migraine has a one-year prevalence of 17.1% for women and 5.6% for men (Lipton et al., 2007) and a lifetime prevalence of approximately 43% for women and 18% for men (Stewart, Wood, Reed, Roy, & Lipton, 2008). Data from the World Health

Organization indicate that migraine is the third most common medical condition on the planet (Vos et al., 2012) and among the top 20 diseases worldwide that cause disability (WHO, 2013). In the US, migraine is responsible for approximately 113 million missed workdays annually, resulting in the loss of more than $13 billion each year (Stewart, Ricci, Chee, Morganstein, & Lipton, 2003). As such, migraine diagnosis and treatment research is of great importance in order to help alleviate this societal and individual burden.

Poor Recognition and Treatment of Migraine

Although migraine is the leading reason for neurologist visits in the United States (Bekkelund & Albretsen, 2002; Carson, Ringbauer, MacKenzie, Warlow, & Sharpe, 2000), migraine remains under-recognized, under-diagnosed, and under-treated. Lipton, Amatniek, Ferrari, and Gross (1994) purported that one of the main barriers to the treatment of migraine was failure to provide an accurate diagnosis (thus precluding adequate treatment) for those who consult a physician. Approximately half of migraineurs never receive a diagnosis from a physician, and of those who do, one-third do not receive adequate treatment (Lipton, Stewart, & Simon, 1998; Lipton et al., 1994; Lipton, Diamond, Reed, Diamond, & Stewart, 2001; Lipton et al., 2002). In one Seattle-based study, primary care physicians correctly diagnosed less than 50% of migraineurs (Stang & VonKorff, 1994).

Migraine remains under-diagnosed for many reasons, one of which may be because the migraine diagnostic criteria have had poor uptake by physicians due to the number of symptoms needing assessment (Martin, Penzien, Houle, Andrew, & Lofland, 2005). Although the best method of identifying migraine would be to assess each of the ICHD-II criteria using a structured diagnostic interview (Andrew, Penzien, Rains, Knowlton, & McAnulty, 1992), clinic settings often do not afford time for an interview of this type. Multiple medical problems are often

assessed during a single primary care office visit, the average time of which is only 11- 20 minutes in the United States (Carr-Hill, Jenkins-Clarke, Dixon, & Pringle, 1998; Mechanic et al., 2001). Furthermore, the presence of multiple headache types (e.g., migraine and tension-type headache [TTH]) within an individual, which occurs in up to 51% of headache sufferers (Stang & Von Korff, 1994), makes it even less likely that migraine will be diagnosed (Lipton et al., 1994). Another reason that migraine remains under-diagnosed is because many physicians are uncomfortable evaluating headache patients due to fears about overlooking the headache with a sinister cause (Detsky et al., 2006). Although headache due to a more serious neurological condition is only present in 1% of those with chronic headache, this concern can often lead to the overuse of neuroimaging and prolong visit times (Detsky et al., 2006). In addition to these barriers, migraine remains under-diagnosed also because most individuals with migraine do not seek treatment for their migraine, likely as a function of their gender (i.e., men tend to seek treatment less frequently than women), the severity of their headache, insurance status, and other economic factors (Lipton et al., 2003; Lipton et al., 2013). Migraine under-diagnosis has several negative consequences and can be improved through effective screening.

Need for Effective Migraine Screening

Poor diagnostic recognition contributes to inadequate treatment and can contribute to higher headache-related disability and poorer health-related quality of life (Lipton et al., 2002). The US Headache Consortium recommended that one way to improve diagnosis of headache in primary care is the use of validated screening instruments (Dowson, Lipscombe, Sender, Rees, & Watson, 2002). A brief screening tool could help by increasing the speed and efficiency of migraine diagnosis, thus identifying individuals needing treatment and at high risk for other comorbidities (Lipton, Bigal, Amatniek, & Stewart, 2004). Migraine is often comorbid with

other disorders, such as depression, anxiety, epilepsy, and stroke (Lipton & Silberstein, 1994), and comorbidity is but one of the reasons that recognizing migraine early in its progression is of importance. Such is the primary goal of screening programs.

In addition, because migraine may be a progressive disease among some individuals (Bigal & Lipton, 2006), the aim of migraine screening is the early identification of individuals with migraine in order to treat current pain and prevent future pain and disability (Lipton et al., 2004). Migraine-screening measures can be viewed as a low-cost, time-effective means of disease detection. Effective screening can reduce the direct (e.g., medical care costs) and the indirect costs of migraine (e.g., unemployment, underemployment, missed work) (Lipton & Silberstein, 2001; Solomon, 1997; Stewart, Lipton, & Simon, 1996; Von Korff, Stewart, Simon, & Lipton, 1998). For decades, researchers have attempted to develop brief algorithms and screening measures for more efficient migraine identification within primary care and neurology clinic settings.

Statistics Used in Screening Instrument Literature

Statistics that are often reported in migraine identification studies of this type include sensitivity, specificity, positive and negative predictive values (PPV and NPV), and positive and negative likelihood ratios (+LR and –LR). Sensitivity (true positives) is the proportion of migraineurs correctly identified by the screening measure. If sensitivity is low, people with migraine will be missed. Specificity (true negatives) refers to people without migraine who are classified by the screener as negative for migraine. If specificity is low, people who do not have migraine will be classified as migraineurs. A sensitivity and specificity of 50% or 0.5 would mean the screening instrument is no better than chance at accurately classifying migraine status. In clinical practice, developers of screening instruments typically emphasize sensitivity over

specificity so as not to overlook individuals with the disease in question (Altman & Bland, 1994a).

Predictive values, unlike sensitivity and specificity, are influenced by the prevalence of the disease in the population of interest. If examining a population with a high prevalence of migraine (such as a headache clinic), the probability is higher that those who screen positive for migraine will actually have migraine. Whereas sensitivity and specificity answer the question "If the patient does or does not have the disease, how likely is he/she to have a positive or negative test?," the predictive values answer the question, "If the patient has a positive or negative test, how likely is he/she to have or not have the disease?" The PPV is the number of true-positives divided by the sum of all positive results (true-positives and false-positives combined), and the NPV is the number of true-negative results divided by the sum of all negative results (true-negative and false-negative results combined). A high PPV indicates a strong likelihood that a person who screened positive has migraine, whereas a low PPV is usually found in samples with low prevalence of migraine. An ideal PPV and NPV would be 100% or 1.0 (Altman & Bland, 1994b; Smith, Winkler, Fryback, 2000).

Likelihood ratios consider the pre-test probability of having a disease and, based on the results of the diagnostic test or screener, determine how much the probability of the disease increase or decreases. +LRs reflect how much the probability of disease increases if the diagnostic test is positive and -LRs reflect how much the probability of disease decreases if the diagnostic test is negative. An LR > 1 indicates an increased probability that the disorder is present, while an LR < 1 indicates a decreased probability that the disorder is present. An LR > 10 reflects a large and often conclusive increase in the probability that the disorder is present, 5-10 a moderate increase, 2-5 a small increase, 1-2 a minimal increase, and 1 reflects no change.

An LR of 0.5-1 reflects a minimal decrease in the probability that the disorder is present, 0.2-0.5 a small decrease, 0.1-0.2 a moderate decrease, and < 0.1 reflects a large and often conclusive decrease in the probability that the disorder is present (Grimes & Schulz, 2005; Jaeschke, Guyatt, & Sackett, 1994).

Symptom Algorithms Most Predictive of Migraine

Past attempts to improve the diagnosis of migraine have included statistical identification of symptoms most predictive of migraine in a given sample (algorithm studies), as well as the development of questionnaires that assess for migraine symptoms (screener-validation studies). Much research has been conducted on the subject but methods and findings are variable, and few studies have yielded brief migraine screening measures that have been subsequently employed in clinical practice.

In 2000, Smetana performed a meta-analysis of headache studies that attempted to determine which clinical features best distinguished migraine from TTH. This meta-analysis included seminal algorithm studies by Rasmussen, Jensen, and Olesen (1991), Henry et al. (1992), Michel et al. (1993), and Tom et al. (1994), among others. All studies included in this meta-analysis reported the most sensitive and specific migraine symptoms but did not attempt subsequently to validate these as part of a screening measure. (Studies attempting to validate screening measures are mentioned later in this literature review.) Smetana separated the findings of his meta-analysis into studies that used IHS diagnostic criteria and those that used other criteria before the development of the 1988 IHS criteria. Both types of studies produced similar findings: nausea showed the highest sensitivity (81%) and specificity (96%) for predicting migraine, followed by photophobia (79%, 86%), phonophobia (67%, 87%), aggravation by physical activity (81%, 78%), unilateral location (65%, 82%), and pulsating quality (73%, 75%).

Some of Smetana's findings would be replicated in subsequent similar studies; however, findings from many symptom algorithm studies often differ from one another, likely as a function of differing methodologies, different samples employed, and different comparison groups.

In 2006, Detsky et al. (2006) conducted a systematic review of the migraine diagnostic literature employing both algorithm studies as well as screener-validation studies. They excluded more than half of identified relevant studies (n = 7) for the following reasons: 1) Two studies evaluated migraine symptom clusters that were very similar to the *full* IHS criteria and, therefore, were not "screening" measures (Rasmussen, 1991; Tom et al. 1994). (These studies were included and evaluated as part of the Smetana [2000] meta-analysis.) 2) One study included only migraine patients and therefore had no estimate of specificity because it lacked a control group (Cady, Borchert, Spalding, Hart, & Sheftell, 2004). 3) Two studies evaluated migraine symptom clusters that consisted of only two questions, one of which was "have you ever had migraine?" (Gervil, Ulrich, Olesen, & Russell, 1998; Maizels & Burchette, 2003). 4) One study sought to compare headache diary diagnoses to a clinical interview without presenting rates of individual migraine symptoms (Russell et al., 1992). 5) One study included no quantitative information regarding sensitivity or specificity of migraine symptoms (Merikangas, Dartigues, Whitaker, & Angst, 1994). As a result of these exclusions, Detsky and colleagues' analysis included only one symptom study and three screener-validation studies, the latter of which are described in detail later (Lainez et al., 2005; Lipton et al., 2003; Pryse-Phillips et al., 2002).

The symptom study Detsky et al. (2006) reviewed was published by Michel et al. (1993). This study assessed for migraine symptoms in a French non-treatment-seeking headache sample. They sought to determine which migraine symptoms best differentiated migraine from "non-migraine headache" (unspecified). They found that the most sensitive migraine symptoms in this

population were headache duration (74%), photophobia/phonophobia (66%), unilateral location (65%), and pulsating quality (64%). The most specific symptoms, on the other hand, were nausea/vomiting (93%), unilateral location (85%), pulsating quality (83%), disturbance of daily activities (76%; sometimes referred to as migraine-related disability and not a diagnostic criterion per se), and aggravation by physical activity (73%). Contrary to Smetana (2000), the authors of this review concluded that headache duration (4-72 hours) and disturbance of daily activity were among the most useful symptoms for discriminating between migraine and non-migraine headache. Based on their review, Detsky et al. (2006) espoused that the mnemonic device of POUND (Pulsating, duration of 4-72 hOurs, Unilateral, Nausea, Disabling) should be used for differentiating migraine from non-migraine headache. If 4 of these 5 criteria were met, the +LR for definite or possible migraine was 24 [95% CI = 1.5-388], and if 3 of the 5 criteria were met, the +LR was 3.5 [1.3-9.2].

