Original Article

# A New Prehospital Score to Predict Hospitalization in Trauma Patients

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## Abstract

**Background:** Prehospital scores are used for determining the prognosis of trauma severity in trauma patients. **Objectives:** This study aimed at developing a new prehospital score for emergency medical service (EMS) staff to predict hospitalization in trauma patients transferred to the hospital. **Patients and Methods**: This study was a diagnostic test evaluation conducted on data of 1185 traumatic patients transferred through EMS to Poursina Hospital of Rasht between March 2012 and March 2013. Data were collected using a questionnaire with two parts. The first part included data on demography, injury, and type of interventions performed at the scene of the accident. The second part consisted of initial evaluations (Glasgow coma scale (GCS), oxygen saturation ($O_2S$), pulse rate (PR), systolic blood pressure (SBP), the ability to walk, and outcome (hospitalization, nonhospitalization). The questionnaire was filled out by EMS staff at the scene or during transfer to the hospital with respect to clinical observations. Data were analyzed using the logistic regression model. The Hosmer–Lemeshow test was also used to examine the good fit of model. **Results:** A total of 1185 patients were evaluated using prehospital data. Of seven variables evaluated by the scoring system, only four variables were identified in the regression analysis as predictors of hospitalization including age, SBP, $O_2S$, and walking ability. Sensitivity, specificity, and positive and negative likelihood ratios were 0.67, 0.68, 2.09, and 0.48, respectively. **Conclusions:** The GOMAAPS (GCS, O2S, mechanism of injury, age, ability to walk, PR, and SBP) score serves as a guide for the EMS staff at the scene to be understood of the necessity of transfer and predicting hospitalization.

**Keywords:** Hospitalization, prehospital, score, trauma

## Background

Trauma is a major problem all over the world, particularly affecting the young. It causes remarkable production loss. In recent decades, it has been considered as a critical health issue. Trauma is reported as the leading cause of death in people between 1 and 44 years old; also the third leading cause for all age groups, following cancer and cardiovascular diseases.[1] Trauma imposes many economic costs on society.[2] Of more than five million annual trauma deaths, over 90% occur in low- and middle-income countries.[3] In Iran, it is the second cause of death after cardiovascular diseases and the leading cause of disability-adjusted life years.[4]

The important steps for managing traumatic patients are to determine the severity and prognosis of trauma. Hence, trauma scoring systems have been used for nearly four decades to characterize the type and severity of trauma, predict outcome, improve resource allocation, and assist in clinical decision-making of trauma patients in both pre- and in-hospital phases.[5-9] Many prehospital trauma scores have been developed so far, which enable the emergency medical service (EMS) staff in the precise evaluation of trauma severity to minimize the multitude damage by early diagnosis and timely actions.[10-12] This can avoid many unnecessary transfers of mild traumatic patients to hospital. Trauma scoring tools include systems based on the anatomical, physiological, or combined criteria.[13] Calculating anatomical scores, such as

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injury severity score (ISS, an index of severity and location of anatomy injury) and combined scores such as trauma ISS (based on the ISS and the revised trauma score (RTS), age, and injury mechanism),[9,14,15] at the scene is difficult. Therefore, physiological scores such as RTS are used more than those scores in the prehospital phase. The RTS is the most widely used physiological score.[16,17] The variables that are taken into consideration in RTS are respiratory rate (RR), systolic blood pressure (SBP), and Glasgow coma scale (GCS). The RTS is the sum of the coded value multiplied of these variables.[9] It can be evaluated on-site; however, too complicated to calculate under stressful situation.[17] Therefore, the triage RTS (T-RTS) was designed with the same variables, but simpler to calculate.[18]

There are some debates about RR, one of the main components in calculating RTS and T-RTS. Respiratory rate is usually measured clinically, and it may not have high reliability.[19] Moreover, because of pain or psychological stress in some patients, the correlation of RR with ventilation and/or oxygenation may be disrupted.[20] In addition, this vital sign is rarely completely recorded[21] and cannot be calculated in patients with intubation.[22]

To improve usefulness, there is a need for scoring systems without respiratory rate.[23,24] Thus, MGAP and GAP scores and model of Toyoda *et al*. in Japan were developed.[8,13,17] The present study was similar to the research of Toyoda *et al*., in which they had attempted to provide a tool for prediction of hospitalization according to prehospital physiological factors such as age, SBP, oxygen saturation ($O_2S$), pulse rate (PR), consciousness level, and ability to walk.[13] In addition to abovementioned factors, we applied mechanism of injury for developing a new prehospital score, as in other similar studies, because it is one of the major factors affecting the outcome of traumatic patients.[25,26] Thus, GOMAAPS, which is a compound score of variables (GCS, O2S, mechanism of injury, age, ability to walk, PR, and SBP), was developed as a new score.

