The effect of peer influence on the use of CT by emergency physicians for patients with headaches

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A B S T R A C T

Background: It is challenging for emergency physicians (EPs) to distinguish between patients with life-threatening and benign headaches. We examined the effect of peer influence on computed tomography use by EPs for patients with headache and evaluated the peer influence effect in EPs with different levels of risk tolerance.

Methods: We conducted a before- and after-retrospective case review, and administered the Risk-Taking subscale of the Jackson Personality Index to attending physicians. Each EP computed tomography (CT) use rate, patient number, and CT use, were e-mailed every two months to enhance EP team norm and establish a trend in behavior.

Results: Of the 665 (before intervention) and 669 (after intervention) patients with headache, 206 (31%) and 171 (25.6%) underwent brain CT scans, respectively. Decreased use of CT examination was found in the post-intervention group (OR = 0.758, 95% CI: 0.593–0.967), especially for most risk-tolerant physicians (OR = 0.530, 95% CI: 0.311–0.889). There was prolonged ED length of stay (LOS) in the pre-intervention group (OR = 51.52, 95% CI: 26.998–76.050).

Conclusions: We observed that peer influence is an effective way to improve CT use rate and emergency department LOS for patients with isolated headache, especially for most risk-tolerant physicians. These findings could enhance the development of appropriate guidelines to assist ED physicians’ CT use.

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1. Introduction

Headaches, one of the most common reasons adults seek medical advice, account for about 1.84–4.5% of emergency department (ED) visits [1–3]. There are many causes of headaches, from benign and self-limiting, to serious and life-threatening causes. Intracranial pathology (ICP) accounts for about 2.5–3.8% of patients reporting to the ED for headaches [1, 3]. It is challenging for emergency physicians (EPs) to distinguish between the few patients with life-threatening headaches and the overwhelming majority with benign headaches. Non-enhanced computed tomography (CT) is a commonly used tool to assess headaches due to its ready accessibility and diagnostic accuracy [1]. Although life-threatening problems account for a small fraction of all headaches, a missed or delayed diagnosis of a potential critical disease might lead to treatment delays or medical disputes. Therefore, EPs may lower the testing threshold for brain imaging. Furthermore, CT utilization for non-traumatic headache in the US emergency departments trended upwards from 1998 to 2008 with a concurrent decrease in the prevalence of ICP [4]. However, unnecessary head CT examinations may lead to increased length of ED stay [5], medical costs [6], and radiation exposure [7, 8]. Some studies attempted to identify specific decision rules for determining who should receive neuroimaging for acute headache, especially when the differential diagnosis includes subarachnoid hemorrhage [9]. Others tried to use clinical risk factors to decrease unnecessary CT use in ED [10].

Although some studies put forward some rules or criteria for head CT use in patients with headache, no protocol can achieve 100% perfection. A missed or delayed diagnosis of headache with ICP, especially subarachnoid hemorrhage, might also lead to treatment delays or medical disputes. A previous study focused on EPs’ risk tolerance and the association with ED CT use for isolated headache [3]. Another study evaluated the effect of peer influence on changing disposition decisions by EPs.
Therefore, we aimed to examine the peer influence effect (by creating a “team norm” imposed peer influence effect) to change computed tomography use decisions for patients with headache. Secondly, we sought to evaluate the peer influence effect in EPs with different levels of risk tolerance.

2. Materials and methods

2.1. Study design

The study was approved by Chang Gung Memorial Hospital’s institutional review board and has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki). Written informed consent was obtained from all EPs before the survey. We conducted a before-and-after retrospective case review of patients who visited the ED to evaluate the effectiveness of peer influence in changing EP decisions about CT use for patients with headache. This intervention study created a ‘team norm’ imposed an unspoken peer-influence effect by announcing the CT use rate of each EP. The CT use rate of each EP, including patient number, and CT use, was calculated and announced via e-mail every two months to enhance the team norm and shape the behavior of each EP. E-mails included the detailed number of patient visits for headache and CT use at each shift handled by each EP. Grading and listing of the CT use rate data for all EPs was also included and the top three (including most CT use and least CT use) EPs were identified. To ensure that no further pressures were mounted on the EPs, only numbers were reported to the EPs without any additional rewards or punishments. Delivery of the e-mail reminders commenced since July 2016. The pre- and post- intervention study periods were from January 1 to June 30, 2016, and September 1, 2016 to February 28, 2017, respectively.