In a more recent study not included in either the Smetana (2000) or Detsky et al. (2006) review, Wang and colleagues (2008) sought to evaluate the diagnostic sensitivity of each ICHD-II criterion within a Taiwanese neurology patient sample. They found that moderate to severe intensity (97%), nausea/vomiting (67%), and disability (65%) were the symptoms with the highest sensitivity, while photophobia (91%), nausea/vomiting (86%), phonophobia (79%), aggravation by physical activity (71%), and disability (70%) had the highest specificity in differentiating migraine, including "probable" episodic migraine (i.e., meeting all but one diagnostic criteria for migraine), from non-migraine headache (unspecified). They found that the optimal symptom cluster was nausea/vomiting, photophobia, and moderate to severe intensity (sensitivity = 73%, specificity = 82%, PPV = 91%, +LR = 4.06, -LR = .33). The second best model was nausea/vomiting, photophobia, and disability (sensitivity = 56%, specificity = 88%,

PPV = 92%, +LR = 4.67, -LR = 0.50), identical to the items that comprise the ID Migraine™ (Lipton et al., 2003). These findings differed from previously mentioned studies in that moderate to severe intensity was among the most sensitive and specific symptoms in differentiating migraine from non-migraine headache.

Other than Michel et al. (1993), a more recent study by Martin, Penzien, Houle, Andrew, and Lofland (2005) is the only other study published to date that has examined headache in non-treatment-seeking sample. They sought to distinguish migraine (including probable migraine or "migrainous headache") from non-migraine headache, such as TTH, cluster headache, medication overuse headache (MOH), chronic daily headache (CDH), and posttraumatic headache. In addition to 680 patients from headache and neurology clinics, Martin and colleagues also evaluated 784 community members and 99 college students. Data on the non-clinical population were collected from 1989-1999. The college sample (*M* age = 27.8, 67% female) showed a migraine prevalence rate of 33%, with 8 headache days per month as the average. Within the college sample, nausea was the best indicator of migraine (+LR = 11.3, -LR = 0.35, PPV = 85%, NPV = 85%) followed by a combination of nausea, photophobia, and pulsating quality (+LR = 9.1, -LR = 0.3, PPV = 83%, NPV = 87%, AUC = 86%) and nausea, photophobia, and aggravation by physical activity (+LR = 22.3, -LR = 0.34, PPV = 92%, NPV = 85%, AUC = 87%). Although this sample was not seeking treatment, similar to that of Michel et al. (1993), the findings differed in that unilateral location and headache duration were not important discriminators of migraine, thus showing that methodological and sample differences (such as differences in comparison groups) may influence differing conclusions. However, nausea consistently appears within the algorithm literature as an important discriminator of migraine.

Symptom-Based Screening Measures

As a supplement to research attempting to identify brief algorithms for migraine diagnosis, studies have also attempted to validate brief screening measures. In one of the first international attempts to employ a migraine screening instrument, Gervil, Ulrich, and Olesen (1998) administered four questions (process of selection unknown) by telephone to a large sample of Danish twins. The questions were: 1) "Have you ever had a migraine?" 2) "Have you ever had severe headache accompanied by nausea?" 3) "Have you ever had severe headache accompanied by hypersensitivity to sound and light?" 4) "Have you ever had visual disturbances lasting 5-60 minutes followed by headache?" Endorsement of all 4 items showed a sensitivity of 85% and a specificity of 81% (PPV = 49%, NPV = 86%) in differentiating migraine from non-migraine (TTH), but the authors did not report the psychometric properties of the individual items. One limitation of this study was that Questions 2 and 3 were not able to identify any more migraineurs than were identified by Question 1 alone. In addition, the fourth question (which assessed aura) incorrectly identified 62 migraineurs who were not classified as having aura by the ICHD criteria as well as 88 non-migraineurs; a total of 45% of individuals who responded to this question were incorrectly screened as having migraine with aura. As such, this questionnaire is not psychometrically sound and has not been employed in any other published studies to date.

In a more widely referenced study conducted outside the United States, Pryse-Phillips and colleagues (2002) assessed for migraine symptoms in a Canadian neurology sample (N = 461). They attempted to identify symptoms that were best able to differentiate migraine from TTH. They found that the three symptoms of daily occurrence (reportedly used to rule-out migraine rather than diagnose migraine), unilateral location, and functional impairment (disability) best differentiated migraine from TTH. They subsequently developed a screening

measure from these three symptoms and administered it to 178 different neurology patients. The sensitivity of the three-item measure was 86%, and the specificity was 73% (PPV = 96%, NPV = 38%). This study was unlike others in that the authors chose to include a screening item that functioned to rule-out migraine rather than identify migraine. In addition, this is one of the only studies that did not include nausea as an important differentiating symptom of migraine.

In one of the first and most well-known migraine screener studies conducted within the United States, Lipton and colleagues (2003) developed what is now the most widely-used screening measure for migraine, the ID Migraine™. The ID Migraine™ is a three-item self-report measure used to screen for migraine in a primary care setting. Lipton and colleagues first administered a 9-item measure of candidate symptoms to patients and retained those that were best at discriminating migraine from other types of headache (not specified). The most sensitive migraine symptoms were nausea (81%), photophobia (74%), and aura (74%). The most specific migraine symptoms were moderate to severe pain (94%), pulsating quality (87%), headache-related disability (any one-day limitation in activities in the past 3 months; 87%), phonophobia (83%), photophobia (75%), and unilateral location (75%). The three final items retained for the ID Migraine™ (by way of backward logistic regression analysis) assess for symptoms of nausea, sensitivity to light, and headache-related disability, with only one symptom (i.e., disability) matching the results of Pryse-Phillips et al. (2002). Positive endorsement on two or more of the three items is considered a positive screen for migraine, having a sensitivity of 81% [77%-85%] and a specificity of 75% [64%-84%] (PPV = 93%, +LR = 3.2 [2.7-3.9], –LR = 0.25 [0.22-0.28]).

The ID Migraine™ has been validated in samples in different countries (Brighina et al., 2007; Gil-Gouveia & Martins, 2010) and within the US (Kim & Kim, 2006; Siva et al., 2008; Di Paolo, Di Nunno, Vanacore, & Bruti, 2009). Furthermore, two Turkish studies and one Brazilian

study have employed the ID Migraine™ to determine migraine prevalence among students (Bicakci et al., 2008; Domingues et al., 2011; Oztora et al., 2011) but did not attempt to validate the screener against a gold standard diagnosis. As such, the ID Migraine™ has never been validated within a student sample, and its diagnostic utility with non-treatment-seeking young adult headache sufferers remains undetermined.

In the same year, Maizels and Burchette (2003) sought to assess not only migraine, but also daily headache syndromes, medication overuse, and disability within a medical population. Their Brief Headache Screen (BHS) consists of seven questions, the diagnostic portion of which consists of three items: 1) "How often do you have headaches?" 2) "How often do you have severe headaches (disabling)?" 3) "How often do you take headache relievers or pain medicines?". The respondent provides an answer to each item from the options: *daily or near daily*, *3-4 days/week*, *2/week-2/month*, *1/month or less*, or *almost never*. Question 1 showed a sensitivity of 85% for identifying migraine when answered with anything other than *daily or near daily* or *almost never* and 98% when answered with anything other than *almost never*. The corresponding specificities were much lower (63% when answered *almost never* or *daily or near daily* and 29% when answered *almost never*). Maizels and Burchette did not report the sensitivity and specificity of Questions 1 and 2 combined because their goal was to differentiate episodic headache from chronic headache rather than differentiating migraine from other headache types. The BHS has limited use as a migraine screening measure, because it is lengthier than most others (7 items total), its format and scoring more complex, and its psychometric properties poorer than those of other validated measures.

Cady et al. (2004) attempted to validate a 3-Question Headache Screen in a large sample of adult migraineurs. Although the method of item selection is unknown, the questions were: 1)

"Do you have recurrent headaches that interfere with work, family, or social functions?" 2) "Does your headache last at least 4 hours?" 3) "Have you had new or different headaches in the past 6 months?" A diagnosis of migraine was suggested by a *yes* answer to questions 1 and 2 and a *no* answer to question 3. Migraineurs were recruited for this study using one of three methods: ICHD criteria (1988), physician's clinical impression, or presence of recurring disabling headaches. The 3-item screener (with a positive response to questions 1 and 2 and a negative response to question 3) identified migraine in 78% of patients meeting ICHD-II criteria. Among the entire sample, Question 2 (duration over 4 hours) was endorsed by 94.7% of migraineurs. Although not part of the screening measure, the symptoms of nausea (86%), photophobia (90%), and phonophobia (74%) were commonly reported in the diagnostic recruitment portion of the study. The use of this instrument is limited as its specificity in differentiating migraine from non-migraine headache is unknown and because its reported psychometric properties are lower than those of other similar instruments. In addition, although nausea and photophobia were commonly reported migraine symptoms, the authors did not indicate how these items performed (in differentiating migraine from other headache) nor explain why these items were not included in the screening measure.

Lainez and colleagues (2005) endeavored to identify migraine in a non-treatment-seeking sample that included individuals with migraine and those with other types of headache (predominantly TTH). They conducted their study in two stages. The initial version of the measure contained 15 questions based on the 1988 IHS diagnostic criteria. Of the original 15 candidate questions, logistic regression analyses identified four optimal questions: 1) "Do you have frequent or intense headaches?" 2) "Do your headaches usually last more than 4 hours?" 3) "Do you usually suffer from nausea when you have a headache?" 4) "Does light or noise bother

you when you have a headache?" In the second stage, the authors added a fifth question related to headache disability and administered this final questionnaire (Migraine Screening Questionnaire; MS-Q) to 137 migraineurs. A positive screen on 4 of 5 questions showed a sensitivity of 92% [87%-99%], specificity of 81% [72%-91%], PPV of 83% [75%-91%], NPV of 92% [85%-99%], +LR of 4.99 [3.04-8.19], and –LR of .09 [0.04-0.21]. The authors have since validated their questionnaire within a primary care setting (82% sensitivity, 97% specificity, PPV = 95%, NPV = 94%; Lainez et al., 2010). The MS-Q inquires about three additional migraine symptoms not in the ID Migraine (headache duration, intensity, and phonophobia) and is the only published questionnaire that was based from an algorithm and validated in a non-treatment-seeking sample of migraineurs. As such, its findings have not been replicated.

Need for the Current Study

In consideration of extant literature, the current study was needed for several reasons. First, methodological and comparison group differences between migraine studies (algorithm and screener-validation studies) limit replicability and comparability and are likely the main reasons for differing findings. Second, most of the previous literature has focused on discriminating migraine from other chronic headache syndromes likely to be represented in medical settings, but little research has been conducted in non-clinical samples that contain a high proportion of individuals with episodic TTH (ETTH), as well as individuals with chronic headache types. Lastly, although some studies have sought to create screening algorithms for identifying migraine and other studies have sought to validate migraine screening measures, rarely has the same study sought to both identify a brief algorithm for migraine and validate that algorithm as a screening measure.

One of the biggest methodological differences in the algorithm literature is that whereas some research reports on optimal "clusters" of symptoms for differentiating migraine (considering both the sensitivity and specificity of each item), other studies only provide information for those items that are the most sensitive versus those that are the most specific, without considering which items may constitute an optimal model for discriminating migraine from non-migraine headache. Additional limitations are that studies of screener validation often do not report how screener items were initially selected and comparison groups are not often described. With regard to meta-analyses and reviews, these varying methods within the culminating studies often are not taken into account before combining and reporting on their general findings. This likely is the main reason for disparate findings between studies, meta-analyses, and reviews.

