

## ORIGINAL RESEARCH

# Glasgow Coma Scale and FOUR Score in Predicting the Mortality of Trauma Patients; a Diagnostic Accuracy Study

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**Abstract:** **Introduction:** Many scoring models have been proposed for evaluating level of consciousness in trauma patients. The aim of this study is to compare Glasgow coma scale (GCS) and Full Outline of UnResponsiveness (FOUR) score in predicting the mortality of trauma patients. **Methods:** In this diagnostic accuracy study trauma patients hospitalized in intensive care unit (ICU) of 2 educational hospitals were evaluated. GCS and FOUR score of each patient were simultaneously calculated on admission as well as 6, 12 and 24 hours after that. The predictive values of the two scores and their area under the receiver operating characteristics (ROC) curve were compared. **Results:** 90 patients were included in the present study (mean age  $39.4 \pm 17.3$ ; 74.4% male). Comparing the area under the ROC curve of GCS and FOUR score showed that these values were not different at any of the evaluated times: on admission ( $p=0.68$ ), and 6 hours ( $p=0.13$ ), 12 hours ( $p=0.18$ ), and 24 hours ( $p=0.20$ ) after that. **Conclusion:** The results of our study showed that, GCS and FOUR score have the same value in predicting the mortality of trauma patients. Both tools had high predictive power in predicting the outcome at the time of discharge.

**Keywords:** Glasgow Coma Scale; Wounds and Injuries; Trauma Severity Indices; Outcome Assessment (Health Care); Critical Care; Intensive Care Units

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## 1. Introduction

In severe injuries, especially traumatic brain injuries, a considerable portion of the patients are hospitalized in intensive care unit (ICU). In recent years, the prevalence of injuries has significantly increased in developing countries. Based on the latest reports of world health organization, injury is the tenth cause of mortality in the world and third cause of death in Iran. This high prevalence leads to increased treatment costs, loss of society's work force, greater burden of diseases and increase in the workload of treatment staff, especially nurses (1-3). By using appropriate tools for

measuring the level of consciousness to evaluate the severity of the injury in head trauma patients, nurses will be able to prepare for taking critical measures for the injury in the shortest time and in the best possible way and reduce the disability and mortality of trauma patients (4-12).

Many scoring models have been proposed to evaluate level of consciousness in patients who are affected with traumatic brain injuries, the most famous of which is Glasgow coma scale. This scale has some limitations such as its low efficiency in intubated patients, its poor use in cases of language differences, and not being able to evaluate the reflexes of brainstem (13, 14). In intubated patients, the verbal part is practically non-measurable and therefore, it is possible that the reported level of consciousness in these patients is lower than its real level (15). Full Outline of UnResponsiveness (FOUR) score is another scale for evaluating level of consciousness, the accuracy and precision of which in critically

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ill patients has been evaluated in only a few studies (16, 17). Availability of a scoring system that in addition to accuracy, precision, and easy use, leads to facilitation of the nursing care of trauma patients is a necessity.

By providing an accurate picture of injury severity, such a system would be able to give a reflection of the outcome of the patient to the health care team. Contradicting results exist from comparing GCS and FOUR score in prediction of final outcomes. In a multi-center study, Wijdicks et al. showed that FOUR score and GCS do not differ in prediction of in-hospital mortality, although they suggested that FOUR score can be a better diagnostic tool for assessing brainstem reflexes and respiratory pattern (17). However, Jalali and Rezaei showed that FOUR score performs better than GCS in prediction of mortality (18). Presence of these contradictions shows the need for carrying out more studies. Therefore, the present study was done with the aim of comparing GCS and FOUR score in predicting the mortality of trauma patients.

