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Authors

Probst, Marc A
Kanzaria, Hemal K
Schriger, David L

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A Conceptual Model of Emergency Physician Decision-making for Head Computed Tomography in Mild Head Injury

Marc A. Probst, MD,

UCLA Emergency Medicine Center, School of Medicine, University of California, Los Angeles, Los Angeles, CA USA

Hemal K. Kanzaria, MD, and

Robert Wood Johnson Foundation Clinical Scholars Program, UCLA Emergency Medicine Center, School of Medicine, University of California, Los Angeles, Los Angeles, CA USA

David L. Schriger, MD, MPH

UCLA Emergency Medicine Center, School of Medicine, University of California, Los Angeles, Los Angeles, CA USA

Abstract

The use of computed tomography (CT) scanning in blunt head trauma has increased dramatically in recent years without an accompanying rise in the prevalence of injury or hospital admission for serious, traumatic conditions. Because CT is neither harmless nor inexpensive, researchers have attempted to optimize utilization, largely through research that elucidates which historical elements, signs, and symptoms predict intracranial injury, and use this information to develop clinical decision instruments (CDIs). While such techniques may be useful when the benefits and harms of each strategy (neuroimaging vs. observation) are known, quantifiable, and amenable to comparison, the exact magnitude of these benefits and harms remains unknown in this clinical scenario. We believe that most CDI development efforts are misguided insofar as they ignore critical, non-clinical factors influencing the decision to image. In this paper, we propose a conceptual model to illustrate how clinical- and nonclinical-factors influence emergency physicians who are making this decision. We posit that elements unrelated to standard clinical factors, such as personality of the physician, fear of litigation and of missed diagnoses, and compensation method may have equal or greater impact on actual decision-making than traditional clinical factors. Further, we suggest that the paucity of research on nonclinical factors is not surprising as such research requires expertise not typically possessed by emergency medicine clinician-researchers. Acknowledgement and study of these factors will be essential if we are to understand how EPs actually make these decisions and how test-ordering behavior can be modified.

Corresponding Author and Reprints: Marc A. Probst, MD, UCLA Emergency Medicine Center, School of Medicine, University of California, Los Angeles, 924 Westwood Blvd., Suite 300, Los Angeles, CA 90024, USA, Fax: 310-794-0599, Telephone: 310-666-3834, mprobst@gmail.com.

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Keywords

Closed head injury; neuroimaging; decision-making

Introduction

Non-contrast head computed tomography (CT) scan is the most commonly ordered test to assess patients with mild head injury (MHI) [1–3]. Every year, there are an estimated 22 million ED visits in the US for injury-related conditions during which over 1 million head CTs are ordered (1 per 330 US population), representing substantial health care expenditures and exposure to ionizing radiation [2, 4, 5]. Despite serious concerns about these adverse effects [6–8], CT use in the ED continues to rise dramatically [4, 5, 9–11]. Fewer than 6% of imaged patients have clinically important intracranial injuries, and fewer than 1% require neurosurgical intervention.[2, 3] The decision to order a head CT for patients with MHI is particularly difficult since the actual magnitude of the harms (increased risk of malignancy, false-positive findings) or benefit (discovery of treatable intracranial injury) is not truly known in aggregate, let alone for each individual patient. Nonetheless, emergency physicians (EPs) must make this decision almost every shift. Many factors – clinical and non-clinical – influence the EP's decision to order a head CT. Current understanding and research efforts focus almost exclusively on the clinical factors underlying this decision, with little attention paid to the myriad and important non-clinical factors [1, 2, 12–18]. Though some emergency researchers have explored psychological, non-clinical factors affecting clinical decision-making [19], this work has generally been done by social scientists [20, 21].