The only migraine symptom that has shown to be an important discriminator of migraine across most studies is nausea, likely because individuals with other types of headache almost never experience nausea. Other symptoms of migraine, however, are less unique. For example, although photophobia, phonophobia, aggravation by physical activity, pulsating quality, and unilateral location are often present in migraine (and are, in some combination, required for a diagnosis of migraine), these symptoms can also be present in other headache syndromes.

With regard to sample differences, most research on migraine symptomatology to date has been conducted within headache clinics or primary care settings. Despite what is known about the large proportion of migraineurs who do not seek treatment or obtain an adequate diagnosis, few researchers have sought to identify the most relevant migraine symptoms within a non-treatment-seeking population. In addition, despite knowledge that incidence of migraine begins to rise most dramatically during young adulthood (Lipton, Bigal, Hamelsky, & Scher,

2008), that migraine prevalence among college students is approximately 25% (Bigal, Bigal, Betti, Bordini, & Speciali, 2001; McDermott, Peck, Walters, & Smitherman, 2013; Smitherman, McDermott, & Buchanan, 2011), and that the disability among these migraineurs is significant (Smitherman et al., 2011; Walters, Hamer, & Smitherman, 2014), only one study to date has attempted to identify the most predictive migraine symptomatology within a young adult sample (Martin et al., 2005). Notably, the student sample within the Martin et al. (2005) study was quite small ($N = 99$).

The current study attempted to differentiate migraine from other headache types within a non-treatment-seeking sample of individuals. ETTH (headache characterized by mild to moderate bilateral pressure on both sides of the head) is the most common headache disorder in the world (Fumal, & Schoenen, 2008; Stovner et al., 2007; WHO, 2013) but, unless very frequent, is uncommon in clinical settings due to its relatively mild presentation. The inclusion of these individuals (in addition to those with more chronic headache, such as medication overuse headache [MOH], cluster headache, and chronic TTH) in the current study may result in a different symptom model than previous literature.

Finally, as mentioned above, few studies have both developed an algorithm for diagnosis and validated the algorithm as a screening measure. Although studies by Pryse-Phillips et al. (2002) and Lipton et al. (2003) attempted to do both, each study has shortcomings that limit the measures' use in other populations and for purposes other than those originally intended. For example, the validation sample within the Pryse-Phillips study was relatively small ($N = 128$), and inclusion of a screening item that was used to rule-out rather than "rule-in" migraine complicates scoring and screening. In addition, their findings that left out nausea as an important discriminator of migraine call into question the study's methodological integrity. Respondents

within the ID Migraine™ validation sample were pre-selected only if they were in an early symptomatic phase of migraine but had not yet presented to their physician, thus greatly limiting generalizability to the broader population. Although the ID Migraine™ measure has since been validated in other samples, it is unclear to what degree the uniqueness of the original validation sample affected the properties of the screening instrument. Further, the disability item included in both the screening measures developed by Pryse-Phillips et al. and Lipton et al. is not a diagnostic criterion of migraine and may also be present in those with other chronic headache types (Schwartz, Stewart, Simon, & Lipton, 1998). As such, specificity of the ID Migraine™ was found to be lower than desired (75%), as was test-retest reliability (kappa = 0.68). Due to these shortcomings of the two studies that have employed both algorithm development and screener-validation, more research is needed to develop a sensitive and specific brief screening measure for migraine diagnosis.

The current study first attempted to determine statistically the most sensitive and specific ICHD-II migraine symptoms for differentiating migraine from other headache types within a non-clinical population (i.e., algorithm development). As a supplement to the work of Martin et al. (2005), the current study then attempted to validate this algorithm of symptoms within a holdout sample from the larger overall sample (i.e., screener validation) and identify an optimal cut-off point for use. As previous literature suggests, nausea was hypothesized to be the strongest discriminator of migraine followed (in no particular order) by photophobia and/or phonophobia, and aggravation by physical activity. However, because findings vary regarding optimal discriminatory migraine symptoms, no a priori hypotheses were made about other candidate symptoms such as unilateral location, duration of 4-72 hours, or pulsating quality.

CHAPTER 2

METHODS

Participants

Participants were undergraduate students at the University of Mississippi who participated in exchange for modest psychology course credit. They completed an online battery of measures beginning in the fall of 2011 and ending in the winter of 2013. For preliminary analyses, those meeting ICHD-II diagnostic criteria for episodic migraine (with or without aura) or chronic migraine comprised the migraine group, while those with episodic, chronic, or probable TTH, cluster headache, posttraumatic headache, medication overuse headache, or those who complained of headache but could not be classified comprised the non-migraine group. For supplementary analyses, probable migraineurs (i.e., meeting all but one diagnostic criteria for migraine) were included as part of the migraine group.

Measures

Structured Diagnostic Interview for Headache-Revised (SDIH-R). Included in the computerized battery of measures were questions from the computer-validated Structured Diagnostic Interview for Headache (SDIH; Andrew et al., 1992), which was modified to comport fully with current ICHD-II criteria. The computer-administered SDIH-R includes ten questions for diagnosing migraine without aura, one question assessing for headache frequency, two questions assessing for aura symptoms, five questions assessing for other headache disorders

(posttraumatic, cluster, and medication overuse headache), and a question about headache-related disability (Appendix C).

Procedures and Statistical Analyses

As mentioned above, the current study occurred in two phases. The dataset was randomly split by approximately 50%, with SDIH-R responses from the first half of participants (i.e., experimental sample) used for algorithm development and from the second half of participants (i.e., validation sample") used for screener validation.

First, chi-square analyses and independent t-tests were performed to confirm that the experimental and validation samples did not significantly differ from one another on demographic variables, headache type, average headache days per month, or average headache severity. For algorithm development, two-by-two tables were constructed using each of the migraine symptoms (present vs. absent) and headache diagnoses (migraine vs. non-migraine). The sensitivity, specificity, predictive values, and likelihood ratios were calculated for each of the migraine symptoms. Receiver-operator characteristic (ROC) curves were then plotted for each of the one-variable migraine symptom models in order to determine which symptoms were most predictive of a migraine diagnosis, as provided by the area under the curve (AUC). The ROC curve plots reflected the extent to which the symptom in question differed in prevalence among people who have migraine versus another type of headache. Next, using the optimal model guidelines in Martin et al. (2005), symptoms were eliminated if they did not have +LRs > 4.5 or –LRs < 0.25. A backward stepwise logistic regression analysis was then performed using the remaining variables to determine the optimal model for differentiating migraine from non-migraine headache. The resulting model was used as the screening measure validated in the next

phase of the study. The optimal symptom model was also explored (supplementary to the main analyses) with the inclusion of probable migraineurs.

For screener validation, two-by-two tables were constructed using each possible cut-off point of the screening measure and headache diagnosis, from which sensitivity, specificity, LRs and PVs were calculated. An ROC curve then was plotted in order to determine the correlation of the screening measure with the gold standard diagnosis (AUC estimations) and the measure's utility in differentiating migraine from other headache types as applied to the holdout validation sample. The ROC curve was used to analyze all possible cut-off points of the new screener and was used to determine the optimal operating point (OOP) of the screener (Halpern, Albert, Krieger, Metz, & Maidment, 1996). The OOP attempts to give the best trade-off between the costs of failing to detect positives and the costs of raising "false alarms." The internal consistency (Cronbach's alpha coefficient) of the new screening measure was also determined from the ROC curve analysis. Finally, the psychometric properties of the screening measure were examined as a function of gender and race. Although the screening measure was not designed to identify probable migraineurs, the utility of the screener was also examined within these individuals to supplement the main analyses.

CHAPTER 3

RESULTS

Data Analytic Assumptions

Histograms, Q-Q plots, and descriptive statistics data (i.e., skewness, kurtosis) were used to assess data analytic assumptions. The average number of headache days per month and average headache severity was normally distributed. No outliers were found on the variables of interest.

Sample Comparison

The total sample consisted of 1,966 participants who responded positively to the initial question "Do you ever get headaches?" Excluding 137 with missing data, 1,829 were classified into 10 headache categories (see Appendix A Table 1) based on their responses to the SDIH-R. The sample of 1,829 was split randomly by approximately 50% to ensure equivalence between the experimental (n = 887) and validation (n = 942) samples. Non-significant chi-square tests (for gender, race [white vs. non-white], and headache category) and independent samples t-tests (for age, headache frequency, and headache severity) confirmed that the two samples did not differ significantly on any of these variables (see Appendix A Tables 1-3).

Phase I: Experimental Sample and Algorithm Development

Characteristics of the Experimental Sample

Participants in the experimental sample were 70.8% female and 74.5% white, with a mean age of 19.05 (*SD* = 1.96). Sixty-nine (7.8%) participants met ICHD-II diagnostic criteria

for migraine (chronic or episodic with or without aura), thus comprising the migraine group, and 552 (62.2%) met diagnostic criteria for another type of headache, thus comprising the non-migraine group. In addition, 266 (30.0%) met criteria for probable migraine. They were excluded from primary analyses in order to comport strictly with the ICHD-II diagnostic criteria for migraine, but they were included as part of the migraine group in supplementary analyses.

Episodic migraineurs with aura (n = 17) and without aura (n = 29) within the experimental sample reported an average of 6.94 (SD = 3.09) and 7.76 (SD = 5.60) headache days per month, respectively, while chronic migraineurs (n = 23) reported an average of 18.61 (SD = 4.07) headache days per month. The average number of headache days per month reported by all migraineurs (11.17 [SD = 6.98]) was significantly higher than the average number of headache days per month reported by individuals with non-migraine headache (5.29 [SD = 4.72]; $t(619) = -9.20$, $p < .001$). Average headache severity was not significantly different between chronic (M = 6.13, SD = 1.06) and episodic (M = 6.37, SD = 1.60) migraineurs, $t(67) = 0.65$, $p = .518$; however, as expected migraineurs reported significantly higher pain severity (6.29 [SD = 1.44]) than did individuals with non-migraine headache (3.88 [SD = 1.62]; $t(619) = -11.76$, $p < .001$).

Algorithm Development

Within the experimental sample, the performance of each migraine symptom was compared to the gold standard diagnosis of migraine as acquired via the SDIH-R. Two-by-two tables were created showing the number of migraineurs and non-migraineurs endorsing each symptom (see Appendix A Table 4), from which sensitivity, specificity, positive and negative likelihood ratios, and positive and negative predictive values were calculated (see Appendix A Table 5). Headache duration of 4-72 hours showed the highest sensitivity (100%), followed by

severity ≥ 5 (91%), photophobia (90%), and phonophobia (90%). In contrast, vomiting showed the highest specificity (98%), followed by duration of 4-72 hours (92%), nausea (89%), and disability (defined as headaches interfering with work, school, or personal life; 88%).

ROC curves were then plotted in order to determine which symptoms were best at differentiating migraine from other headache types (see Appendix A Table 5). Duration of 4-72 hours had the largest AUC (96%), followed by photophobia (78%), severity ≥ 5 (78%), and nausea (77%). Next, unilateral location, pulsing quality, and worsening by physical activity were ruled-out as part of the optimal model as they did not have an +LR > 4.5 or –LR < 0.25. The remaining 7 symptoms (i.e., duration of 4-72 hours, severity ≥ 5, nausea, vomiting, photophobia, phonophobia, and disability) were entered in a backward stepwise logistic regression analysis to determine the optimal model for distinguishing migraine from other headache types. The retained optimal model consisted of duration of 4-72 hours (B = 21.08), nausea (B = 1.18), photophobia (B = 1.87), and phonophobia (B = 1.54). This model was validated as a screening measure in the next phase of the study.

