

## Computer-Aided Diagnoses of Chronic Head Pain: Explanation, Study Data, Implications, and Challenges

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**ABSTRACT:** The differential diagnosis of diseases and disorders having head pain as a symptom is often a difficult challenge for health care professionals. The complexity of this problem, the need for computer aided diagnosis, and the assumptions upon which one diagnostic software program was developed are discussed. A database driven user-oriented Internet website was offered at no charge to headache sufferers, and this vehicle provided the data source for research. The software program compares consistent user surveys to 253 expert profiles compiled from searches of the best available material in the medical/dental literature. A database of 1288 consistent user surveys was studied and analyzed for this paper. Findings discussed are: 1. the large amount of users (63%) who do not match any expert profile to a reasonable degree of medical certainty; 2. the significance of the relatively large amount of headache sufferers (17%) whose diagnosis or diagnoses are solely within the realm of dentistry; and 3. the importance of differentiating between discriminating and substantiating diagnostic criteria. Many users do not fit existing algorithms for chronic head pain. Data generated by this computer-aided diagnostic software program challenge some current paradigms and concepts of diagnosis. The data generated question "correct to a reasonable degree of medical certainty," challenge "a preponderance of the evidence" as scientific diagnostic standards, and also question whether rendering a working diagnosis is possible on each and every patient.

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**D**iagnosis involves analysis of the scientific evidence of what is wrong with a patient, and why, and applying a tentative name to the disease. Headache, used here synonymously with head pain, is a symptom and not a disease. The term head pain encompasses such terms as face pain, jaw pain and toothache. Pain indicates something is wrong. There are at least 25 health care specialties involved in the treatment of headache, yet none of these has differential diagnosis of the etiology of head pain as its unique domain of responsibility. On a regular basis, dentists and physicians are confronted with patients suffering from the generalized symptoms of head pain, stiff neck, and face pain. The initial question facing dentists is, "Temporomandibular disorder (TMD) or something else?" A very basic issue all health care professionals initially address is, "Should I refer or treat?" Central to the problem is the difficult question, "What is the diagnosis?" When a patient suffering from a chronic headache presents to a doctor and asks, "What have I got?" the answer is anything but simple.

In a recent article, Sackett<sup>1</sup> stated that 88% of all diagnoses achieved in primary care<sup>2</sup> and 73% in general med-

icine clinics are established by the end of the initial history taking and physical examination.<sup>3</sup> He explains that despite the importance of the history and physical examination to the clinical process, their accuracy and precision have never been rigorously tested and that frontline clinicians have to decide for themselves which signs and symptoms are most relevant.

Faust<sup>4</sup> has also studied the accuracy of clinical judgment. In his book, *The Limits of Scientific Reasoning*, he relates finding that the absolute level of performance on many judgment tasks is frequently low. The reliability of subjective scientific judgment is poorer than was previously assumed. Cognitive limitations are almost certainly the most basic, most prevalent, and most troublesome source of human judgment difficulties. The existence of scientists' cognitive limitations is not even arguable. Instead, the issue is the extent, manifestations, and consequences of their judgment errors and how to substantially reduce them.<sup>4</sup>

When making decisions, scientists frequently attend to only a few variables or cues, although they believe otherwise.<sup>5</sup> Access to additional information does not increase judgment accuracy. It is not that additional information is uninformative or useless, but that human minds lack the ability to integrate more than a limited amount of information, weigh it properly, and select the most useful part. Convincing available evidence suggests that human ability to detect and comprehend complex configural relationships is very limited.<sup>6,7</sup> There is little doubt that scientific genius exists, but very little evidence that most clinicians are geniuses.

It may be that the information necessary to diagnose head pain contains more variables than the human mind can absorb. If the brain is perceived as an information processor with the limited ability to manipulate four to seven chunks of information or variables in considering a complex problem, and relies on resemblance of a limited set of findings to base clinical diagnoses, then the diagnoses may be faulty. Evidence challenges whether clinicians can be effective diagnostic decision makers, given the limitations of the human mind, the complexity of the problem, and the quantity of data necessary to render a diagnosis.