Conceptual models are theoretical frameworks that have been used extensively in behavioral health science [22], and to some degree in emergency medicine [23–25], to better understand health service use. A greater understanding of why EPs order head CTs for MHI could lead to more effective interventions aimed at changing physician behavior and reducing the rate of unnecessary neuroimaging. We will present a conceptual model integrating both clinical and non-clinical variables to illustrate how they interact and lead to the final decision to order, or not order, a head CT. These variables can be divided into three categories: a) patient factors, b) systems factors and c) physician factors (Figure).

Patient factors

Classical models of decisionmaking in emergency medicine presume that patient factors are the primary determinant of CT testing (dashed box, Figure). Patient factors fall into three main categories: clinical variables, discharge circumstances, and patient or surrogate's wishes - which we refer to henceforth as "patient's wishes" with the understanding that we are including surrogates (e.g. parents of young children, family caregivers) in this term. In the classical model, EPs collect information on clinical variables on which they base their decision to order a CT. These models assume that the EP is weighing some combination of patient age, mechanism of injury, medications (particularly anticoagulants), past medical and social history, symptoms, and physical examination findings, to make a decision. Under this

model, EPs would synthesize these variables and estimate the likelihood that the benefits of CT outweigh the harms.

Patients' varying beliefs, and accompanying wishes, regarding the harms and benefits of radiologic imaging and patients' discharge circumstances often wield influence on this decision, yet have garnered little attention in the MHI research domain. With respect to the former, a patient may request neuroimaging because he has greater faith in technology than human judgment [19]. Conversely, he may request a head CT not be done due to accurate or inflated perceptions of harm. Evaluating the discharge circumstances of the patient (i.e. living situation, access to follow-up care, and presence of a reliable caregiver) will help determine whether proposed "watchful waiting" will truly be watchful, and whether the patient has ready access to care in the event of neurological deterioration. A patient who has reliable supervision, post-discharge, might be managed without imaging, while immediate imaging might be appropriate in a similar patient with less favorable discharge circumstances.

Systems factors

The classical model, focused on patient clinical variables, gives little weight to the many non-clinical systems factors involved in this decision. These include local clinical culture, departmental clinical protocols, compensation method, mid-level-ordered tests, availability of CT, national guidelines, regional variation and medicolegal climate. Often, a "typical work-up" exists for patients presenting to a particular ED with a given chief complaint. This local culture is usually dictated by key opinion leaders within a department [26, 27]. Additional cultural factors related to receiving blame for missed injuries, e.g. "morbidity and mortality rounds", may encourage EPs to order a CT scan for fear of having their "miss" being exposed to their peers. These cultural factors will interact with certain physician factors discussed below, including the risk-tolerance of the EP.

National guidelines may also influence an EP's decision to order neuroimaging. For example, the American College of Emergency Physicians publishes guidelines regarding the management of mild traumatic brain injury [3] which EPs can consult when making this decision. Departments may also have specific clinical protocols guiding the management of certain patients suffering MHI. For example, in Italy, some departments routinely order an initial and interval head CT (at 24 hours) on all elderly, anticoagulated patients presenting with MHI [28].

The compensation method under which the EP works can potentially affect their testing threshold if there exists a financial incentive to increase or decrease the intensity of care delivered to a patient [29]. These potential financial incentives are discussed further below.

Further, in EDs with mid-level providers (physician assistants, nurse practitioners, and residents in training), attending physicians may feel inclined to acquiesce to the plan of a mid-level provider who has already ordered a head CT and, in EDs with extensive triage protocols, CTs may be ordered without the physician's knowledge (see dashed line, Figure).

In certain practice environments, the limited availability of a CT scanner and necessary personnel (CT technologist, radiologist) can affect the decision to order a head CT, especially overnight and in smaller, rural EDs [30]. However with the widespread proliferation of CT scanners, this is likely to be an increasingly rare factor contributing to the decision in the US [11]. As CT scanners have become more common, and image acquisition more rapid, the barriers to CT scanning have fallen substantially which has contributed to a 330% increase in CT scanning in the ED from 1996 to 2007 [9].