### Objectives

This study aimed to develop a new prehospital score for EMS staff at the scene to understand the necessity of transfer and predict hospitalization for trauma patients transferred to a referral hospital in Rasht City, Iran, during 2012–2013.

## Patients and Methods

In this study, after approval by the ethics committee of Guilan University of Medical Sciences (Code: 1910396409), a diagnostic test evaluation was conducted in a public university hospital (Poursina) in Rasht, Guilan, between March 2012 and March 2013. Poursina is a referral hospital for traumatic patients with 263 active beds.

### Inclusion criteria

A total of 1185 trauma patients between 2 and 95 years of age who had been transferred directly to Poursina Hospital by the EMS staff were included in the study. Patients who were dead (on site or arrival) or had incomplete prehospital data were excluded from the study.

### Variables

Our outcome measure was necessity of transfer and admission to hospital in trauma patients according to the severity of trauma. According to a search on literature, this study used seven variables extracted from a researcher-made questionnaire as follows: age, SBP, GCS, PR, ability to walk, $O_2S$, and mechanism of injury.

The questionnaire had two parts. The first one included demographic variables (age, sex [male and female], data on the injury [time, mechanism of injury [as specified in Table 1], type of injury [blunt or penetrate], area of injury [head and neck, face, abdomen, pelvis, spine, extremities, and chest]); type of interventions by the EMS staff at the scene of accident (intubation, intravenous line, infusion of fluids, medication prescription, splinting, wearing cervical collar, cardiopulmonary resuscitation, using backboard for lumbar trauma, putting airway tube, oxygen masks, external hemorrhage control, and putting nasogastric tube); and underlying diseases (cardiovascular, respiratory, neurologic, hepatic, renal, coagulative, gastrointestinal, infectious, diabetes, malignant, disabilities, psychological, and history of trauma or surgery, drug abuse and special diseases). The second part consisted of an initial assessment (GCS, $O_2S$, PR, SBP, the ability to walk, and outcome [hospitalization, nonhospitalization]).

In our study, the questionnaire was filled out by the EMS staff at the scene or during transfer to the hospital with respect to clinical observations. Thus, age, SBP, GCS, PR, ability to walk, $O_2S$, and mechanism of injury were analyzed to calculate the score. All the predictors were entered into logistic regression in categorical form. The coefficients of categories in each predictor were obtained

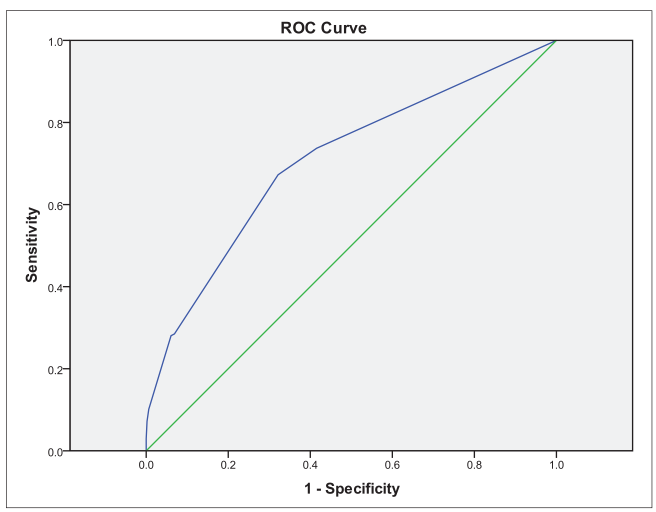


**Figure 1:** ROC Curve to Predict Hospitalization of the Traumatic Patients with a Reference Line. The area under the curve was 0.71. ROC: Receiver Operating Characteristic

**Table 1: Variables Associated with GO MAAPS Score**

| Age | SBP (mmHg) | PR | GCS | O2S | Walking ability | Mechanism of Injury |
|---|---|---|---|---|---|---|
| *<60 | <100 | <60 | ≥8 | < 95% (Hypoxia) | *Yes | Motor-Vehicle |
| 60-69 | *100-149 | *60-89 | 9-12 | *≤ 95% (Normal) | No | Accident |
| 70-79 | ≤150 | 90-99 | *13-15 | | | Violence and Suicide |
| ≥80 | | 100-109 | | | | Falling |
| | | ≤110 | | | | Animals |
| | | | | | | *Sport Injury |
| | | | | | | Sharp Objects |
| | | | | | | Unknown |