Faust<sup>8</sup> summarizes that "Investigations of the predictive efficiency of subjective impressionistic human judgment [such as that exercised by individual clinicians] versus that of even a crude non-optimized mechanical prediction function is about as clearly divided in favor of the latter as we can ever expect to get." Interjudge reliability among diagnosticians in organic specialties also shows cognitive deficiencies and inferiority to objective data combination.

Sackett,<sup>9</sup> in his textbook, cites numerous examples of clinical disagreements over diagnoses. Koran<sup>10</sup> has also reviewed many examples of clinical disagreements, and his general finding is that performance among doctors is inconsistent and suboptimal in both diagnosis and physical findings.

### Conceptual Controversy

There is substantial controversy as to whether headache is a symptom of a disease process (pathophysiological problem) or an illness (psychosocial disorder). There is no professional consensus in dealing with headaches. The study of headache is overlaid and bound by many differing pre-existing disciplinary paradigms.

Marks and Rappoport<sup>11</sup> define primary headache as having no known structural or metabolic cause and secondary headache as having an underlying pathological cause. They cite migraine and tension-type headache as examples of primary headaches and brain tumor as an example of a secondary headache. If there is no underlying pathophysiological cause, they invite the interpretation that all primary headaches are psychogenic in their etiology, a presumption with which many clinicians take issue.

Raskin,<sup>12</sup> writing in *Harrison's Principles of Internal Medicine*, says that migraine and tension-type headache are really manifestations of the same disorder. Diamond,<sup>13</sup> writing in *Wolff's Headache*, relates that tension-type headache is no longer presumed to be caused solely by chronic muscle contraction. It may be associated with muscle tenderness and elevated EMG activity, but there is definitely a psychological component with a diagnostic criterion, being that it is bilateral in nature. No limits of normal for EMG activity have ever been established.

Based on the inherent limitations of the human mind, the complexity of the problem, and the conceptual and paradigmatic controversies, the decision was made to develop computer software for the differential diagnosis of those diseases and disorders having head pain or headache as a symptom.

### Materials and Methods

Initially, a search was made of the ICD-9 (International Classification of Diseases) and the International Headache Society, Headache Classification System. A comprehensive list of diseases and disorders was compiled that have head pain as a symptom, but which have no visible pathological sores or lumps.

It was determined from a thorough search of the literature that the leading textbook authors organize their dis-

ease profile into 15 categories of variables. Continued disease profiling in the literature established the words, terms and characteristics on which the acknowledged *experts* base their diagnoses of those diseases and disorders having head pain. Each of the 15 categories has between seven and 107 possible factors that can be used to characterize all headaches. The Master Expert Data Profile Sheet is thus a compilation of all the categories and factors used in the literature to characterize headache disorders. This study is based on a pathophysiological disease model.

Expert Data Profiles were filled out for each of the 253 diseases and disorders<sup>14</sup> known to have chronic headache as a symptom using the best possible references. The *real* experts were the respected authors of the leading textbooks and journal articles. Many diseases and disorders have multiple references. All references used for each disease or disorder were maintained in the database. Too numerous to list specifically, they are made available on the website. The database driven software answered the question, "Which expert profile or profiles most closely matched the user's completed survey?" Response time was immediate.

Computer-aided diagnosis of head pain was offered via the Internet at no charge, at the web address *www.HeadacheSearch.com* or *www.WhatHaveIgot.net*. The website generated no revenues since its inception, January 10, 2001. It was funded as a research project by the lead author.

Users completed a history, symptom checklist, and self-exam. The website survey queried the necessary information in user-friendly language. Medical literature searches reveal that the overwhelming majority of headache diseases have no pathognomonic and few objective clinical findings. With virtually all diagnostic criteria based on the subjective history, symptoms reported and subjectively evaluated clinical findings, there was no compelling reason not to utilize self-examination. The time necessary to complete the User Profile averaged 20–25 minutes.

A panel of consistency check questions was also utilized. Twelve points queried in the history, symptom checklist, and self-examination were repeated in sentence format. A score of eight out of twelve consistent answers is a requisite for the software program to render a diagnosis or diagnoses. For users with greater than four inconsistent answers, the program simply states, "The large number of inconsistent answers reduced the data confidence factor to levels below which reliable results can be rendered."