Finally, systems factors at the macro level, such as the medicolegal climate in a particular area, may affect an EPs perception of medical liability and, in turn, affect his tendency to practice “defensive medicine.” Looking across 50 states, it was found that for every 10% increase in malpractice payments, imaging rates increased by 2.2%, the greatest increase of any physician service [31]. State-based limitations on non-economic damages, such as California’s Medical Injury Compensation Reform Act (MICRA), have been implemented in an effort to curb increasing malpractice costs and could conceivably alter an EP’s perception of medicolegal risk leading to a less defensive practice style [32].

Regional variation in health care resource utilization in the US has been well-known for quite some time [33]; there exists substantial regional variation in imaging rates not accounted for by differences in patient characteristics [34–36]. The location of an EP’s practice influences the decision to order a CT even after controlling for differences in patient population and injury severity [37].

Physician factors

Notwithstanding situations where imaging is independently ordered by non-physicians or via protocol, both patient and systems factors exert their influence through the EP since he is ultimately the one responsible for ordering the test.

Many physician factors influence this decision, including training and past clinical experience, perception of harms of CT, fear of error, fear of malpractice, personality, financial incentives and consultant input. EPs have varying beliefs regarding the utility of CT imaging determined by their clinical training and experience. Certain EPs feel that advanced imaging is overused leading to increased radiation exposure, false-positive results and unnecessary health care resource utilization [1, 2, 5, 14, 15]. EPs who trained in the era prior to the proliferation of CT scanners may feel more confident excluding significant intracranial injury on clinical grounds alone. Conversely, other EPs may rely heavily on imaging results to manage patients with MHI. Physicians have varying perceptions of the risks of radiation associated with CT [38–40], partly because our current understanding of the risks of CT-induced malignancy is based primarily on studies of atomic-bomb survivors in post-war Japan and radiation workers in the nuclear industry [6–8]. The applicability of these studies is debated.

A crucial, non-clinical factor involved in this decision is the personality of the EP caring for the patient. Many personality traits influence this process in complex psychosocial ways [19]. One key trait is the EP’s tolerance for risk and uncertainty which is inversely

proportional to their fear of error and fear of malpractice. These two fears are critical factors that produce strong incentives to order neuroimaging. These fears can be substantially amplified by personal experience with medical-malpractice lawsuits [41]. The fear of "missing" a critical diagnosis leading to reprimand or shame from colleagues can also be a motivating factor in ordering a CT [42].

An EP's perceived risk of litigation in the event of a bad outcome can influence his decision to order tests. Increased malpractice liability cost is associated with increased imaging use [31]. There is evidence of the widespread practice of "defensive medicine," defined as deviation towards more conservative medical practice induced primarily by the threat of liability [43, 44]. Depending on his risk tolerance, such fear may encourage an EP to practice defensively and order advanced imaging for fear of missing a diagnosis, even when the pretest-probability of significant intracranial injury is extremely low [41]. Studies of EP test-ordering behavior have shown that malpractice fear is correlated with CT and ultrasound imaging rates for patients with abdominal pain, as well as admission and CT coronary angiogram rates for patients with low-risk chest pain [45–47]. Most studies have shown that medicolegal concerns can increase neuroimaging rates substantially [43, 48, 49].

Consultant input is another important non-clinical factor. EPs often work in concert with trauma surgeons, neurosurgeons, and primary care providers who have their own practice style with respect to neuroimaging. To avoid conflict, EPs may honor their colleague's desires despite having different beliefs about the need for imaging [41, 50].

Lastly, in the setting of spiraling health care expenditures, cost-conscious EPs may consider the economic consequences of indiscriminate head CT ordering when evaluating patients with MHI. The hospital charge for a head CT in the US can range from $500–$800 [1, 2]. Interventions focused on cost effective, appropriate resource utilization may stress observation, either in the ED or at home with a reliable caregiver, over immediate neuroimaging. The increased ED length of stay (LOS), estimated to be up to 2.5 hours [13], associated with head CT imaging may encourage EPs to forgo head CTs when not clearly necessary to improve ED throughput [23]. However, such practice could actually increase ED LOS if non-imaged patients are held for prolonged periods of observation.