2.2. Setting and population

This study was conducted in a tertiary academic medical center in Southern Taiwan with over 2500 acute beds and an average of 72,000 adult ED visits per year. The medical records of non-traumatic patients with a principal diagnosis of headache who were older than 17 years and visited the ED were extracted from the ED administrative database using the International Classifications of Diseases (ICD) Tenth Revision coding system (ICD code: R51). Electronic charts were reviewed to identify patients with isolated headache defined as those with a primary complaint of headache but without documented evidence of stroke who were screened by ED clinicians. Patients with documented new onset abnormal neurologic findings based on cranial nerve examination, cerebellar function tests, or muscle power or sensory changes, or patients with changes in levels of consciousness were excluded. We defined headache secondary to ICP based on a new finding on the brain CT images that could cause headache and that were confirmed by brain magnetic resonance imaging or diagnosed as such by a neurologist at hospital discharge.

2.3. Physician risk tolerance evaluation

We used Risk-Taking subscale (RTS) of the Jackson Personality Index to evaluate physician risk tolerance. This scale has been used in prior studies to evaluate EP decision-making and test-ordering behavior [12–14]. Detailed questionnaire for this survey instrument is listed in the Supplementary Table S1.

During the study period, we had a total of 30 EPs in our department, and one (the corresponding author of this study), was excluded. In January 2017, all EPs completed a survey consisting of the questionnaire. Physicians were divided into quartiles based on their test score, with quartile 1 being the group expected (a priori) to be most risk-averse (low risk takers and more fearful of malpractice litigation). All EPs were exposed to a 4-year emergency medicine residency training conducted by the Taiwan Society of Emergency Medicine in a qualified teaching hospital. None of the physicians that were included in this study had been deposed in a lawsuit as a defendant during the previous 5 years. In our ED, residents assist in evaluating patients, but the EPs make the final decision regarding CT examination scheduling and admissions. EPs were paid according to the number of shifts worked and not the number of patients treated; therefore, test ordering was not profit motivated.

2.4. Variables and outcome measures

Age, sex, triage status, and risk factors for secondary headache, including hypertension, diabetes, malignancy, and coronary artery disease, were collected from the medical record charts of patients [15–21]. Mean arterial pressure (MAP) at triage and triage status were also collected. Brain CT use, ED length of stay (LOS), 72 hour revisit, and the final discharge diagnosis of secondary headache by a neurologist were also documented. The primary outcome was brain CT use during ED evaluation, and the secondary outcome was ED LOS and final diagnosis of headache secondary to ICP.

2.5. Data analysis

The results of the descriptive analyses of independent variables are reported as percentages (categorical variables) or mean ± standard deviation and median (interquartile range) for continuous variables. Independent variables were analyzed using χ², Mann-Whitney U, and Student t-tests. The statistical significance of the relationship between the CT use rate before and after intervention in terms of total patients and different EPs groups was analyzed with logistic regression to obtain the odds ratio (OR) and 95% confidence interval (CI). The statistical significance of the relationship between the ED LOS before and after intervention was analyzed with multiple regression analysis to obtain the OR and 95% CI. p value < 0.05 was regarded as statistically significant. SPSS version 18.0 (SPSS, Inc., Chicago, IL) was used for all statistical analyses.

3. Results

3.1. Characteristics of study subjects (before and after intervention)

During the study period, a total of 82,274 patients visited the ED, and 1446 (1.76%) of patients had headaches as their primary diagnosis. Of these, 112 patients were excluded from the analysis because a chart documented new neurological deficit or based on the diagnosis by the corresponding author. Thus, the remaining 1334 enrolled patients (with 665 (before intervention) and 669 (after intervention)), comprised our study group. The median number of patients assessed by each EP was 46 and 45 before and after intervention. Among the 29 EPs, median RTS (interquartile range) was 21 (19–23).

The demographic characteristics of the before and after intervention groups are listed in Table 1. In each intervention group, patients who received brain CT examinations were 206 (31%) and 171 (25.6%), respectively (p = 0.028). At univariate analysis, significant difference between the two intervention groups was shown only with ED LOS in the after intervention group with a shorter ED LOS (p ≤ 0.001). No significant difference was shown between the before and after intervention groups in age, gender, as well as for hypertension, diabetes, malignancy, coronary artery disease, triage status, mean arterial pressure at triage, and final diagnosis of secondary headaches.

There were 44 (3.3%) patients with a final diagnosis of headache secondary to ICP (Table 1). Of these, 9, 7, 16, 10, 1 and 1 patients had tumor lesions (including meningioma and malignancy), intracranial hypotension, hemorrhages (including subarachnoid and subdural hemorrhages), intracranial infections (including encephalitis and meningitis), central vein thrombosis, and vertebral artery dissection, respectively (not shown).
13 (2.0%) and 16 (2.4%) patients revisited the ED within 72 h due to headache (p = 0.299) in each intervention group, respectively. Of these, 2 patients in the pre-intervention group were diagnosed with secondary headache (one had intracranial hypotension and the other had intradural vertebral artery dissection), and 2 patients in the post-intervention group were diagnosed with secondary headache (one had intracranial hypotension and the other had cavernous sinus thrombosis).