Information was also gathered on psychosocial factors, as well as physiological status. Users completed the ques-

tionnaire matched to the Expert Data Profile Sheet and also a very extended health history, a Life Events Scale (factoring in psychologically stressful events), a Pain Inventory Scale (how the pain impacts their life), and a Coping Ability Scale (how effectively they function in their environment). These factors were recorded for informational and research purposes only, and not tied to any diagnoses. Subsequent statistical analysis may be done to seek out significant correlations.

The website content was written using language and vocabulary geared to persons with a twelfth grade reading level and confirmed using the Flesch-Kincaid Readability Index.<sup>15</sup> The website was registered on numerous Internet search engines, the avenue of entry for most users. The sample population for this project was defined as Internet users whose headache is sufficiently annoying that they will spend 20–25 minutes entering data into their personal computer to get closer to a differential diagnosis. While confidential medical information is asked of website users, privacy was maintained because identity was neither asked for nor revealed.

The database utilized is Microsoft SQL (Microsoft Corp., Redmond, WA). Data was downloaded from the Internet web server using P.C. Anywhere. Statistical Analysis was accomplished using SPSS-v.10 software. User identity was never asked for, but demographic questions about gender, age, and race were included in the questionnaire.

## Results

This paper is a preliminary report on 1288 consistent surveys in the database. One hundred (100) different headache diseases were reported as diagnoses. One hundred fifty-three (153) profiled diseases never registered as a diagnosis. Twenty-nine (29) headache diseases appeared at least 1% of the time. Multiple diagnoses were possible: 256 users received one diagnosis, 87 users received two diagnoses, 38 users received three diagnoses, 20 users received four diagnoses, 15 users received five diagnoses, and 13 users received six diagnoses. Forty-seven (47) users received between seven and 13 diagnoses.

### *First Finding: Large Number of Nondiagnoses*

Any diagnosis offered must be correct to a reasonable degree of medical certainty. Diagnoses should be statistically more likely than less likely to be correct. The standard utilized was "a preponderance of the available evidence." A user survey therefore must correlate with greater than 50% of the characteristics noted in any expert disease profile for the computer software to render

it as a possible diagnosis. Of the 1288 consistent user surveys in the study's database, 477 users received a diagnosis or diagnoses. Eight hundred eleven (811) users or 63% did not sufficiently match any expert profile to receive a diagnosis from the computer program.

#### *Discussion of First Finding*

When patients come to a doctor for a consultation, they expect a diagnosis. A doctor's response, "I'm sorry, but the problem you described simply doesn't qualify for a diagnosis" would not be a confidence building response but might be perfectly appropriate. If 100% of all chronic headache patients receive a diagnosis however, the data indicates a possibility that as many as 63% could be unwarranted. The medical facts obtained in a history and an examination do not carry an explanation of how to incorporate them into a diagnosis. If a history and exam were to be taken as the basis to *rule in* the most likely diagnosis and 100% of all patients did in fact receive a diagnosis, this data cast doubt on the efficacy of *rule in* as a diagnostic strategy.

The old adage that the average doctor treats symptoms, the good doctor treats causes, and the excellent doctor treats the patient may need revision. Diagnosis *ex juvan'tibus*, or basing one's diagnosis on the results of trial therapies, regarded by Sackett<sup>9</sup> to be the least efficient of all diagnostic strategies may be the most appropriate. If the user profile does not match any diagnosis to a reasonable degree of medical certainty, a clinician has the option of initiating trial therapies or treating symptoms. The study data alone suggest that the adage needs to change to, "With a diagnosis treat the cause, without a diagnosis treat the symptoms, and always deal with the patient's unique needs."

That 63% of users who do not qualify for a diagnosis would seem to seriously question the standard of *preponderance of the evidence* as being of scientific significance for establishing diagnoses. This issue is dealt with in succeeding paragraphs based on the additional findings from the data.