An additional, rarely discussed, non-clinical factor is the positive financial incentive associated with ordering advanced imaging. In the US, there are various compensation methods for physicians including salary, capitation, and fee-for-service [51]. EPs are generally compensated under a fee-for-service or hourly wage arrangement with the exception of certain organizations where they are salaried. If an EP is compensated under a fee-for-service arrangement or is given bonuses based on productivity, and has an incentive to increase the complexity of patient encounters, one way to do so is to order advanced imaging [52]. Whether through conscious or subconscious processes, compensation mechanisms can influence test-ordering behavior. Several studies have demonstrated the strong influence that financial incentives have on physician practice patterns, including the ordering of advanced imaging [29, 53–55]. However, other studies have shown that while diagnostic imaging has increased in fee-for-service environments, similar increases have occurred in the managed care setting [56]. Although these studies were not conducted in the

emergency setting, the findings likely extrapolate to the ED. More research is needed to determine the effect of financial incentives on CT ordering in the ED setting.

All of these physician factors interact in tangible and intangible ways, consciously and subconsciously, leading to substantial inter-physician variation (up to 10-fold difference) in CT-ordering [37, 57].

Limitations of the classical model

Under the classical model, the EP synthesizes all of the clinical variables to formulate a differential diagnosis and estimate the risk of intracranial injury. The diagnostic hypothesis is refined as additional data becomes available. If the risk of intracranial injury exceeds an EP's testing threshold, he would pursue the evaluation with a head CT. This is also known as the hypothetico deductive method [58]. Despite much research on this topic, the decision to image remains quite subjective and varies greatly from one EP to another, and from one institution to another [34, 36, 57]. In reality, EPs often draw on cognitive processes such as algorithms or heuristics, occurring at the conscious and subconscious level rather than on an explicit numerical estimation of risk [58, 59]. An example of this would be the "age heuristic". In certain scenarios, only one variable may be required to make the decision to order a head CT in the setting of blunt head trauma: advanced, older age. This could conceivably occur without collecting other clinical variables, nor formulating an estimate of either the probability of intracranial injury or the threshold for testing.

Much of the research on this topic has focused on identifying clinical variables which are predictive of intracranial injury. To further aid the EP in this decisionmaking, CDIs have been developed to discern which clinical variables, in concert, can obviate the need for neuroimaging. Examples include the New Orleans Criteria, Canadian Head CT Rule, NEXUS-II criteria, and PECARN criteria for pediatric blunt head trauma [1, 2, 14, 15].

CDIs are a standardized form of case-by-case decision analysis. They bypass the time-consuming and impractical process of precisely balancing the probability of benefit and harm in each individual clinical encounter. CDIs distill the clinical information down to a select few variables and provide a simplified algorithm or checklist to aid clinicians in risk-stratifying patients with MHI. A CT is recommended when that risk estimate exceeds the testing threshold, which is, ideally, the probability of injury at which expected benefit of neuroimaging exceeds expected harm.

While this model has theoretical appeal, its application in clinical situations is compromised by three major problems. First, there is insufficient evidence to establish a threshold, as evidence is sparse and, even in the presence of perfect information, the weighing of benefits and harms is highly subjective and fraught with value judgment (how does missing one non-operative intracranial hemorrhage compare to performing 100 negative CTs?).

