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Research Article

e-Migraine: Development of a Comprehensive Tool to Estimate Migraine Comorbidity Index Score

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Abstract:

e-Migraine is a validated tool to estimate the severity of headache based on Migraine Comorbidity Index (MigCI) that includes comorbidities of migraine, age, baseline duration of headache (hours) and baseline frequency of headache (day/month). The aim of this study is to introduce the prediction tool for physicians to calculate the MigCI score easily. Our study sample consisted of 2012 patients enrolled in the Turkish Headache Database examined by neurologists between 2000 and 2015. Comorbidities were modeled according to posterior probabilities obtained from Latent Class Analysis. The score ranges of the baseline duration and frequency of migraine were determined according to previous studies and histogram charts. Age groups were designated by the classification of World Health Organization. An index formula was created by using all these variables and total score was calculated. The range of MigCI score was 1.02 and 17.22. The median value with the 25th and 75th percentiles were 4.44[2.96-6.00]. The MCI introduced in this study is the first to estimate the headache score considering the posterior probabilities as weights. e-Migraine is a practical tool that may help physicians to detect the headache score and suggest a treatment or care to the patients according to the score.

1. Introduction

Migraine prevalence is reported as approximately 12%, with differences between countries or regions in the same country[1]. Migraine, is a type of headache with attacks and multiple co-morbidities, has the highest prevalence in the 25-55 age range which is the most productive period of life. Migraine not only affects one's self but also family and social life because it is a long term disorder [2,3]. Management of the long-term disorders is the main burden of governments and health-care in the world. Especially, individuals with three or more comorbidities in long term diseases need a special care and increase the burden of government [4,5].
Unfortunately, there is no gold standard method to measure comorbidity effect on disease prognosis. Recently, in support of study findings have presented that comorbidity effect on diseases can be evaluated by comorbidity indices [6-14].It is recommended that a disease- specific comorbidity index should be developed because comorbidities of diseases are changeable. Moreover, the population may have some heterogeneous patterns. The population heterogeneity must be considered at the decision of the best method for evaluation of comorbidity effect. There are lots of comorbidity indices in literature but most of them have an outcome related to mortality [15-18]. In the light of this information, it is the first study that developing a comorbidity index that is specific for migraine [19]. As a result of an increasing interest to mental health applications in the world, these indices have been developed with mobile or web applications to

be more useful for clinicians and patients[20]. For this reason, we developed a web tool for migraine specific comorbidity index. The aim of this study is to introduce e-Migraine that is a user friendly tool to estimate the severity of headache based on comorbidities of migraine, age, baseline duration of headache (hours) and baseline frequency of headache (day/month). Moreover, this tool creates a database for further researches.

Material

The e-Migraine study was based on follow-up data in a 15-year computer-based Turkish Headache Database. The total number of patients followed in the database between 2000 and 2015 was 13465 patients. Diagnosed with non-migraine (n=11377) and missing values in variables (n=76) excluded from the study. Final number of patients taken into study was 2012 according to the inclusion and exclusion criteria. Local ethics committees had approved the study. The study was approved by the clinical research ethics committees of Mersin University on 11/26/2015 (Meeting number/ Decision number: 22/355).

Methods for development of the MigCI score with e-Migraine

e-Migraine had been developed based on the Migraine Comorbidity Index (MigCI), which included migraine comorbidities (epilepsy, allergy, atherosclerosis, hypertension, diabetes mellitus, coronary artery disease, anxiety and depression), baseline duration of headache (hours), baseline frequency of headache (day/month), age and baseline Visual Analog Scale (VAS) as an outcome measure of migraine. For more detailed information about calculation of the score that includes models, analyses and results, utilize the study with reference number[19]. The score ranges of the baseline duration and frequency of migraine were determined according to previous studies and histogram charts[21].Age groups were designated by World Health Organization. An index formula was created by using all these variables, total score was calculated and web application of MigCI (e-Migraine) was developed based on Table 1. The mean age of patients was 37.27±12.11 years. The mean of baseline duration of headache was 26.38±26.06 hours, frequency of headache was 9.79±9.25 day/month and baseline VAS score was 8.04±1.67. The most common comorbidity of our data was hypertension (22.9%) and the least one was atherosclerosis (0.2%). We have planned to collect migraine types of patients with e-Migraine for a further research that investigate the relationship between type and index score. The majority of our data had migraine with aura