#### *Second Finding: Quality of Diagnostic Criteria*

Migraines were the most frequently diagnosed headache group, constituting 23% of all diagnoses. The category, migraines, consists of seven specific subtypes: 1. migraine without aura, 2. migraine with aura, 3. basilar migraine, 4. dysphrenic migraine, 5. familial hemiplegic migraine, 6. ophthalmoplegic migraine, and 7. retinal migraine.

When the expert database was created from literature searches, each characteristic listed was weighted either (++) if it was noted in the literature source as a very strong criteria, (+) if it was mentioned as being frequently

identified with the disease or disorder and (-) if it was noted in the literature that absence of that characteristic is important as a diagnostic criteria: (++) is scored with a two; (+) and (-) are scored with a one.

Of all the migraines, dysphrenic migraine was one of the more frequent diagnoses made by the software. The characteristics in the expert profile used to identify dysphrenic migraine are listed in **Figure 1**.

In dysphrenic migraine, the three characteristics of altered consciousness, disorientation/change in mental alertness, and dysesthesia/distortion of senses are very discriminating criteria. They also occurred in over 80% of the users receiving dysphrenic migraine as a diagnosis. A principle being suggested by data analysis in diagnosing a *headache disease* is that there must be some discriminating criteria. Discriminating criteria are characteristics whose presence are essential to distinguish a disease from others. A substantiating criterion provides a weaker form of evidence that merely serves to strengthen a diagnostic hypothesis.

Another computer-aided diagnosis that occurred with unusual frequency was von Munchausen's Syndrome. Patients with this very rare condition fabricate symptoms to attract the attention of physicians. They may ingest, rub or inject irritants to create laboratory findings. They undergo unnecessary surgical and medical procedures. The expert profile in the database identified nine diagnostic criteria for von Munchausen's Syndrome (**Figure 2**). The characteristics for von Munchausen's Syndrome, while all true, merely describe a nonspecific, generic headache. The von Munchausen's expert profile only consists of substantiating diagnostic criteria. It was not difficult to understand why many users received the diagnosis. Their surveys corresponded with five out of the nine possible criteria, i.e., variable intensity, differing types of pain, variable duration, variable frequency of pain, and 13–45 years of age at onset.

#### *Discussion of Second Finding*

It is essential that each disease profile have discriminating as well as substantiating diagnostic criteria. An entity defined only by substantiating criteria, such as von Munchausen's, results in creation of a subcategory of head pain that can best be described as *generic or non-specific headache*. Headache disease, to be properly classified as a unique diagnosis, must have some discriminating characteristics or symptoms. As a consequence, von Munchausen's Syndrome provided a valuable lesson but was subsequently eliminated from the headache disease list. Further, the discriminating diagnostic criteria must relate to a pathologic or abnormal physiological function. Otherwise *headaches* defined by what the person was

**EXPERT PROFILE - DYSPHRENIC MIGRAINE**

- Pain Intensity**
  - +Moderate: slight interference with normal daily activities
  - +Severe: pain significantly interferes with normal daily activities
- Pain Quality**
  - +Throbbing, pulsating
- Pain Location / Common Site**
  - +Forehead
  - +Occipital/base of skull
  - +Orbital/around the eye
  - +Temples/temporal
- Onset of Pain**
  - +Aura
  - +Scotomata/altered vision on side of headache
- Initiating/Precipitating Factors of Pain**
  - +Coitus/sexual activity
  - +Head injury
  - +Use of alcohol
- Worsening/Aggravating Factors**
  - +Exercise/exertion
  - +Foods
- Personal Characteristics**
  - +Female
  - +Family history of problem
    - + Loss of interest or pleasure in all activities/ depression
    - + Apprehension, nervousness/anxiety
- Characteristic Symptoms**
  - +Altered consciousness
  - +Behavioral changes
  - +Blindness one-half visual field
  - +Cognitive changes
  - +Difficulty in speech articulation/impaired speech
  - ++Disorientation/change in mental alertness
  - +Dizziness
  - ++Dysesthesia/distortion of senses
  - +Fatigue
  - +Head pain
  - +Lethargy
  - +Light sensitivity
  - +Loss of concentration
  - +Mental disturbance
  - +Numbness
  - +Other sensory changes
  - +Paresthesia/tingling
  - +Visual disturbance
  - +Vomiting
- Characteristic Signs**
  - +Swollen tender scalp arteries

**Figure 1**  
Expert Profile, Dysphrenic Migraine

eating or doing could become discriminating diagnostic criteria. Normal nonpathological functions such as coughing, having coitus, eating cheese, hot dogs, ice cream, Chinese food, or drinking red wine, therefore, are not discriminating disease criteria.