Using the same procedures delineated above, analyses were repeated when including probable migraineurs as part of the migraine sample (see Appendix A Table 6). When including those with probable migraine in the migraine group, duration of 4-72 hours no longer displayed the greatest sensitivity. Instead, photophobia showed the highest sensitivity (90%), followed by phonophobia (89%), pulsing quality (77%), and severity ≥ 5 (73%). AUCs were also different from the original model; photophobia showed the highest AUC (78%), followed by phonophobia (72%), nausea (70%), and severity ≥ 5 (69%) (see Appendix A Table 7). Optimal likelihood ratios when including those with probable migraine were found for nausea (B = 1.77) and photophobia (B = 2.73). Because this was a supplementary aim of the present study, validation

was not attempted on this 2-symptom model. Instead, the validity of the original 4-symptom screener was explored within probable migraine sufferers in subsequent validation analyses.

Phase II: Validation Sample and Screener Validation

Characteristics of the Validation Sample

Participants in the validation sample were 72.2% female and 74.2% white, with a mean age of 19.12 (*SD* = 2.13). Eighty-nine (9.4%) participants met ICHD-II diagnostic criteria for migraine (chronic or episodic with or without aura), thus comprising the migraine group, and 552 (58.6%) met diagnostic criteria for another type of headache, thus making up the non-migraine group. In addition, 301 (32.0%) met criteria for probable migraine and were explored as part of the migraine group in supplementary analyses.

Episodic migraineurs with aura (*n* = 26) and without aura (*n* = 45) within the validation sample reported an average of 6.65 (*SD* = 3.43) and 6.29 (*SD* = 3.28) headache days per month, respectively, while chronic migraineurs (*n* = 18) reported an average of 18.44 (*SD* = 4.66) headache days per month. The average number of headache days per month reported by all migraineurs (8.85 [*SD* = 6.04]) was significantly higher than the average number of headache days per month reported by individuals with non-migraine headache (5.46 [*SD* = 4.87]; $t(639) = -5.89$, $p < .001$). Average headache severity was not significantly different between chronic (*M* = 6.78, *SD* = 1.35) and episodic (*M* = 5.99, *SD* = 1.66) migraineurs, $t(87) = -1.87$, $p = .065$; however, as expected migraineurs reported significantly higher pain severity (6.15 [*SD* = 1.63]) than did individuals with non-migraine headache (3.81 [*SD* = 1.64]; $t(638) = -12.49$, $p < .001$).

Screener Validation

To validate the prior 4-factor model as a screening algorithm in the holdout validation sample, two-by-two tables were created for each possible cut-off point of the screener (see

Appendix A Table 8), from which sensitivity, specificity, positive and negative likelihood ratios, and positive and negative predictive values were calculated (see Appendix A Table 9). The OOP for the screener was positively endorsing 3 out of 4 items. This OOP had a sensitivity of 94% and a specificity of 92% (+LR = 12.37, -LR = .06, PPV 67%, NPV 99%). ROC curve analyses were used to determine the correlation of each cut-off point with the gold standard diagnosis of migraine (see Appendix A Table 9). The AUC of positively endorsing 1 or more items was 69% [95% CI: 65-74%], of 2 or more items was 87% [85-90%], of 3 or more items was 93% [90-96%], and of all 4 items was 78% [72-85%]. When including probable migraineurs, the 4-item screener showed an OOP of responding positively to 2 or more items (AUC = 87% [84-89%]; see Appendix A Table 11). All items in the screening algorithm were significantly intercorrelated (rs from .18 to .51, ps $\leq$ .01) and were highly correlated with the OOP of the screener (rs from .42 to .71, ps $\leq$ .01). The internal consistency (Cronbach's alpha) for this measure was .60.

Group Differences in Screener Performance

As shown in Appendix A Table 12, the screening measure performed better statistically among men than in women at all 4 cut-off points; however this statistically significant difference is almost certainly a function of the large sample size and not clinically meaningful, as the AUC at the OOP of the screener was 94% among men versus 93% among women) The screener performed equally well among white and non-white individuals (see Appendix A Table 13).

CHAPTER 4

DISCUSSION

The current study sought to identify an algorithm for migraine diagnosis and to validate this algorithm as a screening instrument in a non-treatment-seeking sample of young adults. Previous studies within this area of study rarely have attempted to accomplish both these goals within the same sample, and prior research of this type varies widely with regard to methodology, comparison groups, and results. Duration of 4-72 hours, nausea, photophobia, and phonophobia composed the optimal model for differentiating migraine from non-migraine headache and showed high sensitivity, specificity, and correlation with the gold standard diagnosis at the OOP. The screening measure was not as well able to differentiate migraine from non-migraine headache when including probable migraineurs but still proved useful at distinguishing migraine (when including probable migraineurs) at a different OOP.

The screening measure had very strong clinical utility among men and women and among white and non-white individuals at its optimal operating point. Although the internal consistency (Cronbach's alpha) for this measure was poor, this finding is not surprising given the few number of items retained and their lack of redundancy; this does not preclude its use given the purpose of the measure (Tavakol & Dennick, 2011). In general, the current findings confirmed the a priori hypotheses and resemble findings of extant literature.

Migraine Prevalence

The prevalence rate of migraine within the current study (8.6%) was lower than that suggested by previous literature conducted within the same population (Smitherman et al., 2011; Walters et al., 2014). These studies found that approximately one quarter of college students met criteria for episodic migraine. However, these studies extended migraine duration to two hours instead of four, and thus included probable migraineurs. When including probable migraineurs in the current sample, prevalence rises to approximately 40%, which more closely matches the findings of Martin and colleagues (2005), who found a prevalence rate of 33% (including probable migraineurs) in a college sample. Another possible explanation for the disparity in prevalence could be the difference in methodology used for diagnosing headache. For example, Smitherman et al. and Walters et al. employed the same computer-administered diagnostic interview as the current study, but the former studies administered the interview in-person, rather than online. This in-person method allowed for more clinical judgment regarding diagnosis, as well as the ability for clarification and follow-up questions, whereas the computer-administered version of the diagnostic criteria in the current study did not allow for this type of follow-up and was more rigid in diagnosis.

Comparison to previous findings

In the current study, duration of 4-72 hours, severity ≥ 5, photophobia, and phonophobia showed the highest sensitivity, while vomiting, duration of 4-72 hours, nausea, and disability showed the highest specificity. Ultimately, the 10 migraine symptoms were effectively reduced to a 4-item screener including the symptoms of duration of 4-72 hours, nausea, photophobia, and phonophobia. These findings are generally similar to those of most previous studies, but this is the first study to find this unique combination of duration of 4-72 hours, nausea, photophobia, and phonophobia as an effective screener for migraine. The meta-analysis by Smetana (2000);

the review by Detsky et al. (2006); and studies by Michel et al. (1993), Wang et al. (2008), Martin et al. (2005), Lipton et al. (2003), Cady et al. (2004), and Lainez et al. (2005) all found that nausea and photophobia were among the most sensitive and specific symptoms for distinguishing migraine from other headache types. In addition, five of these studies also found phonophobia to be one of the most sensitive and specific symptoms for identifying migraine (Cady et al., 2004; Lainez et al., 2005; Michel et al., 1993; Smetana, 2000; Wang et al., 2008), but it was included as part of the optimal model in only one of these studies (Lainez et al., 2005).

The main difference in findings between the current study and previous literature is that of duration being an important differentiator of migraine in combination with these other symptoms. While Detsky et al. (2006), Michel et al. (2006), and Cady et al. (2004) found duration to be one of the most important distinguishers of migraine, the other aforementioned studies did not have these same findings. This disparity in findings is most likely due to the difference in comparison groups among the studies. Studies by Wang et al. (2008) and Martin et al. (2005) indicated that their migraine samples included probable migraineurs, while the meta-analysis by Smetana (2000) likely also included probable migraineurs (although it was unclear from the methods). As noted earlier, younger probable migraineurs often endorse shorter-than-typical headache duration (i.e., under 4 hours), and thus may mitigate the importance of duration in differentiating migraine from non-migraine headache. This rationale is strengthened by the present finding that duration showed poor sensitivity when including probable migraineurs (27% vs. 100% without probable migraineurs).

Another notable difference between this study and others is the lack of predictive importance of disability within the current study. Studies that found disability to be an important predictor of migraine, such as those by Wang et al. (2008), Cady et al. (2004), and Lipton et al.

(2003), were inconsistent in how disability was defined, and therefore, their findings regarding the utility of this variable cannot be directly compared. In addition, these studies were conducted with treatment-seeking samples that are overall more likely to endorse a greater level of disability, while the current study was conducted using a comparison group of individuals having numerous forms of primary and secondary headaches and thus varying levels of disability.

Implications of the current findings

The OOP of the current 4-question screener was a positive endorsement on 3 or more items, showing 94% sensitivity and 92% specificity. The current screener outperformed the ID Migraine™ (81% sensitivity, 75% specificity; Lipton et al., 2003), the 3-item screener developed by Cady et al., 2004 (77% sensitivity), the screener recommended by Pryse-Phillips et al. (2002) (86% sensitivity and 73% specificity), and even a longer measure, the MS-Q (92% sensitivity and 81% specificity; Lainez et al., 2005). The screener also performed well among probable migraineurs, showing a sensitivity of 98% and specificity of 75% at its OOP (positively endorsing at least 2 out of 4 items). Although the current screener appears to be extremely accurate at differentiating migraine from other headache and may be especially useful clinically, screeners are often best used among the population in which they are developed until further validation assesses their utility in other populations.

The use of this screening measure within a non-treatment-seeking sample could help to identify individuals with migraine who have not previously been diagnosed by a healthcare professional. Early diagnosis is essential to adequate treatment for migraine (Lipton et al., 1994) and early diagnostic screening is one of the best ways to reduce societal burden and cost, as well as individual burden, disability, and chronification of headache over time (Dowson et al., 2002; Lipton & Silberstein, 2001; Lipton et al., 2002, 2004; Solomon, 1997; Stewart et al., 1996; Von

Korff et al., 1998). This screener may prove to be useful in differential diagnosis for individuals with multiple headache types (Stang & VonKorff, 1994) and could help to identify those at risk for other comorbidities (Lipton et al., 2004), although these possibilities await empirical verification.

Limitations and Future Directions

Some limitations of the current study and screener exist. One main limitation is that the authors did not re-administer independently to the holdout sample the 4 items that comprised the screening measure. Although there is not yet any evidence to suggest that symptom endorsement would differ if the screening measure was administered in isolation (versus with other items), the possibility exists and awaits empirical confirmation. In addition, as mentioned above, headache sufferers in the current study were diagnosed using a computerized questionnaire, which does not allow for inquiry or clarification of responses, as does an in-person interview. Future research should attempt to validate this screening measure in this same population by administering the screener and comparing results to gold standard diagnosis as assigned by in-person diagnostic interviews.

Future research should also attempt to validate this measure within a treatment-seeking sample. Preliminary findings suggest that this measure could be extremely useful in differentiating migraine from other headaches in non-treatment-seeking young adults; however, the use of this screener does not have to be limited to this population. Further attempts to validate this screening measure in other samples could expand its usefulness to clinical populations. Because physicians often do not have time to assess all diagnostic criteria or conduct a lengthy structured interview (Martin et al., 2005), the inclusion of this 4-item measure could be used to identify a large proportion of migraineurs that are often not diagnosed (Lipton et al., 2002; Stang

& VonKorff, 1994). In addition to clinical uses, the screener could also be used in research studies to more accurately estimate the prevalence rate of migraine in a given population. Finally, head-to-head comparisons of this screener and other widely used migraine screening measures are warranted. Collectively, this study and future validation efforts will clarify the potential utility of this promising screener.