## 2. Methods

### 2.1. Study design and setting

The present prospective diagnostic accuracy study was designed with the aim of comparing the 2 systems of GCS and FOUR score in predicting the outcome of trauma patients hospitalized in ICU of 2 hospitals affiliated with Shahid Beheshti University of Medical Sciences. For this purpose, data of 90 patients were evaluated in the time interval between February and September 2017. This study was approved by the Ethics committee of Tehran University of Medical Sciences and Shahid Beheshti University of Medical Sciences. Throughout the study, the researchers adhered to the principles indicated in the declaration of Helsinki. Before inclusion in the study, an informed consent was obtained from the patient or their relative.

### 2.2. Participants

Over 14 years old trauma patients hospitalized in ICU were studied using consecutive sampling. Patients with hearing and talking disabilities and with a history of sensorimotor disability were excluded from the study.

### 2.3. Data gathering

Demographic data (age, sex), trauma mechanism (pedestrian-car accident, motorcycle accident, falling, pedestrian-motorcycle accident, direct trauma, car rollover, and car-car accident), and length of stay in ICU were gathered. In addition, a checklist consisting of items used for calculating GCS (evaluation of eye, speech, and motor score) and FOUR score (evaluation of eye, motor, brainstem reflexes, and respiratory pattern score) was also used in this study. Data were gathered by 2 trained ICU nurses who

were completely familiar with data gathering tools. Before the initiation of the study, in order to approve inter-rater reliability of the 2 nurses in scoring of GCS and FOUR score, a primary study was performed in which both nurses evaluated both scores simultaneously for the same 15 patients. The agreement rate obtained was 91% ( $\kappa=0.91$ ).

### 2.4. Index test

In the present study, predictive values of GCS and FOUR score in prediction of in-hospital mortality of trauma patients were assessed. The details of scoring methods of the 2 mentioned scores have been reported in previous studies (19, 20). GCS and FOUR score of each patient were simultaneously calculated on admission as well as 6, 12 and 24 hours after that.

### 2.5. Reference test

Death or survival of the patient at the time of discharge from the hospital was used as the reference test. Patients were followed until their discharge from the hospital and their living status at the time of discharge was evaluated.

### 2.6. Statistical Analysis

Area under the curves reported for GCS and FOUR score have been 0.78 and 0.84, respectively (21). Therefore, by considering 95% confidence interval ( $\alpha=5\%$ ) and power of 90% ( $\beta=10\%$ ), sample size is calculated as about 90 patients. Data were analyzed using STATA 14.0 statistical software. Descriptive analyses were presented as mean and standard deviation, or frequency and percentage, for quantitative and qual-

**Table 1:** Demographic and baseline characteristics of the studied patients

| Baseline Characteristics            | Value      |
|-------------------------------------|------------|
| <b>Sex</b>                          |            |
| Female                              | 23(25.6)   |
| Male                                | 67(74.4)   |
| <b>Trauma mechanism</b>             |            |
| Motorcycle accident                 | 32 (35.6)  |
| Car accident                        | 22 (24.4)  |
| Falling                             | 20 (22.2)  |
| Pedestrian                          | 10 (10.1)  |
| Other                               | 6 (6.7)    |
| <b>Vital signs on admission</b>     |            |
| Systolic blood pressure (mmHg)      | 115.4±6.27 |
| Diastolic blood pressure (mmHg)     | 72.5±3.16  |
| Heart rate (beat per min)           | 94.6±0.26  |
| Respiratory rate (beat per min)     | 18.2±9.6   |
| Temperature (degree of Celsius)     | 36.9±0.3   |
| Oxygen saturation (%)               | 92.2±9.9   |
| <b>Length of stay in ICU (days)</b> | 7.4±5.9    |

Data were presented as mean ± standard deviation or number (%).