This is not to deny that coughing can precipitate a headache. Rather it is to point out that until health professionals elicit the specific pathology or abnormal physiology that initiates the *headache* triggered by the cough, red wine, or cheese (etc.), these characteristics do not constitute a unique diagnostic classification and are most correctly treated nonspecifically or by avoidance of the trigger.

In the differential diagnosis of diseases and disorders with headache as a symptom, there is no one characteristic or criterion that is pathognomonic or “sine’ qua non” of any headache disease. Criteria such as history of herpes, history of psoriasis, hyoid bone tenderness, back hump, moon face and purple streaks on the stomach are very discriminating, but alone are not pathognomonic of any specific *headache disease*. They need substantiation by the presence of other criteria for a clinician to make a diagnosis. The best diagnostic indicators of diseases having headache as a symptom are clusters of symptoms containing both discriminating and substantiating characteristics that closely resemble disease profiles in the expert database. The differentiation of substantiating

**EXPERT PROFILE - VON MUNCHAUSEN’S SYNDROME**

- Pain Intensity**
  - +Variable
- Pain Quality**
  - +Differing pain types
- Pattern/Flow of Pain**
  - +No pattern
- Length of Time Illness Has Been Present**
  - +Years
- Duration of Pain Episodes**
  - +Variable duration
- Frequency of Pain Episodes**
  - +Variable frequency
- Age at Onset**
  - +Adolescent, 13-45 years
- Characteristic Signs**
  - Motor deficit
  - Neurological deficit

**Figure 2**  
Expert Profile, von Munchausen’s Syndrome

from discriminating diagnostic criteria also necessitates a concept that all disease criteria are not equal. This then poses another challenge to *preponderance of the evidence* as a scientific basis for diagnosis. Heavier weighting of certain discriminating disease criteria offers the possibility that significantly less than 51% of diagnostic criteria could be sufficient for a diagnosis.

### *Third Finding: Large Number of Headache Problems Specific to Dentists*

Seventeen percent (17%) of all users submitting consistent surveys received diagnoses for diseases and disorders that should be referred exclusively to a dentist. One hundred sixty-three (163) or 13% were in the subcategory Masticatory Disorders, and 47 or 4% were of odontogenic origin.

### *Discussion of Third Finding*

There are approximately 25 healthcare specialties involved in diagnoses and treatment of headaches. No one has as its sole responsibility the differential diagnosis of all 253 *headache diseases*. Few medical specialties include schooling in the diagnosis of odontogenic or masticatory disorders and fewer still include training in treatment of these problems. "Is the head pain from masticatory or odontogenic origin, or from something else?" is a valid question. The hard reality is that the majority of medical and dental students are not properly trained to make this differential, and omissions and mistakes could have severe consequences.

How do patients get the proper referral? Computer-aided diagnosis can instantly consider all 253 diseases and disorders having headache as a symptom. The software provides possible diagnoses *having a reasonable degree of medical certainty*. When a diagnosis is suggested by the computerized system, the proper healthcare specialist for treatment and confirmation of diagnosis is made obvious. Prompt appropriate interprofessional referrals should be greatly facilitated.

### **Conclusions**

References cited at the beginning of this paper (1-8) relate how daunting a task it is for the human mind to accurately deal with problems as complex as the diagnosis of chronic head pain. The present study certainly underscores that difficulty. However, according to the data generated by this study, the problem facing the clinician is not how to deal with the maze of complex variables involved in making a diagnosis, but whether the rendering of a diagnosis is even possible for every patient. The primary question facing the health care professional

is not, "Can I reliably make correct diagnoses?" but "Is making a diagnosis appropriate in the case being considered, or should I just treat the symptoms?"