### 3.2. Association between patient and physician characteristics and decision-making

As shown in Table 2, univariate analysis revealed that EPs tend to order brain CTs in older (p = 0.008) patients and patients with hypertension (p < 0.001), diabetes (p < 0.001), malignancy (p = 0.049), human immunodeficiency virus (HIV) (p = 0.001), triage status I and II (p < 0.001), as well as patients with higher mean arterial pressure at triage (p = 0.003). Patients who received CT examinations had longer ED LOS (p < 0.001). Risk tolerance, based on RTS scores was not significantly associated with a higher likelihood of head CT use (p = 0.09).

### 3.3. Association between intervention and decision-making

In Table 3, findings of multivariate logisitic regression of secondary headache adjusted for patient level confounding factors including age, history of diabetes, hypertension, malignancy, HIV, mean arterial pressure during triage and triage status of I and II are shown. A significant association between intervention (overall) and head CT use (p = 0.026) was observed. Compared with the pre intervention, the post intervention group demonstrated a statistically significantly decreased probability of CT examination (OR = 0.758, 95% CI: 0.593–0.967). At linear regression analysis, in Table 3, a significant association between intervention and ED LOS was also observed (beta coefficient = 51.52, CI: 26.998–76.050). When patients were categorized into four groups by EPs according to RTS, we found a significant association with CT use between most risk-tolerant EPs and intervention (OR = 0.530, CI: 0.311–0.889).

### 4. Discussion

Our study showed a statistically significant decrease (OR = 0.758) in CT use based on the dissemination of information on the CT use rate by each EP for patients with isolated headache, resulting in 24.2 less CT examinations per 100 patients with isolated headache in the United States, where head CT cost $1220 [22]. This study may therefore provide a possible way to reduce the rate of CT use and further reduction in medical cost.

To decrease CT use for patients with isolated headache in ED, we used audit and feedback method by sending e-mail to EPs to stimulate a peer effect. This method, as documented by Weiner et al. [23] reported...
based on the weekly e-mail reminders, performance on antibiotic administration (with shorter time to antibiotics administration) and increased compliance with a clinical guideline. Similar audit and feedback methodology was also applied in other studies. Wu et al. [11] created peer influence to enhance patient flow and throughput by announcing discharge rate of each EP monthly. A review focused on audit and feedback effect, revealed improved performance reporting in 23 of the included 24 studies [24]. Audit and feedback interventions used in the majority of these studies were feedback targeting errors of omission and explicit errors with measurable instruction and a plan for change delivered in the clinical setting after 1 week of the audited performance. In a study, the use of audit and feedback effect was analyzed by sending a one-time e-mail to change the ordering patterns in the ED thus reducing the utilization of CT for pulmonary thromboembolism in young patients, but the result was not statistically significant (p = 0.343) [25]. There was no standardized reporting time and method to identify the specific aspects of audit or feedback that drives the effectiveness in the ED.

In the present study, we created audit and feedback effect by sending e-mail of the rate of CT use every two months. This is the first study focused on audit and feedback effect on the use of CT in patients with headache. We found a statistically significant decrease in CT use (OR = 0.758, CI = 0.593–0.967). We chose to send e-mail every two months because the average case number in our ED was about 100 per month with an average of 3 cases per EP per month. Identifying difference within a month might be difficult due to limited case numbers. However, further study might be needed to clarify idealized methods and times for creating appropriate audit and feedback that might detect an effect in different situations.

Some economic studies showed that peer influence had a positive and significant effect on worker productivity in real time [26]. Real-time interactions between workers allow peer influence to be determined throughout the work period. Some studies attempted applying patient-level peer effect on diabetes control [27]. They trained some patients as peer coaches and assigned other patients to receive health coaching. Peer health coaching significantly improved diabetes control. In this study, we created peer influence by sending e-mail to every EP. EPs can see their own CT use rate and the rate of other EPs in the e-mail. This result showed a positive effect on CT use. Similar result was found in a previous study, which revealed improved patient flow in ED [11].

ED overcrowding is a growing problem with aging [28]. Overcrowding might increase the frequency of medication errors [29] and have an adverse impact on the quality of clinical care, including increased risk of blood culture contamination [30]. To decrease ED LOS might prevent overcrowding. Several studies have examined factors which may reduce LOS. Previous studies showed that the implementation of computerized physician order entry reduced LOS by 23 min [31] while implementing a rapid whole blood quantitative o-dimer test, reduced LOS by 1.32 h [32]. In our study, we found that the after intervention group had a statistically significant decrease in the probability of CT examination and reduced LOS by 51.52 min compared with the before intervention group. Another study [33] found that CT use facilitated patient disposition if they were finally hospitalized but slightly prolonged ED LOS in patients discharged from the ED. This finding seems to have a different conclusion from ours, which might be because they enrolled all adult non-trauma patients and stratified by different dispositions, while we only enrolled adult patients with non-traumatic headache regardless of their disposition. Further studies will be needed to clarify the differences.