Second, there is evidence that few EPs use these instruments to guide the ordering of head CTs [60]. One international survey found that only 31% of EPs in the US were aware of the Canadian Head CT rule and only 12% reported using it [61]. Even when implemented, these instruments are often improperly applied and can actually increase the rate of CT imaging

[62]. Complex or cumbersome CDIs may experience lesser penetration due to an EPs inability to readily recall them [2]. Certain patient factors can be difficult to include in the derivation of these instruments due to low inter-rater agreement or high subjectivity [12]. Examples of this are the discharge circumstances of each patient (discussed above) and patient preferences. Of note, the PECARN study on pediatric blunt head trauma does loosely incorporate physician experience and parental preference in their algorithms for imaging [15]. Third, there is little reason to believe that the thought processes of the majority of EPs follow the hypothetico deductive method for this clinical scenario. As discussed above, many non-clinical factors, unrelated to the risk of traumatic injury, influence the EP. For example, an EP working in a litigious environment, feeling pressure to move fast due to a crowded waiting room, may order a head CT after a cursory evaluation of a patient to achieve greater diagnostic certainty and potentially arrive at a disposition more quickly.

A practicing EP does not make decisions in isolation. The interaction between the patient and EP is a dynamic process that can be affected by the personalities of each, and their perceptions of the harms and benefits of CT scanning [19]. The relative weight given to the patient's and EP's opinions will vary depending on the personalities of each and the dynamics of that particular patient-physician dyad. The trust an EP engenders in his patient can vary based on many factors such as cultural concordance, bedside manner and time spent with the patient. This trust can be leveraged to reassure a patient without using medical technology [19]. The style of interaction in a patient-physician dyad can range from mutualism to paternalism. In a mutualistic relationship, the physician and patient actively share information and take steps to build a consensus about preferred management [63]. In the face of clinical equipoise, the EP would presumably be more likely to strive for mutuality and actively seek the input of the patient. Conversely, in the absence of equipoise, the EP will be more likely to act paternalistically and make this decision with little input from the patient. Of course, what constitutes clinical equipoise is highly subjective and can vary greatly among EPs.

Although some EPs may be reluctant to engage patients in these decisions for fear that patients might refuse imaging due to concern of developing cancer, this has not been borne out in studies [10, 64, 65]. A greater concern may be whether the busy EP has time to engage in a protracted discussion each time a head CT is being contemplated.

Thus, while CDIs are the most studied solution to test ordering in low-probability, high-morbidity situations, it appears that EPs are often indifferent to them, relying heavily on non-clinical variables instead. We propose an alternative, more encompassing model which takes into account factors beyond traditional clinical variables.

Currently, the relative importance of patient, systems, and physician factors on the decision to order a head CT is unknown. By their nature, these effects likely vary regionally, from ED to ED, from EP to EP, and from patient to patient. What is clear is that models that consider only clinical patient variables have no chance of explaining all the reasons behind test-ordering decisions. It would behoove us, as a community of emergency medicine physicians and researchers, to not, like an inebriate looking for his keys under the lamppost, focus exclusively on clinical variables, but rather acknowledge and begin to study these non-

clinical variables. Only then can we design and implement interventions which really and truly influence EP test-ordering behavior. Such endeavors will require collaboration with social scientist with specific expertise in the social and cognitive psychology that underlies such decisions.

Conclusion

In summary, many factors, clinical and non-clinical, affect the patient-physician decisionmaking dyad. These can be divided into patient, systems, and physician factors which exert influence at the conscious and subconscious level in a complex pattern that ultimately leads to a decision regarding neuroimaging for mild head injury. The large variability in head CT utilization and the multiple unsuccessful attempts at implementing CDIs for this clinical entity provide further evidence of the complexity of this issue and the crucial role of non-clinical factors. We offer a conceptual model, with an emphasis on non-clinical factors, which may serve as a roadmap for further research to improve our understanding of physician test-ordering behavior and methods to optimize utilization. Such endeavors could inform the development of more effective interventions to safely reduce testing without comprising quality of care.