* Reference Group, SBP: Systolic Blood Pressure, PR: Pulse Rate, GCS: Glasgow Coma Scale, O2S: Oxygen Saturation

**Table 2: Sensitivity, Specificity, $LR^+$ and $LR^-$ for Predicting Hospitalization in Traumatic Patients**

| Prehospital Score | Sensitivity % | Specificity % | $LR^+$ | $LR^-$ | PPV | NPV |
|---|---|---|---|---|---|---|
| 1 | 0.74 | 0.59 | 1.8 | 0.44 | 0.72 | 0.61 |
| 2.5 | 0.67 | 0.68 | 2.09 | 0.48 | 0.75 | 0.59 |
| 3.5 | 0.28 | 0.93 | 4.66 | 0.77 | 0.85 | 0.47 |
| 4.5 | 0.28 | 0.94 | 4.67 | 0.76 | 0.87 | 0.48 |
| 5.5 | 0.1 | 0.99 | 16.66 | 1 | 0.93 | 0.44 |

AUC: (95% CI=%68 - %73) 71%

**Table 3: Values of the Coefficients and Odds Ratios by Logistic Regression Model**

| Prehospital Data | β | SE | *P* | OR (95% CI) |
|---|---|---|---|---|
| Age | | | | |
| *<60 (Reference Group) | 0 (Reference Group) | -- | -- | 1 |
| 60-69 | 0.11 | 0.34 | 0.75 | 1.11 (0.56-2.20) |
| 70-79 | 0.96 | 0.49 | 0.05 | 2.60 (0.99-6.84) |
| ≥80 | 1.64 | 0.79 | 0.04 | 5.18 (1.1-24.67) |
| SBP | 0.58 | 0.22 | 0.01 | 1.78 (1.15-2.77) |
| <100 | 0 (Reference Group) | -- | -- | 1 |
| *100-149(Reference Group) | 0.33 | 0.37 | 0.36 | 1.39 (0.68-2.91) |
| ≤150 | | | | |
| O2S | | 0.21 | 0.003 | 1.86 (1.23-2.83) |
| < 95% ( Hypoxia) | 0.62 | -- | -- | 1 |
| *≤ 95% (Normal) | 0 (Reference Group) | | | |
| (Reference Group) | | | | |
| Walking ability | 0 (Reference Group) | -- | -- | 1 |
| *Yes (Reference Group) | 1.1 | 0.14 | 0.000 | 2.99 (2.28-3.92) |
| No | | | | |
| Sex | | 0.15 | 0.000 | 0.57 (0.42-0.76) |
| Female | -0.58 | -- | -- | 1 |
| *Male (Reference Group) | 0 (Reference Group) | | | |
| Type of injury | | 0.22 | 0.000 | 4.61 (2.95-7.21) |
| Penetrate | 1.52 | -- | -- | 1 |
| *Blunt (Reference Group) | 0 (Reference Group) | | | |
| Constant | -0.51 | 0.1 | 0.001 | 0.6 |

* Reference Group, SE: Standard Error, OR: Odds Ratio

considering the reference group. In SBP, GCS, $O_2S$, and PR, a normal clinical range was considered as the reference group [Table 1].

It should be noted that this classification is based on a Japanese research by Toyoda *et al*.,[13] but we had to make changes in some of the subgroups due to their poor distribution.

### Logistic regression model (the backward likelihood ratio method)

The logistic regression model was fitted to the data, and hospitalization was predicted accordingly. The Backward LR model was used, and the Hosmer–Lemeshow goodness of fit was applied for assessing the fitness of the model. The results of

**Table 4: GOMAAPS Score for Predictive Variables of Hospitalization in Poursina Hospital**

| Prehospital Data | β | *P* | OR (95% CI) | GOMAAPS Score |
|---|---|---|---|---|
| Age | | | | |
| *<60 | 0 | -- | 1 | 0 |
| 60-69 | 0.11 | 0.75 | 1.11 (0.56-2.20) | 0 |
| 70-79 | 0.96 | 0.05 | 2.60 (0.99-6.84) | 2 |
| ≥80 | 1.64 | 0.04 | 5.18 (1.1-24.67) | 3 |
| SBP | | | | |
| <100 | 0.58 | 0.01 | 1.78 (1.15-2.77) | 2 |
| *100-149 | 0 | -- | 1 | 0 |
| ≤150 | 0.33 | 0.36 | 1.39 (0.68-2.91) | 0 |
| O2S | | | | |
| < 95% (Hypoxia) | 0.62 | 0.003 | 1.86 (1.23-2.83) | 2 |
| *≤ 95% (Normal) | 0 | -- | 1 | 0 |
| Walking ability | | | | |
| *Yes | 0 | -- | 1 | 0 |
| No | 1.1 | 0.000 | 2.99 (2.28-3.92) | 3 |