In our study, 377 of 1334 (28.3%) patients with headache received brain CT examinations in the ED. A previous study indicated that about 14% of patients with headache received an imaging examination in the ED from 1992 to 2001 [34]. Another study indicated that about 16% of patients with non-traumatic headache received brain CT examinations from 2003 to 2006 [35]. The reported proportion in this study seems higher than that of previous studies. This might be due to two possible reasons. The frequency of imaging (including x-ray study, CT, and nuclear medicine imaging) use has gradually increased over time [36]. For example, CT examinations in the United States were 10 times higher in 2006 compared to 1980. Another study indicated that the number of CT examinations in ED increased from 2.7 million to 16.2 million, constituting a 5.9-fold increase and a compound annual growth rate of 16.0% from 1995 to 2007 [37]. Another study [4] also indicated that the percentage of patients presenting to the ED with a traumatic headache who underwent imaging increased from 12.5% to 31.0% between 1998 and 2008. The study period during which we assessed visits to our ED was between 2016 and 2017, hence, the higher usage of brain CTs might be compatible with the trend reported in previous studies. Another possible reason is that the cost of brain CT is nearly 100% covered by the Taiwan National Health Care Insurance emergency medical services. Previous studies have revealed that patients with health insurance are more likely to have undergone diagnostic testing and non-urgent ED visits [38, 39]. All of the patients included in this current study were covered by the national insurance and paid approximately US $23 for ED medical services, which included the CT scan. It is possible that the lower relative cost of ED medical services and the high insurance coverage might have contributed to the increased CT examinations in the ED.

Previous studies [12, 14] have also demonstrated that risk tolerance is associated with practice variations which can drive physicians to exercise risk-averse behavior. For example, risk-averse EPs that fall into quartiles concerned with malpractice will order more cardiac marker tests and increase hospitalization rates when treating patients with chest pain. In addition, variations in personal risk-taking behavior also influence imaging use in patients who present with abdominal pain [12]. Another study [3] found that individual EP risk tolerance measured by the RTS, was not predictive of CT use in patients with isolated headaches. In the present study, the most risk-tolerant EPs tend to order less CT and the decline of CT use, after intervention, was more significant (OR = 0.530, CI = 0.311–0.889). Different effects caused by peer influence may be associated with risk tolerance behavior, and this needs to be studied further for better clarification.

There was about 3.3% of ICP in adult patients with non-traumatic headache who received brain CT in the ED in this study. Previous studies indicated about 2.5% [3] and 3.8% [1] of ICP in patients with headache in the ED. Another study [40] found the proportion to be about 3.1%. The reported proportion of ICP in this study is similar with others. 13 (2.0%) and 16 (2.4%) patients revisited the ED within 72 h due to headache in the pre- and post-intervention groups, respectively. There was no significant difference in revisit rate between the groups within 72 h (p = 0.299). Thus, our intervention might not increase the 72-hour revisit rate. No medical dispute occurred during the study period. However, the rate of head CT use in the outpatient department could not be obtained in our study; further studies might be needed to clarify the effects in both the emergency and outpatient departments.

4.1. Limitation

There are several limitations to this study. First, the relatively small sample number of EPs at a single teaching hospital may affect the interpretation of the findings and limit the generalizability of the conclusions to other ED settings. Second, the relatively small number of patients with headache secondary to ICP may have limited the statistical power of between-group analyses. There were chances that a patient with a chief complaint of headache escaped our review because the inclusion criterion was ICD-10 diagnosis code R51. If a physician had not used this code, those cases would not have been included. Third, the current study was conducted in a single country. Other countries have diverse laws and regulations, such that an EP's behavior may be different when facing medical disputes; these factors could affect risk tolerance. Fourth, this study was conducted in a country where national
health insurance penetration is high, medical costs are relatively low, and baseline CT utilization is high. The findings may not be necessarily applicable for countries in which health insurance penetration is low, medical costs are relatively high, or baseline CT utilization is low. Fifth, we created peer influence by sending e-mail every two months due to the relatively small numbers of patients with a headache evaluated by each EP.

5. Conclusion

Peer influence enhanced by e-mail reminders is an effective way to improve CT use rate and ED LOS for patients with isolated headache, especially for most risk tolerant physicians. Since peer influence has the potential to reduce the number of CT examinations and ED LOS, these findings could enhance the development of appropriate guidelines to assist ED physicians’ CT use. Further studies are needed to understand the ideal method and appropriate timing interval of peer influence among ED physicians.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajem.2018.07.030.

Conflict of interest

The authors declare that they have no conflict of interest.

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