Table 1. *The source comorbidity index of e-Migraine*

Migraine Comorbidity Index		Score
Age	0-17	1
	18-65	2
	66-79	3
	80-99	4
Baseline Duration of headache (hours)	0-16	1
	17-41	2
	42-62	3
	63+	4
Baseline Frequency of headache (day/month)	0-15	1
	16-26	2
	27+	3
*Baseline Severity of headache (VAS) (0-10)		
Existence of Comorbidities	Yes(1)	No(0)
Epilepsy	☐	☐
Allergy	☐	☐
Atherosclerosis	☐	☐
Hypertension	☐	☐
Diabetes Mellitus	☐	☐
Coronary Artery Disease	☐	☐
Anxious	☐	☐
Depression	☐	☐
Posterior probability of individual		
Index score	Age score*Posterior probability*(Frequency of headache score + Duration of headache score)	

**Baseline severity of headache was collected for further database and researches. This measurement was not included in the index formula.*

(60.2%) and migraine with visual aura (25.6%), respectively. The range of MigCI score was 1.02 and 17.22 for our study sample. The mean of score was 5.07±2.19. The median value with the 25th and 75th percentiles was 4.44[2.96-6.00]. The patients with the score six or more may follow more careful than the others. The histogram of MCI scores was given in Figure 1.

Statistical Analysis

Group Based Trajectory Models (GBTM) were used to determine the best weighting method for the heteregeneous and longitudinal population. After GBTM analysis, it was decided that the most successful weighting method was posterior probabilities of comorbidity combinations obtained from Latent Class Analysis (LCA) according to Akaike and Bayesian Information Criteria. These posterior probabilities were calculated with the Equation 1.

$$\hat{\pi}_{tijkl}^{X|ABCD} = \frac{\hat{\pi}_{tijkl}^{ABCDX}}{\sum_{t=1}^{T} \hat{\pi}_{tijkl}^{ABCDX}} \quad (1)$$

i=0,1; j=0,1; k=0,1; l=0,1; t=1,2

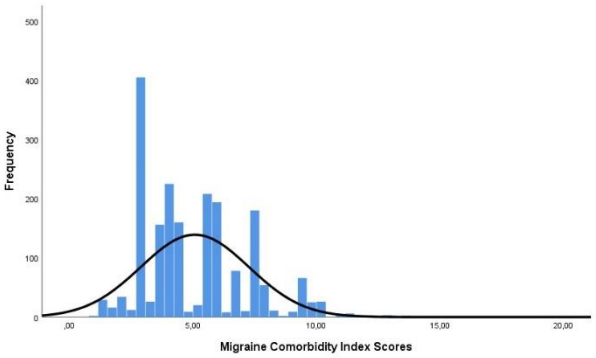

Figure 1. *Histogram of MigCI Scores*

$\hat{\pi}_{tijkl}^{ABCDX}$ was obtained by multiplying the responses of the comorbidities and the class membership probability. $\pi_{it}^{A|x}$ was the i. response to comorbidity A, $\pi_{jt}^{B|x}$ was the j. response to comorbidity B, $\pi_{kt}^{C|x}$ was the k. response to comorbidity C, $\pi_{lt}^{D|x}$ was the l. response to comorbidity D and π_{t}^{x} was the class membership probability [22,23]. Analysis were conducted in STATA MP/11 and Latent Gold 5.1.