**Table 2:** Mean GCS and Full Outline of UnResponsiveness (FOUR) score at different times with 95% confidence interval (CI)

|                   | Survived |             | Non survived |           |
|-------------------|----------|-------------|--------------|-----------|
|                   | Mean     | 95% CI      | Mean         | 95% CI    |
| <b>GCS</b>        |          |             |              |           |
| On admission      | 11.3     | 10.6 – 12.1 | 5.5          | 4.0 – 7.1 |
| After 6 hours     | 11.7     | 11.0 – 12.5 | 5.1          | 3.9 – 6.3 |
| After 12 hours    | 11.8     | 11.1 – 12.5 | 5.6          | 4.9 – 6.3 |
| After 24 hours    | 11.6     | 10.8 – 12.3 | 4.0          | 3.3 – 4.6 |
| <b>FOUR score</b> |          |             |              |           |
| On admission      | 12.7     | 11.8 – 13.6 | 4.1          | 1.8 – 6.3 |
| After 6 hours     | 13.0     | 12.1 – 13.9 | 2.7          | 1.2 – 4.2 |
| After 12 hours    | 13.9     | 13.1 – 14.7 | 3.4          | 2.0 – 4.8 |
| After 24 hours    | 13.6     | 12.7 – 14.4 | 0.1          | 0.0 – 0.3 |

**Table 3:** Multiple logistic regression analysis for the values of GCS and FOUR score in predicting the morality of trauma patients with 95% confidence interval (CI)

| Variable                  | Odds ratio | 95% CI       | P*      |
|---------------------------|------------|--------------|---------|
| <b>Glasgow coma scale</b> |            |              |         |
| At admission              | 0.72       | 0.53 to 0.98 | 0.04    |
| 6 hours                   | 0.57       | 0.38 to 0.86 | 0.007   |
| 12 hours                  | 0.28       | 0.10 to 0.76 | 0.01    |
| 24 hours                  | 0.21       | 0.06 to 0.75 | 0.02    |
| <b>FOUR score</b>         |            |              |         |
| At admission              | 0.79       | 0.62 to 0.99 | 0.049   |
| 6 hours                   | 0.55       | 0.36 to 0.83 | 0.004   |
| 12 hours                  | 0.43       | 0.22 to 0.84 | 0.01    |
| 24 hours                  | 0.05       | 0.02 to 0.08 | <0.0001 |

\*: Adjusted for age, systolic blood pressure, oxygen saturation, need for intubation and need for sedation.

itative factors, respectively. To compare mean score of GCS and FOUR score in dead and alive patients at the evaluated times, two-way repeated measures ANOVA with Bonferroni post hoc was applied.

In addition, the predictive values of GCS and FOUR score were evaluated in predicting the outcome of patients via drawing receiver operating characteristic (ROC) curve. Fitness of the model was evaluated using Hosmer-lemeshow test and in the end, the mentioned values were compared between the 2 models. In this study,  $p < 0.05$  was considered as level of significance.

### 3. Results

#### 3.1. Demographic and clinical data

In this study, data of 90 trauma patients hospitalized in ICU were evaluated. Mean and standard deviation of patients' age was  $39.4 \pm 17.3$  years (74.4% male). The most important mechanisms of trauma were motorcycle (35.6%) and car (24.4%) accidents, and falling from a height more than 3 meters (13.3%). 13.3% of the patients had hypertension, 4.4% had diabetes, 3.3% had neurologic deficiencies, 2.2% had cardiovascular diseases, and 3.3% had other underlying dis-

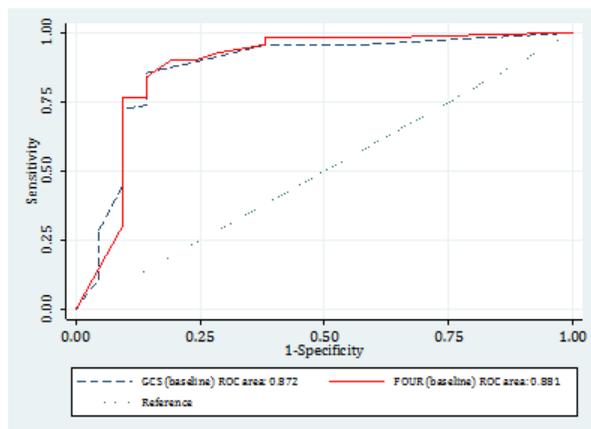
eases. Outcome of hospitalization in ICU was death in 21 cases (23.3%) (Table 1). The trend of changes in GCS and FOUR score during 24 hours based on death or survival of the patients is presented in table 2. Based on these findings mean GCS (df: 1, 87;  $F = 6.58$ ;  $p = 0.01$ ) and FOUR score (df: 1, 88;  $F = 46.64$ ;  $p < 0.001$ ) were lower in those who died compared to those who survived.