* Reference Group, GOMAAPS: Glasgow Coma Scale, Oxygen Saturation, Mechanism of Injury, Ability to Walk, Age, Pulse Rate, Systolic Blood Pressure

**Table 5: Mean of GOMAAPS Score in Prehospital Phase in both Groups (Hospitalization and non-Hospitalization)**

| Outcome | Number | Mean of GOMAAPSv Score in Prehospital Phase | SD |
|---|---|---|---|
| Hospitalization | 682 | 2.923 | 2.222 |
| Non-hospitalization | 479 | 1.290 | 1.653 |

SD: Standard Deviation

logistic regression analysis showed the sensitivity, specificity, and accuracy of the model. Predictive variables for the logistic regression model included variables such as age, SBP, GCS, PR, $O_2S$ categorized, ability to walk, and the mechanism of injury. To control the probable confounding effects, other variables were included in the model such as underlying disease history (yes or no), type of injury (penetrating, blunt, both, unknown), and sex (male/female).

Using the logistic regression model, the effective variables on hospitalization prediction were determined. Then, the β-coefficients were specified for each independent variable. The value of the GOMAAPS score was given regarding the significant β-coefficient in each group compared with the reference group. Thus, when β-coefficients in significant predictors was <0.5, 0.5–1, or ≥1, we considered the prehospital score component equated 1, 2, or 3, respectively. In the case of nonsignificant β-levels, zero score was given as the reference group. Finally, the total score was calculated by summing the scores of components in the range of 0–10.[13]

The diagnostic value of the score was evaluated by sensitivity, specificity, accuracy, diagnosis likelihood ratio (LR+, LR−), and cut-off point based on receiver operating characteristics. Next, the associated variables with the outcome (hospitalization, nonhospitalization) and value of this score for each individual were identified. The overall mean was calculated for both as well as individual hospitalization and nonhospitalization groups. Data were analyzed using the SPSS version 18.0 (SPSS Inc. Released 2009. PASW Statistics for Windows, Chicago: SPSS Inc.).

## Results

A total of 1185 traumatic patients were included. Most patients were men (72.6%). The mean age of the patients was 35.13 ± 21.69 years. The mean age of women (37.85 ± 21.21 years) was more than that of men (34.11 ± 21.79 years). Univariate regression analysis was performed for each of the factors. The size of the standard error related to GCS was too high; so, the GCS variable was excluded. The area under the curve was 71% (95% confidence interval = 68%–73%) [Figure 1], and optimal cutoff point score ≥2.5 was determined for predicting hospitalization. Sensitivity, specificity, positive-, and negative-likelihood ratios were 0.67, 0.68, 2.09, and 0.48, respectively [Table 2].

The multivariate regression model was designed using age, SBP, walking ability, $O_2S$, PR, and mechanism of injury. Then, a regression model was developed in three steps. At first, all the independent predictive variables (the six remaining variables) and potential confounding variables (sex, type of injury, and underlying disease history) were included in the model. In the second step, PR was excluded. Finally, the mechanism of injury was also excluded and other predictive and confounding variables of sex and type of injury remained.

On variable of "type of injury," due to a small sample size in items "both" and "unknown," the "unknown" ones were automatically excluded from the study and "both" items were mixed in the "penetrate" group.

The final model containing four variables of age, SBP, $O_2S$, and the ability to walk (main predictors of hospitalization of traumatic patients) was identified by the logistic regression model [Table 3]. Thereby, the new score was calculated based on only four variables (age, SBP, $O_2S$ and the ability to walk) [Table 4].

The mean score in all patients in the prehospital phase was 2.25 (standard deviation [SD] = 2.16), the lowest and highest values were 0 and 10, respectively. The mean score in hospitalization group (mean = 2.923, SD = 1.290) was higher than that in nonhospitalization group (mean = 1.653, SD = 1.290), which was statistically significant ($P < 0.001$) [Table 5].

## Discussion

This study aimed at developing a new score and evaluating the relationship between prehospital data and need to hospitalization in traumatic patients. The new introduced score included seven predictive factors including GCS, $O_2S$, mechanism of injury, age, walking ability, PR, and SBP. Using a prediction tool will help us to objectively assess prognosis, focus on resource management as well as optimize the level of care.