Technical information of MigCI

e-Migraine is a patient recording, searching and index score calculating system based on client-server architecture, r-project and World Wide WEB technology. The technical information of MigCI is explained in Figure 2. The application or interface can be used for physicians from **e-Migraine.mersin.edu.tr** with email and password. The interface is available in two languages: Turkish and English. It is free of charge for all users.

Results

The relationship between sample characteristics (age and gender) and these severity groups was evaluated. There was no significant relationship between gender and severity of headache (p=0.160). There were differences between severity groups in terms of age (p=0.007). All comorbidities included to the model and index because of the clinical significance. The best weighting method was posterior probabilities calculated with three-latent class approach according to the Akaike and Bayesian Information Criteria of the model.

The Developed Web Tool

Client User Interface has three tabs. In the first tab (Home symbol), user authentication registered doctor can login with his/her email and password (Figure 3). In the second tab (Plus symbol): Patient Recording, text of CUI will change according to registered language of doctor. All fields in CUI should be filled and "Save and Calculate" button should be clicked (Figure 4). After recording and calculation of processes finish, the index score is

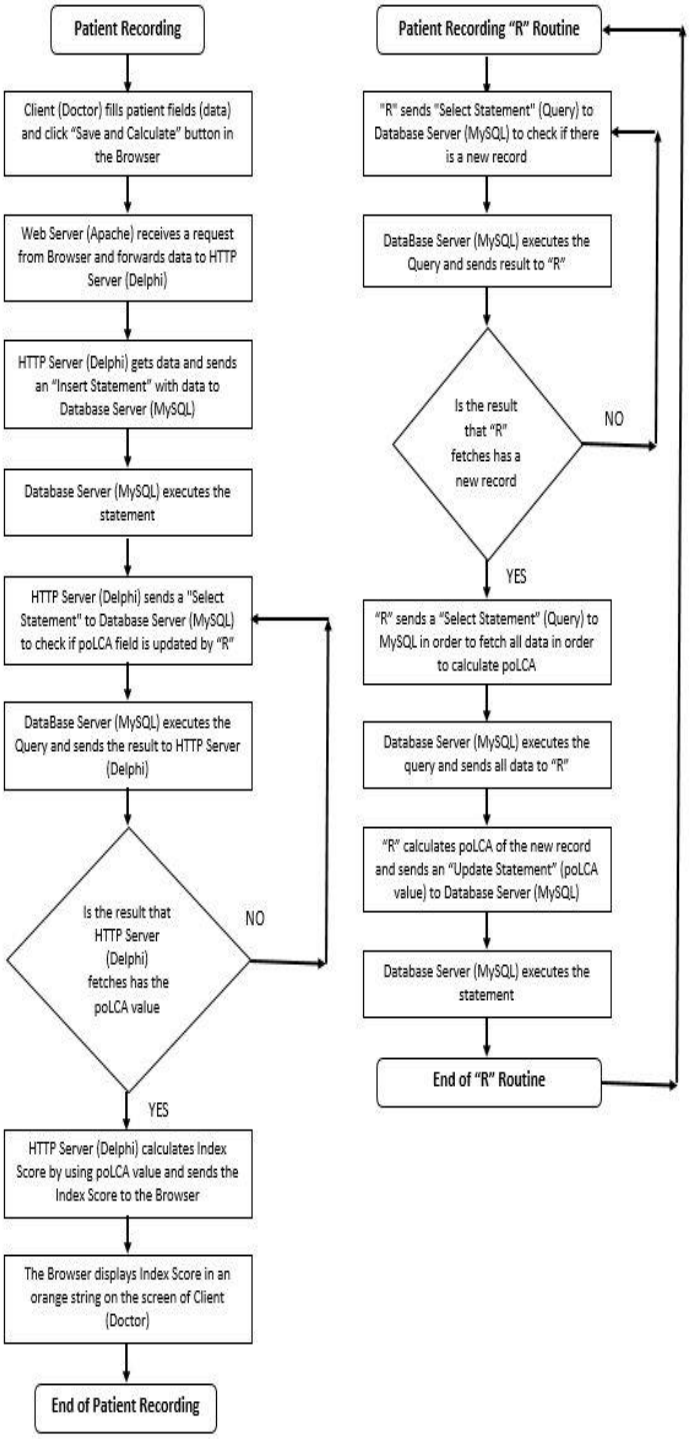

Figure 2. *Workflow diagram of MigCI*

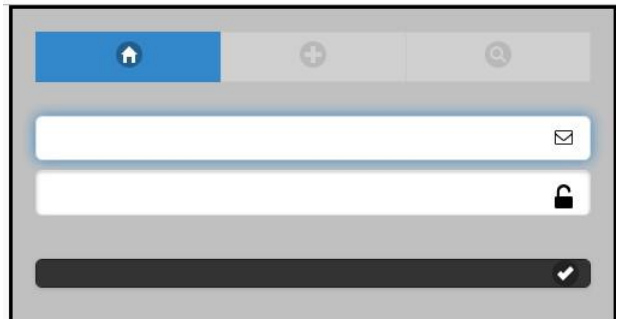

Figure 3. *e-Migraine screenshot displaying the login*

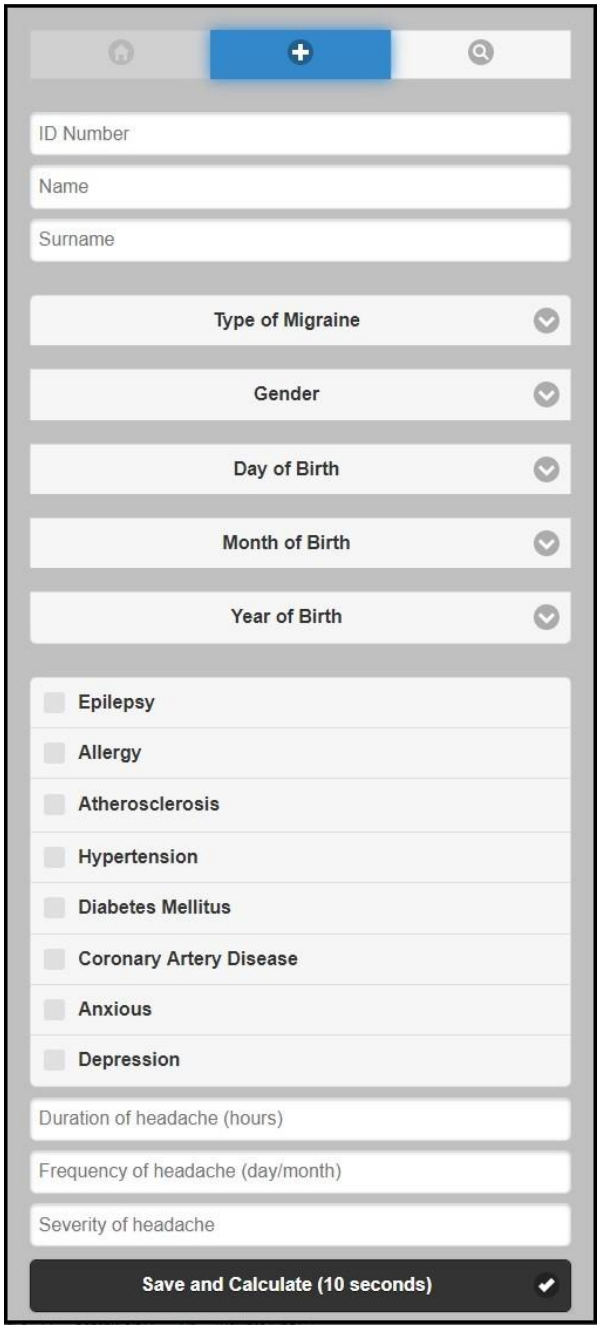

Figure 4. *The Migraine Comorbidity Index data entrance*

Figure 5. *The result of index score*

displayed in an orange string and the "Save and calculate" button is disappeared (Figure 5). Recorded data cannot be changed or deleted by any doctor. The only way to change or delete a record is to send an email to the administrator of e-Migraine. To record a new patient, plus icon in menu bar should be clicked. In the third tab (Plus symbol): Patient Searching, patient coming to follow-up examination should be searched by clicking magnifier icon in the menu bar. Either ID Number or name-surname of patient should be typed and search button should be clicked. Patients whose ID number or name, surname matches are fetched into a list. (Figure 6) If there is a type mistake in name-surname of a patient when patient is recorded, patient record may not be found. In such situations, typing one character (letter) of patient's name and one character (letter) of patient's surname are sufficient to search the patient record. One character searching process fetches all patients having those characters in name-surname into the list. After clicking appropriate patient, record