#### 3.2. GCS and FOUR score in predicting mortality

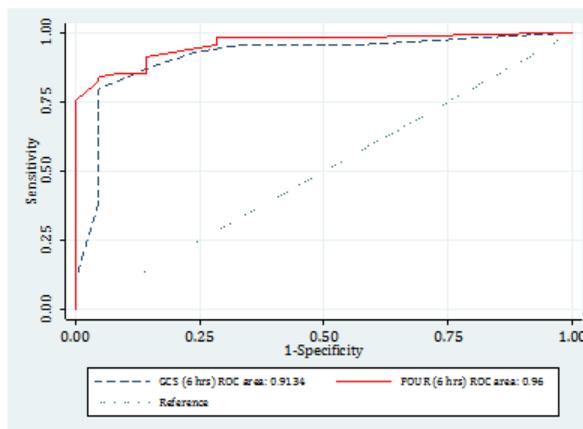
Area under the ROC curve calculated for GCS on admission and 6, 12, and 24 hours after that were 0.87 (95% CI: 0.77 to 0.98), 0.91 (95% CI: 0.84 to 0.99), 0.95 (95% CI: 0.90 to 0.99) and 0.97 (95% CI: 0.95 to 1.0), respectively. These values were calculated as 0.88 (95% CI: 0.77 to 0.99), 0.96 (95% CI: 0.92 to 1.0), 0.97 (95% CI: 0.92 to 1.0) and 0.99 (95% CI: 0.97 to 1.0), respectively for FOUR score. Comparison of area under the ROC curve of GCS and FOUR score showed that this value was not different between the 2 systems in any of the evaluated times of on admission ( $p = 0.68$ ), 6 hours ( $p = 0.13$ ), 12 hours ( $p = 0.18$ ), and 24 hours ( $p = 0.20$ ) after that (figure 1). The correlation between predicted in-hospital mortality and the 2 scales (GCS and FOUR score) was also similar (Figure 2). Findings resulting from multivariate logistic regres-



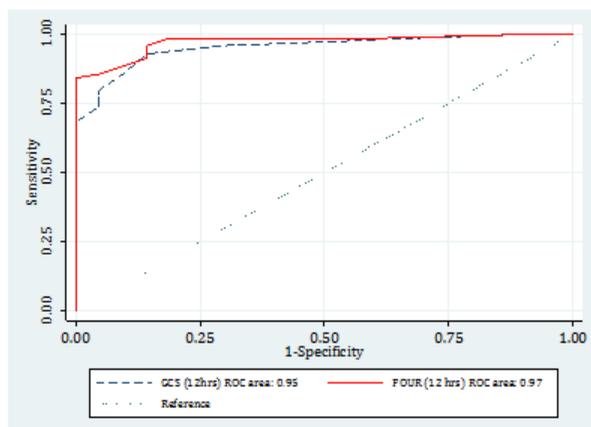
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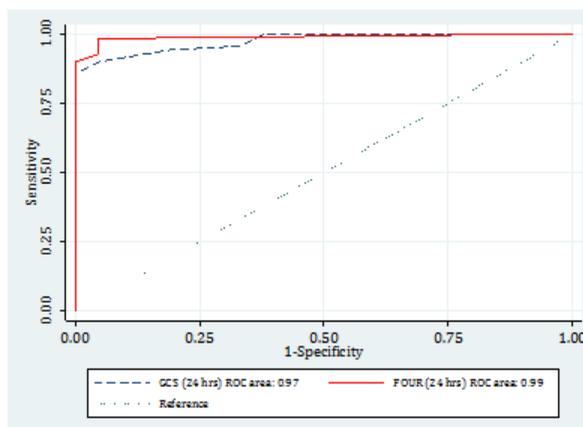
## 6 hours