REFERENCES

Altman, D. G., & Bland, J. M. (1994a). Diagnostic tests 1: Sensitivity and specificity. *BMJ, 308*, 1552.

Altman, D. G., & Bland, J. M. (1994b). Diagnostic tests 2: Predictive values. *BMJ, 309*, 102.

Altman, D. G., & Bland, J. M. (1994c). Diagnostic tests 3: Receiver operating characteristic plots. *BMJ, 309*, 188.

Andrew, M. E., Penzien, D. B., Rains, J. C., Knowlton, G. E., & McAnulty, R. D. (1992). Development of a computer application for headache diagnosis: The Headache Diagnostic System. *International Journal of Biomedical Computing, 31*, 17-24.

Bekkelund, S. I., & Albretsen, C. (2002). Evaluation of referrals from general practice to a neurological department. *Family Practice, 19*, 297-299.

Bicakci, S., Bozdemir, N., Over, F., Saatci, E., & Sarica, Y. (2008). Prevalence of migraine diagnosis using ID Migraine among university students in southern Turkey. *Journal of Headache Pain, 9*, 159-163.

Bigal, M. E., Bigal, J. M., Betti, M., Bordini, C. A., & Speciali, J. G. (2001). Evaluation of the impact of migraine and episodic tension-type headache on the quality of life and performance of university student population. *Headache, 41*, 710-719.

Bigal, M. E., & Lipton, R. B. (2006). Modifiable risk factors for migraine progression (or for chronic daily headaches): Clinical lessons. *Headache, 46*(Suppl 3), S144-S146.

Brighina, F., Salemi, G., Fierro, B., Gasparro, A., Balletta, A., Aloisio, A….Morana, R. (2007). A validation study of an Italian version of the ID Migraine. *Headache, 47*, 905-908.

Cady, R. K., Borchert, L. D., Spalding, W., Hart, C. C., & Sheftell, F. D. (2004). Simple and efficient recognition of migraine with 3-question headache screen. *Headache, 44*, 323-327.

Carr-Hill, R., Jenkins-Clarke, S., Dixon, P., & Pringle, M. (1998). Do minutes count? Consultation lengths in general practice. *Journal of Health Services Research and Policy, 3*, 207-213.

Carson A. J., Ringbauer, B., MacKenzie, L., Warlow, C., & Sharpe, M. (2000). Neurological disease, emotional disorder, and disability, they are related: A study of 300 consecutive new referrals to a neurology outpatient department. *Journal of Neurology, Neurosurgery, and Psychiatry, 68*, 202-206.

Celentano, D. D., Linet, M. S., & Stewart, W. F. (1990). Gender differences in the experience of headache. *Social Science & Medicine, 30*, 1289-1295.

Detsky, M. E., McDonald, D. R., Baerlocher, M. O., Tomlinson, G. A., McCrory, D. C., & Booth, C. M. (2006). Does this patient with headache have a migraine or need neuroimaging? *JAMA, 296*, 1274-1283.

Di Paolo, C., DiNunno, A., Vanacore, N., & Bruti, G. (2009). ID Migraine questionnaire in temporomandibular disorders with craniofacial pain: A study by using a multidisciplinary approach. *Neurological Sciences, 30*, 295-299.

Domingues, R. B., & Domingues, S. A. (2011). Headache is associated with lower alcohol consumption among medical students. *Arquivos de Neuro-Psiquitria, 69*, 620-623.

Fumal, A., & Schoenen, J. (2008). Tension-type headache: Current research and clinical management. *The Lancet Neurology, 7*, 70-83.

Gervil, M., Ulrich, V., Olesen, J., & Russell, M. B. (1998). Screening for migraine in the general population: Validation of a simple questionnaire. *Cephalalgia, 18*, 342-348.

Gil-Gouveia, R., & Martins, I. (2010). Validation of the Portuguese Version of the ID Migraine. *Headache, 50*, 396-402.

Grimes, D. A., & Schulz, K. F., (2005). Refining clinical diagnosis with likelihood ratios. *Lancet, 365*, 1500-1505.

Halpern, E. J., Albert, M., Krieger, A. M., Metz, C. E., & Maidment, A. D. (1996). Comparison of receiver operating characteristic curves on the basis of optimal operating points. *Academic Radiology, 3*, 245-253.

Headache Classification Committee of the International Headache Society. (1988). Classification and diagnostic criteria for headache disorders, cranial neuralgias and facial pain. *Cephalalgia, 8*, 1-96.

Headache Classification Committee of the International Headache Society. (2004). The international classification of headache disorders. *Cephalalgia*; 24(suppl 1):1-160.

Henry, P., Michel, P., Brochet, B., Dartigues, J. F., Tison, S., & Salamon, R. (1992). A nationwide survey of migraine in France: Prevalence and clinical features in adults. *Cephalalgia, 12*, 229-237.

Jaeschke, R., Guyatt, G. H., & Sackett, D. L. (1994). Users' guides to the medical literature. *JAMA, 271*, 703-707.

Kim, S. T., & Kim, C. Y. (2006). Use of the ID Migraine questionnaire for migraine in TMJ and Orofacial Pain Clinic. *Headache, 46*, 253-258.

Lainez, M. J. A., Dominguez, M., Rejas, J., Palacios, G., Arriaza, E., Garcia-Garcia, M., & Madrigal, M. (2005). Development and validation of the Migraine Screen Questionnaire (MS-Q). *Headache, 45*, 1328-1338.

Lipton, R. B., Amatniek, J. C., Ferrari, M. D., & Gross, M. (1994). Migraine: Identifying and removing barriers to care. *Neurology, 44*(Suppl 4), S63-S68.

Lipton, R. B., Bigal, M. E., Diamond, M., Freitag, F., Reed, M. L., & Stewart, W. F. (2007). Migraine prevalence, disease burden, and the need for preventative therapy. *Neurology, 68*, 343-349.

Lipton, R. B., Bigal, M. E., Amatniek, J. C., & Stewart, W. F. (2004). Tools for diagnosing migraine and measuring its severity. *Headache, 44*, 387-398.

Lipton, R. B., Bigal, M. E., Hamelsky, S., & Scher, A. I. (2008). Headache: Epidemiology and impact. In S. D. Silberstein, R. B. Lipton, & D. W. Dodick (Eds.), *Wolff's headache and other head pain* (pp. 45-62). New York, NY: Oxford University Press.

Lipton, R. B., Diamond, S., Reed, M., Diamond, M. L., & Stewart, W. F. (2001). Migraine diagnosis and treatment: Results from the American Migraine Study II. *Headache, 41*, 638-645.

Lipton, R. B., Dodick, D., Sadovsky, R., Kolodner, K., Endicott, J., Hettiarachchi, J., & Harrison, W. (2003). A self-administered screener for migraine in primary care: The ID migraine validation study. *Neurology, 61*, 375-382.

Lipton, R. B., Scher, A. I., Kolodner, K., Liberman, J., Steiner, T. J., & Stewart, W. F. (2002). Migraine in the United States: Epidemiology and patterns of health care use. *Neurology, 58*, 885-894.

Lipton, R. B., Scher, A. I., Steiner, T. J., Bigal, M. E., Kolodner, K., Liberman, J. N., & Stewart, W. F. (2003). Patterns of health care utilization for migraine in England and in the United States. *Neurology, 60*, 441-448.

Lipton, R. B., Serrano, D., Holland, S., Fanning, K. M., Reed, M. L., & Buse, D. C. (2013). Barriers to the diagnosis and treatment of migraine: Effects of sex, income, and headache features. *Headache, 53*, 81-92.

Lipton, R. B., & Silberstein, S. D. (1994). Why study the comorbidity of migraine? *Neurology, 44*(suppl 7), S4-S5.

Lipton, R. B., & Silberstein, S. D. (2001). The role of headache-related disability in migraine management: Implications for headache treatment guidelines. *Neurology, 56*(suppl 1), 35-42.

Lipton, R. B., Stewart, W. F., & Simon, D. (1998). Medical consultation for migraine: Results from the American migraine study. *Headache, 38*, 87-96.

Maizels, M., & Burchette, R. (2003). Rapid and sensitive paradigm for screening patients with headache in primary care settings. *Headache, 43*, 441-450.

Martin, V. T., Penzein, D. B., Houle, T. T., Andrew, M. E., & Lofland, K. R. (2005). The predictive value of abbreviated migraine diagnostic criteria. *Headache, 45*, 1102-1112.

McDermott, M. J., Peck, K. R., Walters, A. B., & Smitherman, T. A. (2013). Do migraineurs selectively attend to headache-related visual stimuli? *Headache*, *53*, 356-364.

Mechanic, D., McAlpine, D. D., & Rosenthal, M. (2001). Are patients' office visits with physicians getting shorter? *New England Journal of Medicine, 344*, 198-204.

Merikangas, K. R., Dartigues, J. F., Whitaker, A., & Angst, J. (1994). Diagnostic criteria for migraine: A validity study. *Neurology, 44*(suppl 4), S11-S16.

Michel, P., Henry, P., Letenneur, L., Jogeix, M., Corson, A., & Dartigues, J. F. (1993). Diagnostic screen for assessment of the IHS criteria for migraine by general practitioners. *Cephalalgia, 13*(suppl 12), 54-59.

Oztora, S., Korkmaz, O., Dagdeviren, N., Celik, Y., Caylan, A., Top, M. S., & Asil, T. (2011). Migraine headache among university students using ID Migraine as a screening tool. *BioMed Central Neurology, 11*, 103.

Pryse-Phillips, W., Aube, M., Gawel, M., Nelson, R., Purdy, A., & Wilson, K. (2002). A headache diagnosis project. *Headache, 42*, 728-737.

Rasmussen, B. K., Jensen, R., & Olesen, J. (1991). Questionnaire versus clinical interview in the diagnosis of headache. *Headache, 31*, 290-295.

Rasmussen, B. K., Jensen, R., & Olesen, J. (1991). A population-based analysis of the diagnostic criteria of the International Headache Society. *Cephalalgia, 11*, 129-134.

Russell, M. B., Rasmussen, B. K., Brennum, J., Iversen, H. K., Jensen, R. A., & Olesen, J. (1992). Presentation of a new instrument: The diagnostic headache diary. *Cephalalgia*, *12*(6), 369-374.

Schwartz, B. S., Stewart, W. F., Simon, D., & Lipton, R. B. (1998). Epidemiology of tension-type headache. *JAMA, 279*, 381-383.

Siva, A., Zarifoglu, M., Ertas, M., Saip, S., Karli, H. N., Baykan, B.,…Senocak, M. (2008). Validity of the ID Migraine screener in the workplace. *Neurology, 70*, 1337-1345.

Smetana, G. W. (2000). The diagnostic value of historical features in primary headache syndromes. *Archives of Internal Medicine, 160*, 2729-2737.

Smith, J. E., Winkler, R. L., & Fryback, D. G. (2000). The first positive: Computing positive predictive value at the extremes. *Annals of Internal Medicine, 132*, 804-809.

Smitherman, T. A., McDermott, M. J., & Buchanan, E. M. (2011). Negative impact of migraine on a university population: Quality of life, functional impairment, and comorbid psychiatric symptoms. *Headache, 51*, 581-589.

Solomon, G. D. (1997). Evolution of the measurement of quality of life in migraine. *Neurology, 48*(suppl 3), 10-15.

Stang, P. E., & Von Korff, M. (1994). The diagnosis of headache in primary care: Factors in the agreement of clinical and standardized diagnoses. *Headache, 34*, 138-142.