of that patient is fetched (Figure 7). The record is displayed in two tables. The first one is base table in which all data are stable, except age. The latter is detail table in which Examination Date, Duration of headache and Frequency of headache are displayed. Doctor may just watch the record or fill new Duration and Frequency fields in order to calculate a new Index Score. After clicking "Save and calculate" button, the index score is displayed in an orange string, the "Save and calculate" button is disappeared and new Duration and Frequency of headache that date are inserted at the top of detail table in a yellow string (Figure 8). To search a new patient, magnifier icon in the menu bar should be clicked.

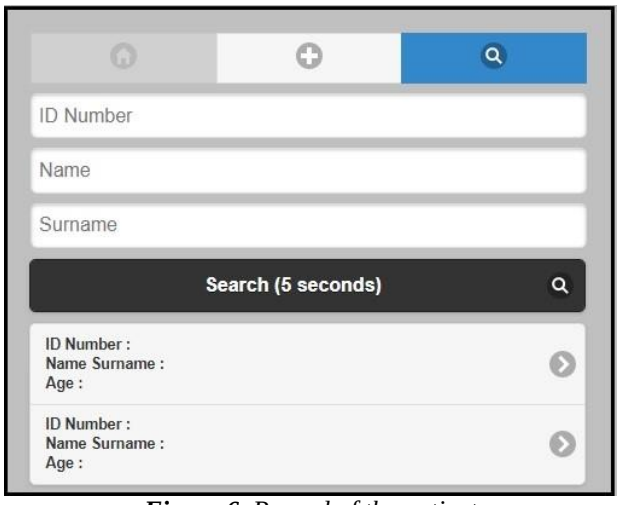

Figure 6. *Record of the patient*

Discussion

While developing the MigCI, we tried different methods to model the comorbidities. Firstly, comorbidities were modeled according to the presence or absence of comorbidities or the total number of comorbidities but these methods did not consider the weight of comorbidities. It was so important that all comorbidities of the disease have not the same effect on the outcome. Weighting methods in literature were summarized as comorbidity frequencies; hazard ratios calculated with cox regression and adjusted odds ratios calculated with logistic regression analysis as weights[7-18]. In our study, primary outcome is the