## 12 hours



## 24 hours



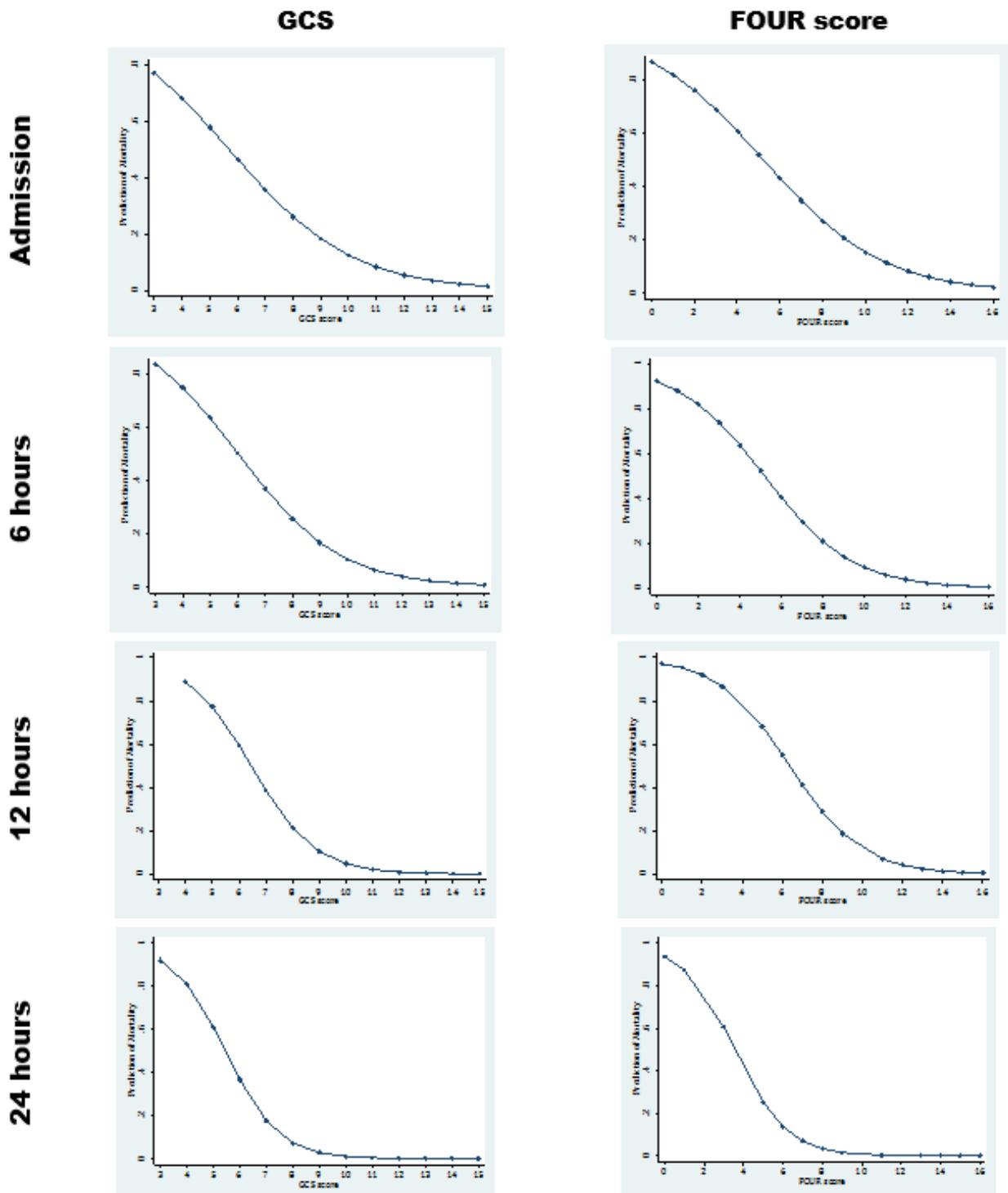
**Figure 1:** Area under the ROC curve of Glasgow coma scale (GCS) and Full Outline of UnResponsiveness (FOUR) score for predicting the mortality of trauma patients at different times.