Data generated by this computer-aided software program challenge current paradigms and concepts of diagnosis and challenge the standard of *preponderance of the evidence* as a scientific diagnostic standard. The data challenge the idea that a doctor must make a diagnosis on each and every patient. A logical conclusion of this study is that at the present time, diagnosis of chronic headaches is an inexact science—an art if you would. All patients do not fit existing algorithms for chronic head pain. The medical literature has not established clear, identifiable parameters for diagnostic criteria. The real hope for the future is that information from database analysis can yield clusters of symptoms and characteristics that elucidate new categories, thus upgrading diagnosis to a science.

The large number of nondiagnoses rendered by the software and the substantial number of headache problems referable to a dentist were unexpected findings that lend support to the importance of more research on computer-aided diagnoses. Further work needs to be done on standards for differentiating discriminating from substantiating diagnostic criteria. A scientific basis for this differentiation would be ideal, but statistical analyses or determination by consensus conferences may be acceptable in some cases. The results of the data analysis emphasize the need for thorough exploration of the potential of computer-aided diagnoses. As an example, assume that strong statistical evidence suggests a diagnosis of a headache disease or disorder be based on presence of one to three discriminating criteria and three to five substantiating. Thus using the case of dysphrenic migraine, as few as five out of 38 possible criteria may be sufficient to diagnose a headache disease or disorder. At the present time, such statistical, evidence-based standards do not exist. Data mining and information technology however, offer such a potential.

Computer-aided diagnoses enhance the capability of the human mind by considering every single factor for which it was programmed, assuring that *no stone was unturned*. It can help physicians because it considers the exotic and rare diseases that they might not have seen or with which they are unfamiliar. It can integrate more information and instantly search far more information than the human mind is capable of doing. No doctor who has considered the results of a computer-aided diagnostic survey should ever reasonably be sued for *failure to diagnose* based on lack of consideration of any disease. Computer aided diagnosis does not stifle the creativity of the human mind. The creativity of the human mind is nec-

essary to ask the appropriate questions of the data and create the conceptual paradigms by which the data can best be understood and utilized.

Computer-aided diagnostic software does not threaten the importance or need for physicians as key players in diagnosis. No person is ever the *average* patient, so no clinician should ever feel bound by a computer-generated diagnosis. Consideration of the factors unique to each patient is an essential part of clinical practice. The knowledge and judgment of the doctor is essential to the diagnostic decision-making process. Doctors must always diagnose and treat patients one at a time. Utilizing the computer's capability to instantly analyze data from hundreds of thousands of other human beings with similar problems can be of value in uncovering certain factors that were previously not obvious. The value is not just in diagnosing and treating better, but also in doing no harm.

Sackett<sup>16</sup> has advocated evidence-based medicine as a reasonable standard of care. Database computer software built on expert profiles from the best available scientific literature and consistent data from thousands of users exemplifies evidence-based medicine. If evidence-based studies indicate that symptomatic treatment is most appropriate in nearly 63% of all patients complaining of chronic headache in whom a specific diagnosis is unwarranted, computer-aided diagnosis offers real potential to trim billions of dollars annually from healthcare costs. It also appears that the data add to the credibility of the psychosocial model in which a great deal of nonspecific treatment is administered to chronic headache patients.

Certainly the research data pose many questions, but pursuit of the answers appears worthwhile and well within the realm of possibility. A computerized database appears to be a reasonable and useful vehicle for data gathering. A substantially larger user database is needed for statistically significant analysis of the individual diagnoses rendered. Statistical analysis of databases as large as the Internet is capable of generating could contain relevant information on more headache sufferers than is compiled in all the textbooks combined. If we acknowledge that some of the findings in this paper may be reasonable or possible, then revisiting current concepts and paradigms using data mining technology may be indicated.

Information relative to diagnosis has only begun to be tapped and it is already broadening our insight. Information technology utilizing the Internet and database computer diagnostic systems offers the potential to re-engineer the paradigm by which health professionals treat not only headache, but possibly all chronic diseases.

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