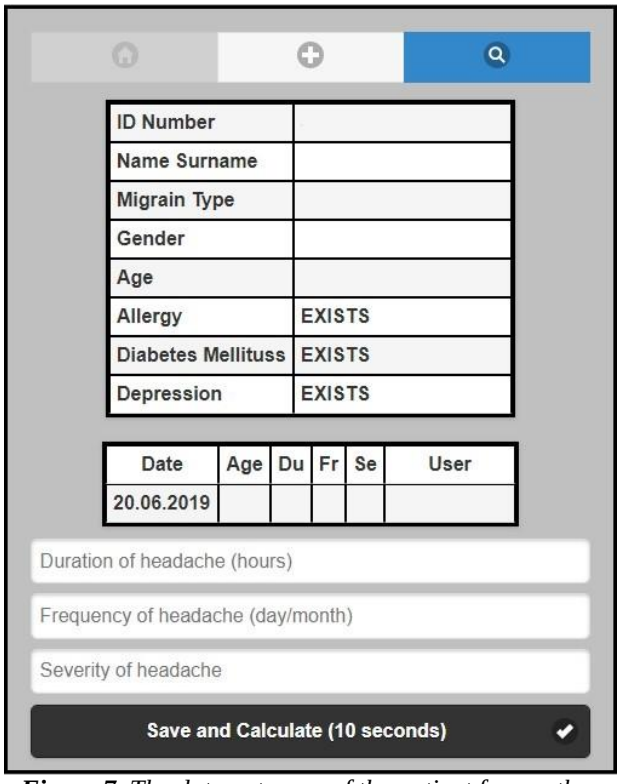

Figure 7. *The data entrance of the patient for another time*

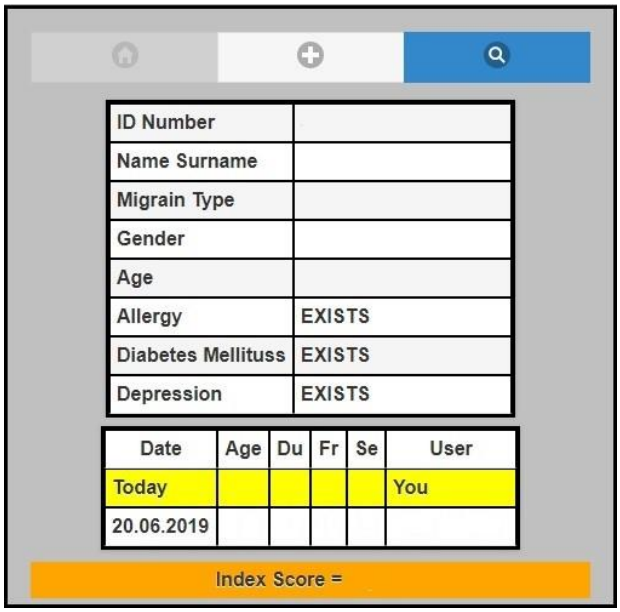

Figure 8. *The information of the selected patient for all dates*

severity of headache and has a heterogeneous structure. Therefore, the most appropriate weighting method based on posterior probabilities obtained from latent class analysis according to the model selection criteria[19].

In support of our study findings which the proposed migraine specific comorbidity index developed, three latent groups defined as mild, moderate and severe were detected with Group Based Trajectory Models (GBTM). But, the best fitted model was obtained after the inclusion of baseline frequency and duration of headache to the model. With these results, a formula was created based on all these clinically and statistically significant factors for severity of headache. (MCI score=Age*Posterior probability*(Baseline duration + Baseline frequency)).

e-Migraine is the first and user friendly tool to calculate the index score for migraine. The tool is used by clinicians who are included in migraine database. It provides them to evaluate the patients' headache score easily. They recommend treatment or preventive methods to patients according the magnitude of score. In real, utilizing such tools or applications has become popular worldwide. Thanks to these tools, the disease burden on patients and governments decreases[24].

The clinical validity and reliability may be evaluated after the usage of e-Migraine by the neurologists. The data obtained from e-Migraine is stored in a privacy database. In support of this database, further researches are planned for example the distinction between migraine types, the relationship between the common comorbidities and headache score and etc. Neurologists can start using e-Migraine, taking into consideration that (1) e-Migraine has developed utilizing a big sample size and validated for this sample[19], (2) the burden of long term diseases such as migraine increases day by day, (3) the patients' lifestyle is affecting worse because of the severity, duration and frequency of headache.

Declarations Conflicting interests: The Author(s) declare(s) that there is no conflict of interest.

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