Stewart, W. F., Lipton, R. B., & Simon, D. S. (1996). Work-related disability: Results from the American Migraine Study. *Cephalalgia, 16*, 231-238.

Stewart, W. F., Ricci, J. A., Chee, E., Morganstein, D., & Lipton, R. (2003). Lost productive time and cost due to common pain conditions in the US workforce. *JAMA, 290*, 2443-2454.

Stewart, W. F., Wood, C., Reed, M. L., Roy, J., & Lipton, R. B. (2008). Cumulative lifetime migraine incidence in women and men. *Cephalalgia, 28*, 1170-1178.

Stovner, L. J., Hagen, K., Jensen, R., Katsarava, Z., Lipton, R. B., Scher, A. I.,…Zwart, J-A. (2007). The global burden of headache: A documentation of headache prevalence and disability worldwide. *Cephalalgia, 27*, 193-210.

Schwartz, B. S., Stewart, W. F., Simon, D., & Lipton, R. B. (1998). Epidemiology of tension-type headache. *JAMA, 279*, 381-383.

Tavakol, M. & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education, 2*, 53-55.

Tom, T., Brody, M., Valabhji, A., Turner, L., Molgaard, C., & Rothrock, J. (1994). Validation of a new instrument for determining migraine prevalence: The UCSD Migraine Questionnaire. *Neurology, 44*, 925-928.

Von Korff, M., Stewart, W. F., Simon, D. S., & Lipton, R. B. (1998). Migraine and reduced work performance: A population-based diary study. *Neurology, 50*, 1741-1745.

Vos, T., Flaxman, A. D., Naghavi, M., Lozano, R., Michaud, C., Ezzati, M., … Murray, C. J. L. (2012). Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries

1990-2010: A systematic analysis for the Global Burden of Disease Study 2010. *Lancet*, *280*, 2163-2196.

Walters, A. B., Hamer, J. D., & Smitherman, T. A. (2014). Sleep disturbance and affective comorbidity among episodic migraineurs. *Headache, 54,* 116-124.

Wang, S. J., Fuh, J. L., Huang, S. Y., Yang, S. S., Wu, Z. A., Hsu, C. H., Wang, C. H., Yu, H. Y., & Wang, P. J. (2008). Diagnosis and development of screening items for migraine in neurological practice in Taiwan. *Journal of the Formosan Medical Association, 107*, 485-494.

APPENDICES

APPENDIX A: TABLES

Table 1

Demographics and Headache Diagnoses

	Experimental Sample n = 887	**Validation Sample** n = 942	***P* =**	**Entire Sample** N = 1,829
Demographics				
Age *M* (*SD*)	19.05 (1.96)	19.12 (2.13)	.476	19.09 (2.05)
Gender			.511	
Female	628 (70.8%)	680 (72.2%)		1,308 (71.5%)
Male	259 (29.2%)	262 (27.8%)		521 (28.5%)
Race			.877	
White	661 (74.5%)	699 (74.2%)		1,360 (74.4%)
Black	147 (16.6%)	184 (19.5%)		331 (18.1%)
Other	79 (8.9%)	59 (6.3%)		138 (7.5%)
Headache Type				
CM	23 (2.6%)	18 (1.9%)	.325	41 (2.2%)
EM w/out aura	29 (3.3%)	45 (4.8%)	.102	74 (4.0%)
EM w/aura	17 (1.9%)	26 (2.8%)	.234	43 (2.4%)
Migraine	**69 (7.8%)**	**89 (9.4%)**	**.137**	**158 (8.6%)**
*PM	*266 (30.0%)	*301 (32.0%)	*.364	*567 (31.0%)
CTTH	12 (1.4%)	16 (1.7%)	.547	28 (1.5%)
ETTH	184 (20.7%)	177 (18.8%)	.294	361 (19.7%)
PTTH	219 (24.7%)	203 (21.5%)	.111	422 (23.1%)
Cluster	18 (2.0%)	18 (1.9%)	.855	36 (2.0%)
Posttraumatic	40 (4.5%)	52 (5.5%)	.323	92 (5.0%)
MOH	1 (0.1%)	1 (0.1%)	.966	2 (0.1%)
No Diagnosis	78 (8.8%)	85 (9.0%)	.863	163 (8.9%)
Non-Migraine	**552 (62.2%)**	**552 (58.6%)**	**.137**	**1,104 (60.4%)**

CM = Chronic migraine; EM = Episodic migraine; PM = Probable migraine; CTTH = Chronic tension-type headache; ETTH = Episodic tension-type headache; PTTH = Probable tension-type headache; MOH = Medication overuse headache

*Probable migraineurs were excluded from the preliminary analyses, but were included as part of the migraine group in secondary analyses

Table 2

Mean Headache Days Per Month (0-30)

Headache Type	**Experimental Sample** n = 887	**Validation Sample** n = 942	***P* =**	**Entire Sample** N = 1,829
CM	18.61 (*SD* = 4.07)	18.44 (4.66)	.905	18.54 (4.28)
EM w/out aura	7.76 (5.60)	6.29 (3.28)	.159	6.86 (4.37)
EM w/aura	6.94 (3.09)	6.65 (3.43)	.782	6.77 (3.27)
PM	7.27 (5.53)	7.38 (5.90)	.831	7.33 (5.72)
CTTH	16.67 (3.26)	18.94 (5.54)	.218	17.96 (4.77)
ETTH	4.91 (3.41)	4.85 (2.91)	.844	4.88 (3.17)
PTTH	5.03 (4.76)	5.16 (4.17)	.766	5.09 (4.48)
Cluster	9.67 (5.25)	8.78 (5.02)	.607	9.22 (5.08)
Posttraumatic	7.53 (5.47)	8.13 (6.46)	.633	7.87 (6.03)
*MOH	17	25	NA	21 (5.66)
No Diagnosis	2.83 (3.00)	2.34 (1.80)	.207	2.57 (2.45)

CM = Chronic migraine; EM = Episodic migraine; PM = Probable migraine; CTTH = Chronic tension-type headache; ETTH = Episodic tension-type headache; PTTH = Probable tension-type headache; MOH = Medication overuse headache

*MOH sufferers could not be compared on average headache days per month because there were only two MOH sufferers.

Table 3

Mean Headache Severity (0-10)

Headache Type	**Experimental Sample** n = 887	**Validation Sample** n = 942	***P* =**	**Entire Sample** N = 1,829
CM	*M* = 6.13 (*SD* = 1.06)	6.78 (1.35)	.093	6.41 (1.22)
EM w/out aura	6.48 (1.77)	5.73 (1.76)	.079	6.03 (1.79)
EM w/aura	6.18 (1.29)	6.42 (1.39)	.562	6.33 (1.34)
PM	5.24 (1.60)	5.15 (1.65)	.540	5.19 (1.63)
CTTH	5.33 (1.23)	4.44 (1.21)	.065	4.82 (1.28)
ETTH	4.01 (1.43)	3.88 (1.28)	.366	3.95 (1.36)
PTTH	3.67 (1.47)	3.68 (1.49)	.909	3.67 (1.48)
Cluster	5.28 (1.99)	5.50 (1.82)	.729	5.39 (1.89)
Posttraumatic	5.10 (1.85)	5.12 (1.87)	.969	5.11 (1.85)
MOH	5	9	NA	7 (2.83)
No Diagnosis	3.00 (1.60)	2.65 (1.50)	.148	2.82 (1.55)

CM = Chronic migraine; EM = Episodic migraine; PM = Probable migraine; CTTH = Chronic tension-type headache; ETTH = Episodic tension-type headache; PTTH = Probable tension-type headache; MOH = Medication overuse headache

*MOH sufferers could not be compared on average headache severity because there were only two MOH sufferers.

Table 4

Experimental Sample: 2X2 Symptom Tables for Each Migraine Symptom (n = 621 with headache)

		Migraine (excluding PM)	
		Yes	**No**
Duration (4-72 hours)	**Present**	69	42
	Not Present	0	510
	Total	69	552
Unilateral	**Present**	34	211
	Not Present	35	339
	Total	69	550
Pulsing	**Present**	55	279
	Not Present	14	272
	Total	69	551
Severity ≥ 5	**Present**	63	194
	Not Present	6	358
	Total	69	552
Worsened by activity	**Present**	53	180
	Not Present	15	372
	Total	69	552
Nausea	**Present**	45	61
	Not Present	24	491
	Total	69	552
Vomiting	**Present**	13	11
	Not Present	56	539
	Total	69	550
Photophobia	**Present**	62	180
	Not Present	7	363
	Total	69	543
Phonophobia	**Present**	62	246
	Not Present	7	306
	Total	69	552

Disability	**Present**	44	65
	Not Present	25	482
	Total	69	547

Table 5

Experimental Sample: Migraine Symptom Performance

	Sensitivity	**Specificity**	**+LR**	**-LR**	**PPV**	**NPV**	**AUC**
Duration (4-72 hrs)	100% (95% CI: 95-100)	92% (90-94%)	13.14 (9.83-17.58)		62% (52-71%)	100% (99-100%)	96% (95-98%)
Unilateral	49% (37-62%)	62% (57-66%)	1.28 (.99-1.67)	.82 (.65-1.05)	14% (10-19%)	91% (87-93%)	56% (49-63%)
Pulsing	80% (68-88%)	49% (45-54%)	1.57 (1.36-1.82)	.41 (.26-.66)	16% (13-21%)	95% (92-97%)	65% (58-71%)
Severity ≥ 5	91% (82-97%)	65% (61-69%)	2.60 (2.27-2.97)	0.13 (.06-.29)	25% (19-30%)	98% (96-99%)	78% (73-83%)
Worsened by activity	78% (66-87%)	67% (63-71%)	2.39 (2.01-2.85)	.33 (.21-.51)	23% (18-29%)	96% (94-98%)	72% (66-79%)
Nausea	65% (53-76%)	89% (86-91%)	5.90 (4.40-7.91)	.39 (.28-.54)	42% (33-52%)	95% (93-97%)	77% (70-84%)
Vomiting	19% (11-30%)	98% (96-99%)	9.42 (4.39-20.20)	.83 (.74-.93)	54% (33-74%)	91% (88-93%)	58% (50-66%)
Photophobia	90% (80-96%)	67% (63-71%)	2.71 (2.35-3.13)	0.15 (.08-.31)	26% (20-32%)	98% (96-99%)	78% (73-83%)
Phonophobia	90% (80-96%)	55% (51-60%)	2.02 (1.78-2.28)	.18 (.09-.37)	20% (16-25%)	98% (95-99%)	72% (67-78)
Disability	64% (51-75%)	88% (85-91%)	5.37 (4.02-7.17)	.41 (.30-.56)	40% (31-50%)	95% (93-97%)	76% (69-83)

CI = Confidence Interval; Prevalence = 11%

Table 6

Experimental Sample: 2X2 Symptom Tables for Each Migraine Symptom (including probable migraineurs) (n = 887 with headache)

		Migraine (including PM)	
		Yes	**No**
Duration (4-72 hours)	**Present**	91	42
	Not Present	242	510
	Total	333	552
Unilateral	**Present**	179	211
	Not Present	155	339
	Total	334	550
Pulsing	**Present**	256	279
	Not Present	78	272
	Total	334	551
Severity ≥ 5	**Present**	246	194
	Not Present	89	358
	Total	335	552
Worsened by activity	**Present**	222	180
	Not Present	112	372
	Total	334	552
Nausea	**Present**	167	61
	Not Present	168	491
	Total	335	552
Vomiting	**Present**	30	11
	Not Present	304	539
	Total	334	550
Photophobia	**Present**	302	180
	Not Present	33	363
	Total	335	543
Phonophobia	**Present**	296	246
	Not Present	38	306
	Total	334	552