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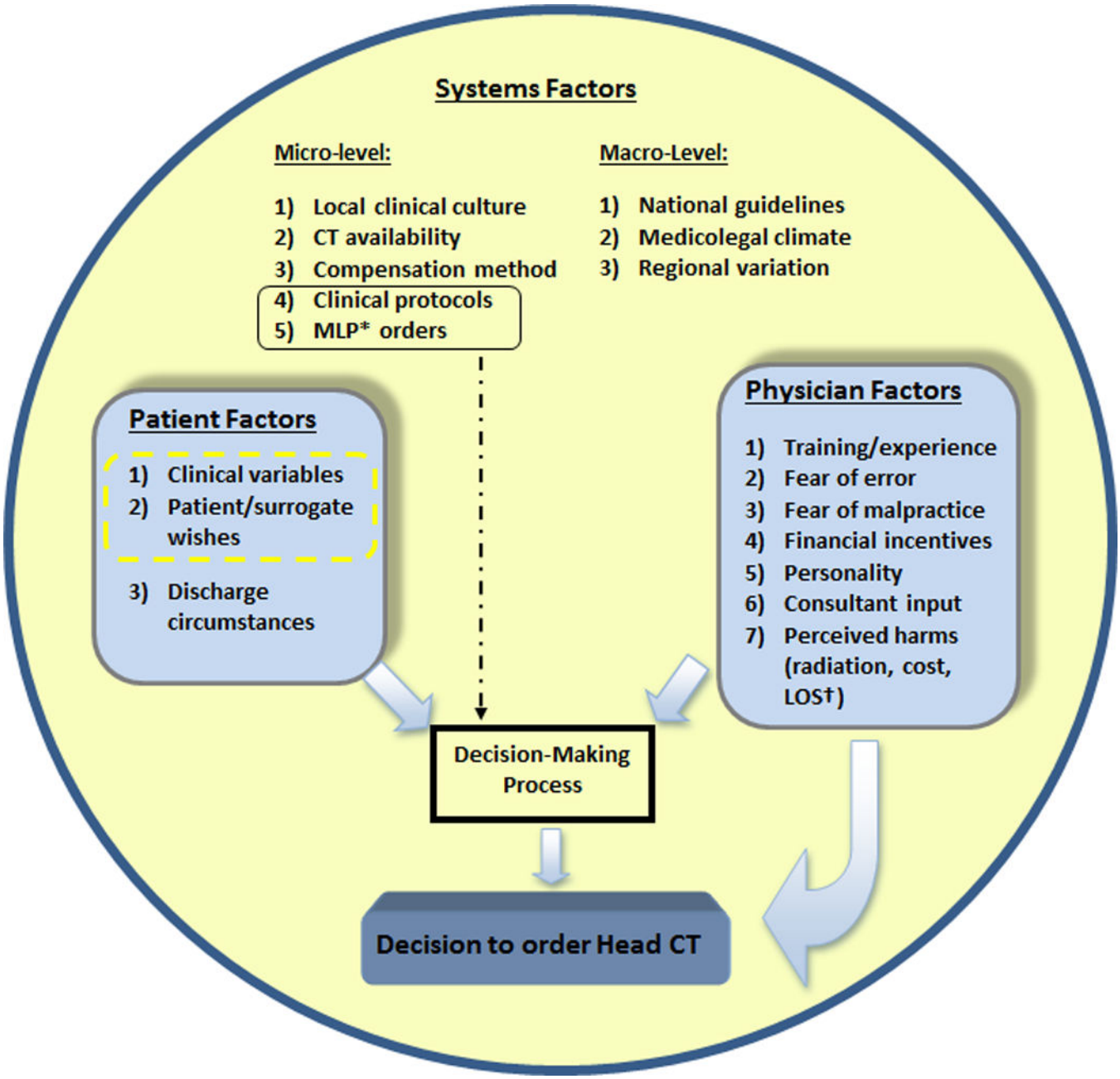

Figure. Conceptual model of decisionmaking for head CT use in mild head injury
*MLP: Mid-level provider. †LOS: Length of stay.