sion showed that with a decrease in scores of GCS and FOUR score, the probability of mortality increases in trauma patients. Range of predicted mortality was similar in both GCS and FOUR score models (Table 3).

## 4. Discussion

Based on the findings of our study, area under the ROC curve of both GCS and FOUR score on admission and 6, 12, and 24 hours after that were not different and both scales had the same predictive values in identifying the outcome at the time of discharge. In line with our study, the results of the study by Sahin et al. (2015) in evaluation of 105 patients also showed that GCS and FOUR score have similar value in prediction of patient mortality and can be used interchangeably (22). The results of a study by Atahar et al. (2017) also showed that GCS and FOUR score have the same predictive value in predic-

tion of in-hospital mortality and mortality within 3 months of discharge among children (23). The findings of Gujjar et al. study showed that FOUR score is a better scale compared to GCS for evaluation of changes in level of consciousness in medical wards (24). One of the reasons for the dissimilarity of the results of this study with ours might be their different research environment. The research environment in our study was trauma ICU department. In line with our findings, the study by Temiz et al. (2016) also showed that FOUR score has the same prediction value as GCS in evaluating the level of consciousness and follow-up of patient's status in neurosurgery ICU (25). In contrast to these findings, the results of the study by Nair et al. (2017) showed that there is a statistically significant difference between FOUR score and GCS in estimating the severity of injury in head traumas. They reported that FOUR score is a better index for evaluating the



**Figure 2:** The correlation of Glasgow coma scale (GCS) and Full Outline of UnResponsiveness (FOUR) score with in-hospital mortality of trauma patients at different times.

level of consciousness in patients with head trauma (26). The results of Wolf et al. study (2011) showed that GCS is one of

the proper indices in prediction of mortality in emergency medical admission (27). In this study we evaluated GCS and



FOUR score in 4 points of time: on admission, and 6 hours, 12 hours, and 24 hours after admission. The results showed that the mean and standard deviation of both of these scales were different between those who died and those who survived in the 4 evaluated points of time. In line with these findings were the results of a study by Gujjar et al. (2013) that evaluated GCS and FOUR score during the initial 3 days of patients' hospitalization and showed that there is no significant difference regarding mean value of these scales on the second and third day between dead and survived patients but there is a significant difference between these mean values on the first day (24).

## 5. Limitation

This study also had limitations including its small sample size and being performed in 2 trauma centers. Using a larger sample size and designing a multicenter study might provide more valuable and reliable results.

## 6. Conclusion

The results of our study showed that, GCS and FOUR score have the same value in predicting the mortality of trauma patients. Both tools had high predictive power in predicting the outcome at the time of discharge.

## 7. Appendix

### 7.1. Acknowledgements

The authors would like to thank all of participants during the different stages of this study.

### 7.2. Funding/Support

This study was one part of the MS dissertation of the first author, financially supported by Tehran University of Medical Sciences.

### 7.3. Conflict of interest

No conflict of interest has been declared by the authors.

### 7.4. Author contribution

Parisa Ghelichkhani, Maryam Esmaeili, and Khatereh Seylani designed the study. Parisa Ghelichkhani participated in data gathering. Mostafa Hosseini analyzed data. Parisa Ghelichkhani and Maryam Esmaeili wrote the first draft and others critically revised it.

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