Disability	**Present**	131	65
	Not Present	204	482
	Total	335	547

Table 7

Experimental Sample: Migraine Symptom Performance (including probable migraineurs)

	Sensitivity	**Specificity**	**+LR**	**-LR**	**PPV**	**NPV**	**AUC**
Duration (4-72 hrs)	27% (95% CI: 23-32)	92% (90-94%)	3.59 (2.56-5.04)	.79 (.73-.84)	68% (60-76%)	68% (64-71%)	60% (56-64%)
Unilateral	54% (48-59%)	62% (57-66%)	1.40 (1.21-1.62)	0.75 (.66-.86)	46% (41-51%)	69% (64-73%)	58% (54-62%)
Pulsing	77% (72-81%)	49% (45-54%)	1.51 (1.37-1.68)	0.47 (.38-.58)	48% (44-52%)	78% (73-82%)	63% (60-67%)
Severity ≥ 5	73% (68-78%)	65% (61-69%)	2.09 (1.83-2.38)	.41 (.34-.49)	56% (51-61%)	80% (76-84%)	69% (66-73%)
Worsened by activity	66% (61-72%)	67% (63-71%)	2.04 (1.77-2.35)	0.50 (.42-.58)	55% (50-60%)	77% (73-81%)	67% (63-71%)
Nausea	50% (44-55%)	89% (86-91%)	4.51 (3.48-5.85)	.56 (.50-.63)	73% (67-79%)	75% (71-78%)	70% (65-73%)
Vomiting	9% (6-13%)	98% (96-99%)	4.49 (2.28-8.84)	.93 (.90-.96)	73% (57-86%)	64% (61-67%)	53% (49-57%)
Photophobia	90% (86-93%)	67% (63-71%)	2.72 (2.40-3.08)	0.15 (.11-.20)	63% (58-67%)	92% (89-94%)	78% (75-81%)
Phonophobia	89% (85-92%)	55% (51-60%)	1.99 (1.80-2.20)	.21 (.15-.28)	55% (50-59%)	89% (85-92%)	72% (68-75%)
Disability	39% (34-45%)	88% (85-91%)	3.29 (2.53-4.29)	.69 (.63-.76)	69% (60-73%)	70% (67-74%)	63% (59-67%)

CI = Confidence Interval; Prevalence = approximately 37%

Table 8

Validation Sample: 2X2 Tables of Screener at Different Cut-off Points

		Migraine (excluding PM)	
		Yes	**No**
1 or more symptoms	**Positive screen**	87	329
	Negative screen	0	209
	Total	87	538
2 or more symptoms	**Positive screen**	87	136
	Negative screen	0	402
	Total	87	538
3 or more symptoms	**Positive screen**	82	41
	Negative screen	5	497
	Total	87	538
All 4 symptoms	**Positive screen**	50	5
	Negative screen	37	533
	Total	87	538

Table 9

Validation Sample: Screener Performance at Different Cut-off Points

	Sensitivity	**Specificity**	**+LR**	**-LR**	**PPV**	**NPV**	**AUC**
1 or more	100% (95% CI: 96-100)	39% (35-43%)	1.64 (1.53-1.75)		21% (17-25%)	100% (98-100%)	69% (65-74%)
2 or more	100% (96-100%)	75% (71-78%)	3.96 (3.42-4.57)		39% (33-46%)	100% (99-100%)	87% (85-90%)
3 or more	94% (87-98%)	92% (90-94%)	12.37 (9.17-16.67)	.06 (.03-.15)	67% (58-75%)	99% (98-100%)	93% (90-96%)
All 4	57% (46-68%)	99% (98-100%	61.84 (25.37-150.73)	.43 (.34-.55)	91% (80-97%)	94% (91-95%)	78% (72-85%)

Disease prevalence = 13%

Table 10

Validation Sample: 2X2 Tables of Screener at Different Cut-off Points (including probable migraineurs)

		Migraine (including PM)	
		Yes	**No**
1 or more symptoms	**Positive screen**	384	329
	Negative screen	0	209
	Total	384	538
2 or more symptoms	**Positive screen**	378	136
	Negative screen	6	402
	Total	384	538
3 or more symptoms	**Positive screen**	197	41
	Negative screen	187	497
	Total	384	538
All 4 symptoms	**Positive screen**	61	5
	Negative screen	323	533
	Total	384	538

Table 11

Validation Sample: Screener Performance at Different Cut-off Points (including probable migraineurs)

	Sensitivity	**Specificity**	**+LR**	**-LR**	**PPV**	**NPV**	**AUC**
1 or more	100% (95% CI: 99-100)	39% (35-43%)	1.64 (1.53-1.75)		54% (50-58%)	100% (98-100%)	69% (66-73%)
2 or more	98% (97-99%)	75% (71-78%)	3.89 (3.37-4.51)	.02 (.01-.05)	74% (70-77%)	99% (97-99%)	87% (84-89%)
3 or more	51% (46-56%)	92% (90-94%)	6.73 (4.94-9.18)	.53 (.47-.59)	83% (77-87%)	73% (69-76%)	72% (68-75%)
All 4	16% (12-20%)	99% (98-100%	17.09 (6.93-42.14)	.85 (.81-.89)	92% (83-97%)	62% (59-66%)	58% (54-61%)

Disease prevalence = 42%

Table 12

Performance of Screener Among Genders

	1 or more	**2 or more**	**3 or more**	**All 4**
Men				
- screen	77	137	220	248
+ screen	178	118	35	7
AUC	72% (95% CI: 62-83)	89% (84-94%)	94% (84-100%)	70% (51-89%)
Women				
- screen	132	271	464	608
+ screen	535	396	203	59
AUC	68% (63-74%)	86% (83-90%)	93% (89-96%)	80% (73-87%)
Chi Square	11.395	12.824	26.896	10.330
***P* =**	=.001	<.001	<.001	=.001

Table 13

Performance of Screener Among Races

	1 or more	**2 or more**	**3 or more**	**All 4**
White				
- screen	157	300	502	634
+ screen	529	386	184	52
AUC	70% (95% CI: 64-75)	87% (84-91%)	93% (89-97%)	81% (73-89%)
Other				
- screen	52	108	182	222
+ screen	184	128	54	14
AUC	68% (59-78%)	87% (82-93%)	95% (90-100%)	72% (59-85%)
Chi Square	.073	.294	1.424	.718
***P* =**	.787	.588	.233	.397

APPENDIX B: MIGRAINE DIAGNOSTIC CRITERIA

1. G43 Migraine

1.1 G43.0 Migraine without aura

A. At least 5 attacks fulfilling criteria B–D

B. Headache attacks lasting 4-72 hours (untreated or unsuccessfully treated)

C. Headache has at least 2 of the following characteristics:

1. unilateral location

2. pulsating quality

3. moderate or severe pain intensity

4. aggravation by or causing avoidance of routine physical activity (e.g., walking or climbing stairs)

D. During headache at least 1 of the following:

1. nausea and/or vomiting

2. photophobia and phonophobia

E. Not attributed to another disorder

1.2. G 43.10 Typical aura with migraine headache

A. At least two attacks fulfilling criteria B-D

B. Aura consisting of at least one of the following, but no motor weakness:

1. Fully reversible visual symptoms including positive features (e.g. flickering lights, spots or lines) and/or negative features (i.e. loss of vision)

2. Fully reversible sensory symptoms including positive features (i.e. pins and needles) and/or negative features (i.e. numbness)

3. Fully reversible dysphasic speech disturbance

C. At least two of the following:

1. Homonymous visual symptoms and/or unilateral sensory symptoms

2. At least one aura symptom develops gradually over ≥5 minutes and/or different aura symptoms occur in succession over ≥5 minutes

3. Each symptom lasts ≥5 minutes and ≥60 minutes

D. Headache fulfilling criteria B-D for *1.1 Migraine without aura* begins during the aura or follows the aura within 60 minutes

E. Symptoms not attributed to another disorder

APPENDIX C: SDIH-R

Included are 10 migraine diagnostic questions (marked with *), a question of headache frequency, two questions assessing for aura symptoms, five questions to assess for other headaches (posttraumatic, cluster, and medication overuse [MOH]), and a question regarding disability.

1. Do you ever get headaches?
    a. Yes b. No

2. On average, how many DAYS PER MONTH do you have a headache? (PLEASE ENTER A NUMBER BETWEEN 0-30)
    _____ days

*3. If 0 is no pain, 5 is moderate pain, and 10 is the worst pain imaginable, what is the average pain intensity of these headaches? (*pick one number between 0 and 10*)
    _____

*4. If left untreated or unsuccessfully treated, about long would these headaches usually last?
    a. Less than 30 minutes
    b. At least 30 minutes but less than 2 hours
    c. At least 2 hours but less than 4 hours
    d. Between 4 hours and 3 days
    e. Between 3 days and 7 days
    f. Longer than 7 straight days

5. For approximately how long have you been having these headaches?
    a. Less than 3 months
    b. 3 months
    c. 4 months or more

*6. How many of these headaches have you had in your life?
    a. Less than 5
    b. 5 – 9
    c. 10 – 20
    d. More than 20

*7. Which of the following best describes your pain?
    a. Pulsating/Throbbing b. Tight pressure (non-pulsating)

*8. Is the pain typically experienced on one side or both sides of your head?
    a. Typically one side b. Typically both sides

*9. Is the pain made worse by routine physical activities or cause you to avoid routine physical activities (like walking, bending over, or climbing stairs)?
    a. Yes b. No

*10. Do you often feel nauseous or sick to your stomach during these headaches?
a. Yes b. No

*11. Do you often vomit or throw up during these headaches?
a. Yes b. No

*12. Are you often sensitive to light during these headaches?
a. Yes b. No

*13. Are you often sensitive to sound during these headaches?
a. Yes b. No

14. Do you often experience any symptoms shortly before the headache pain actually begins, such as changes in your vision (blurry vision, seeing spots or zigzag lines), changes in your sensation (numbness, tingling), or changes in your speech?
a. Yes
b. No

15. How many times have you experienced these symptoms (i.e., blurry vision, seeing spots or zigzag lines) before having a headache?
a. 1
b. 2 – 5
c. 6 – 10
d. More than 10

16. Do you use any medications to treat these headaches?
a. Yes
b. No

17. If you use medication, how many days per week do you use any type of medication to treat your headaches?
a. Less than 1 day per week
b. 1-2 days per week
c. 3 days per week
d. 4 or more days per week

18. How long have you been using these medications at this frequency?
a. 3 months or less
b. More than 3 months

19. Did your headache develop or get worse when you started using these medications at this frequency?
a. Yes
b. No

20. Did this headache develop shortly after a head injury or head trauma?
    a. Yes
    b. No

21. Have you ever been diagnosed with cluster headaches?
    a. Yes
    b. No

22. Do these headaches interfere with your work, school, or personal life?
    a. Yes
    b. No

APPENDIX D: 4-ITEM SCREENING MEASURE

1. If left untreated or unsuccessfully treated, about long would these headaches usually last?
    a. Less than 30 minutes
    b. At least 30 minutes but less than 2 hours
    c. At least 2 hours but less than 4 hours
    d. Between 4 hours and 3 days
    e. Between 3 days and 7 days
    f. Longer than 7 straight days

2. Do you often feel nauseous or sick to your stomach during your headaches?
    a. a. Yes b. No

3. Are you often sensitive to light during your headaches?
    a. a. Yes b. No

4. Are you often sensitive to sound during your headaches?
    a. a. Yes b. No

*An answer of "d" on question 1 indicates migraine while all other responses indicate non-migraine headache.

VITA

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American Headache Society (AHS)	2011-present
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Featured on viewfromventress.org: *BP oil spill aftermath*	July 2012
Featured in *Grad Psych* magazine: *The oil spill's reverberations*	March 2012
John and Lillian Wolfe Graduate Award Nominee	2012
Phi Kappa Phi Honor Society	2006-2008
Psi Chi Honor Society	2006-2008
Alpha Kappa Delta Honor Society	2006-2008
Psi Chi Regional Research Award	2007
SEPA Conference, New Orleans, LA	
All-Conference Research Team Award	2007

Big SURS Conference, Myrtle Beach, SC
Winthrop Undergraduate Research Scholar 2007
Winthrop Psychology Department Outstanding Researcher Award 2007

LICENSES/CERTIFICATIONS

Provisionally Certified Mental Health Therapist Jurisdiction: MS
Examination for Professional Practice in Psychology- Passed at PhD level 8/21/12

PUBLICATIONS AND PRESENTATIONS

Published Book Chapters

Sattler, J. M., & **Walters, A. B.** (2014). Assessment of Executive Functions. In J. M. Sattler (Ed.), *Foundations of Behavioral, Social, and Clinical Assessment of Children, Sixth Edition*. Jerome M. Sattler, Publisher Inc.

Publications in Peer-Reviewed Journals

Smitherman, T. A., Davis, R. E., **Walters, A. B.,** Young, J., & Houle, T. T. (under review). *Anxiety sensitivity and headache: Diagnostic differences, impact, and relations with headache triggers.*

Walters, A. B., Hamer, J. D., & Smitherman, T. A. (2014). Sleep disturbance and affective comorbidity among episodic migraineurs. *Headache, 54,* 116-124.

Walters, A. B., Drescher, C. F., Baczwaski, B. J., Aiena, B. J., Darden, M. C., Johnson, L. R., Buchanan, E. M., & Schulenberg, S. E. (2013). Getting active in the gulf: Environmental attitudes and action following two Mississippi coastal disasters. *Social Indicators Research.* DOI: 10.1007/s11205-013-0428-2.

McDermott, M. J., Peck, K. R., **Walters, A. B.,** & Smitherman, T. A. (2013). Do Episodic Migraineurs Selectively Attend to Headache-Related Visual Stimuli? *Headache, 53,* 356-364.

Drescher, C. F., Baczwaski, B. J., **Walters, A. B.,** Aiena, B. J., Schulenberg, S. E., & Johnson, L. R. (2012). Coping with an ecological disaster: The role of perceived meaning in life and self-efficacy following the Gulf Oil Spill. *Ecopsychology, 4,* 56-63.

Smitherman, T. A., **Walters, A. B.**, Maizels, M., & Penzien, D. B. (2011). The use of antidepressants for headache prophylaxis. *CNS Neuroscience & Therapeutics, 17,* 462-469.

Published Abstracts (also presented as posters at national conferences)

Walters, A. B., Smitherman, T. A., Davis, R. E., Townsend, E. A., Hamer, J. D., & Blann, K. R. (2011, June). Sleep hygiene and psychiatric comorbidity in episodic migraineurs.

Headache, 51(Suppl 1), S50.

Smitherman, T. A., Maizels, M., **Walters, A. B.**, Henley, M. Bounds, L. B., Presley, E., et al. (2009). Negative impact of episodic migraine on a college population: Psychiatric comorbidity, functional impairment, and school interference. *Cephalalgia*, *29*(Suppl 1), S148.

Oral Presentations

Walters, A. B., Davis, R. E., Houle, T. T., & Smitherman, T. A. (2014, April). *Perceived headache triggers: A meta-analysis of over 50 years of literature.* Paper presented at the 2014 UM Conference on Psychological Science, Oxford, MS.

Walters, A. B., Hamer, J. D., & Smitherman, T. A. (2013, June). *Sleep disturbance and affective comorbidity among episodic migraineurs.* Paper presented at the 2013 International Headache Congress, Boston, MA.

Walters, A. B., Schulenberg, S. E., Baczwaski, B. J., Campbell, S. N., Drescher, C. F., Schultz, K. V.... Willoughby, S. G. (2012, September). *Research and evaluation following the Gulf Oil Spill in Mississippi.* Panel discussion at the 63rd annual meeting of the Mississippi Psychological Association, Gulfport, MS.

Walters, A. B. (2012, August). *Collaborating with a State-Funded Mental Health Agency*. In S. Schulenberg (Chair), Interdisciplinary Grant-Funded Research as a Training Tool. Symposium presented at the 120th annual meeting of the American Psychological Association, Orlando, FL.

Poster Presentations

Flegle, L. B., **Walters, A. B.,** & Schulenberg, S. E. (2012, November). *Treatment as usual in the wake of the gulf oil spill*. Poster presented at the annual meeting of the Association for Behavioral and Cognitive Therapies, National Harbor, MD.

Walters, A. B., McDermott, M. J., Young, J., & Smitherman, T. A. (2012, November). *Psychiatric comorbidity among primary episodic headache types.* Poster presented at the annual convention of the Association for Behavioral and Cognitive Therapies, National Harbor, MD.

Walters, A. B., Hamer, J. D., Houle, T. T., & Smitherman, T. A. (2012, June) *Anxiety sensitivity and headache*. Poster presented at the annual convention of the American Headache Society, Los Angeles, CA.

Walters, A. B., Davis, R. E., Hamer, J. D., Townsend, E. A., Blann, K. R., Schulenberg, S. E., & Smitherman, T. A. (2011, November). *Relations between migraine, psychological variables, and meaning in life in a college population.* Poster presented at the annual convention of the Association for Behavioral and Cognitive Therapies, Toronto, Canada.

Campbell, S. W., **Walters, A. B.**, Baczwaski, B. J., Schulenberg, S. E., Drescher, C. F. & Smith, C. V. (2011, August). *Disaster-related research and consultation: Lessons learned from*

two events. Poster presented at the annual convention of the American Psychological Association, Washington, D.C.

Walters, A. B., Baskin, B. L., McDermott, M. J., & Smitherman, T. A. (2010, November). *Chronic daily headache in a college population: Psychiatric comorbidity and functional impairment*. Poster presented at the annual convention of the Association for Behavioral and Cognitive Therapies, San Francisco, CA.

McDermott, M. J., **Walters, A. B.,** Smitherman, T. A., Gratz, K. L., & Tull, M. T. (2010, November). *The role of anxiety sensitivity and migraine symptoms in posttraumatic stress disorder among individuals in residential substance abuse treatment*. Poster presented at the annual convention of the Association for Behavioral and Cognitive Therapies, San Francisco, CA.

Smitherman, T. A., Maizels, M., **Walters, A. B.**, Kirkland, K. & Penzien, D. (2009, November). *Development and validation of the Mood, Anxiety, and Physical Symptoms Scale: A brief measure for assessing depression and anxiety symptoms among medical patients.* Poster presented at the annual convention of the Association for Behavioral and Cognitive Therapies, New York, NY.

Walters, A. B., Nunnally, B., & Sinn, J. (2007, March). *Political conservatism as a predictor of ecological attitudes: Socially motivated cognition and the issues of global warming and species extinction.* Poster presented at the Big South Undergraduate Research Symposium, Myrtle Beach, SC.

Woods, A., **Walters, A. B.**, & Sleigh, M. J. (2007, February). *The Big Five personality traits and young adults' perceptions of workplace romance.* Poster presented at the Southeastern Psychological Association conference, New Orleans, LA.

EDITING AND REVIEWING

Ad Hoc Reviewing

JAMA
Pain
Annals of Behavioral Medicine
Behaviour Research and Therapy
International Journal of Neuroscience
Headache
Psychological Methods

Edited Book Chapters

ADHD and Developmental Disabilities book chapters for forthcoming *Foundations of Behavioral, Social, and Clinical Assessment of Children, Sixth Edition* text by Jerome Sattler

Book Chapter by John Cacioppo on Introduction to Research Methods in psychology text

Grant-Funded Research Experience

Project Coordinator. *Efficacy of behavioral insomnia treatment for chronic migraine: A randomized controlled pilot study*. Migraine Research Foundation. (May 2011- October 2013). $49,858. (PI: Todd A. Smitherman, Ph.D.)

Project Coordinator. *Efficacy of mental health interventions in response to the effects of the Deepwater Horizon Oil Spill.* Mississippi Department of Mental Health. (November 2010-June 2012). $281,556. (PI: Stefan E. Schulenberg, Ph.D.)

Data Collector. *Community Assessment for Public Health Emergency Response (CASPER) after the Gulf Coast Oil Spill.* Centers for Disease Control and Prevention, National Center for Environmental Health, Division of Environmental Hazards and Health Effects (August, 2011).

Other Research Experience

Graduate Lab Member 2008-present
Migraine and Behavioral Health Laboratory, University of Mississippi, *Oxford, MS*

Graduate Lab Member 2010-2012
Positive Psychology Laboratory, University of Mississippi, *Oxford, MS*

Clinical Practicum Experience

Clinic Manager 2013-present
Psychological Assessment Clinic, University of Mississippi, *Oxford, MS*

Supervised other graduate students conducting assessments. Consulted with other departments with assessment needs. Supervised other graduate students interpreting assessments at the office of Student Disability Services on campus. Individual and group supervision provided by Scott Gustafson, Ph.D.

Verification Specialist 2010-present
Office of Student Disability Services, University of Mississippi, *Oxford, MS*

Examined psychological evaluations and determined academic accommodations based on results and diagnosis. Conducted interviews with students in order to determine academic impact based on diagnosis. Individual and group supervision provided by Stefan Schulenberg, Ph.D. & Scott Gustafson, Ph.D.

Contracted Assessor 2011-present
Psychological Assessment Clinic, University of Mississippi, *Oxford, MS*

Conducted psychoeducational evaluations (including cognitive, achievement, attention, behavior, and personality testing) and wrote integrated reports. Individual supervision provided by Stefan Schulenberg, Ph.D. & Scott Gustafson, Ph.D.

Graduate Clinician 2009-present
Psychological Services Center, University of Mississippi, *Oxford, MS*

Conducted intakes, delivered individual, couples, and family psychotherapy, and wrote integrated psychosocial intake reports. Individual and group supervision provided by Todd Smitherman, Ph.D., Stefan Schulenberg, Ph.D., & Scott Gustafson, Ph.D.

Mental Health Therapist 2012-2013
Communicare, *Oxford, MS*

Conducted intakes, delivered individual, couples, and family psychotherapy, and wrote integrated psychosocial intake reports. Individual and group supervision provided by Dixie Church, M.A., LMFT.

Consulted Assessor for the Social Security Administration 2011
Delta Autumn Consulting, *Oxford, MS & Cleveland, MS*

Conducted cognitive, achievement, and competency evaluations for individuals applying for Social Security Disability and wrote integrated reports. Individual supervision provided by John Young, Ph.D. & Danielle Maack, Ph.D.

Graduate Student Therapist and Researcher 2009-2011
The Baddour Center, *Senatobia, MS*

Conducted intakes, delivered individual and group psychotherapy, conducted cognitive and neuropsychological evaluations, wrote integrated reports, and implemented behavior plans [all] in adults with developmental and intellectual disabilities.

Teaching Assistant for Cognitive and Personality Assessment 2010-2011
Department of Psychology, University of Mississippi, *Oxford, MS*

REFERENCES

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