The T-RTS and T-RTS are the most widely used scores in prehospital setting but are not easy to calculate. Therefore, MGAP was designed that could predict mortality better than RTS. This score was able to clearly identify patients with low-, intermediate-, and high-risk of mortality.[17] Then, the GAP score was suggested, a better predictor and more generalizable than the MGAP score. This score predicted trauma severity as well as or better than the other trauma scores and was easier to calculate. All the prior scores were based on prehospital data. Overall, they are broadly used in the emergency department (ED) rather than in the prehospital phase for predicting the outcome of traumatic patients. If they are used in the ED, they should be allocated according to ED data.[8] While similar to the results of the study of Toyoda *et al*.,[13] the GOMAAPS score is calculated according to prehospital data to help the EMS staff in critical decision-making about transfer and hospitalization of traumatic patients in a referral hospital.

We used all the variables of this study, in addition to the mechanism of trauma. It is an important factor influencing the outcome of traumatic patients. The mechanism of injury, a major trauma identifier, is considered as a symptom for patient transfer to the trauma center and one of the components of triage score in trauma.[27] Furthermore, this variable reduces overtriage and undertriage when it is placed along with other components of a trauma scoring tool.[25]

Following modeling using multiple logistic regression, age, SBP, $O_2S$, and the ability to walk were found significant predictive factors for hospitalization. However, GCS, the mechanism of injury and PR excluded from the model. Perhaps, the main reason was the small sample size. Indeed, there are possibilities for GCS that may limit accuracy and usefulness of GCS classification at the scene. For example, in patients who suffered from poisoning or face injuries,[28,29] the score could not be calculated correctly. Another reason is the poor performance of the predictive power of initial GCS score in the prehospital phase, especially in the epidural hematoma. Despite the bad prognosis of epidural hematoma, patients are conscious in the early hours following trauma.[30] Furthermore, Kehoe *et al*. (2015) in their study showed that in all cases, GCS is not regarded as a reliable factor for predicting outcomes, especially in elderly patients with severe brain trauma.[31] It should be noted that in the present study, people older than 60 years of age constitute about 10% of the sample size.

In this study, the mechanism of injury was not significant. Other studies are consistent with our results that showed no significant relationship between the mechanism of injury and the patients' outcomes.[32,33] Besides, the trauma mechanism score might not work without an anatomical score.[34]

Sensitivity, specificity, positive-, and negative-likelihood ratios, positive and negative predictive values (PPV and NPV) with the cutoff point score of ≥2.5 were 0.67, 0.68, 2.09, 0.48, 0.75, and 0.59, respectively. Sensitivity, specificity, positive-, and negative-predictive values in Toyoda *et al*. score with cutoff ≥2 were 97%, 16%, 39%, and 89%, respectively. In MGAP, sensitivity, specificity, positive-, and negative-likelihood ratios were 0.95, 0.70, 3.13, and 0.07, respectively.

An increased GOMAAP score led to an increase in the number of patients who required hospitalization. So that if score ≤1 and score ≥8, approximately 39% and 100% of the patients were hospitalized, respectively. Given that in score ≤1, most transferred patients were considered in the nonhospitalization group. The EMS staff could, with correct triage and proper management, avoid transfer of such patients to Poursina Hospital. Toyoda *et al*. (2007) showed that if the patients with score ≤1 were not transferred with ambulance, 16% of the cases with inappropriate ambulance usage would be prevented.[13]

Therefore, GOMAAPS is a scoring system which can enable EMS staff at the scene to prioritize the transfer of trauma patients to hospital.

The present study has several limitations. First, some patients may take score ≤1 with this scoring system, while requiring quick transfer to hospital and receiving emergency treatment interventions, such as head trauma patients with epidural hematoma.[30] These patients appear to have no clinical symptoms in the initial evaluation. Hence, exact evaluation on patient's basic problems should be performed along with the score calculation. Second, in addition to the seven variables studied in this scoring system, other variables such as body temperature may affect the prediction of outcomes that were not considered in this study because the body temperature is not evaluated for all patients according to the report form on emergency care in the prehospital phase. Therefore, it is recommended that the impact of this variable on patients' outcome is assessed in the future studies. Third, criteria for hospitalization partly depend on individual skills of emergency physicians. Some might be misdiagnosed in the emergency room and not hospitalized promptly or vice versa. Finally, more studies are required to research the exact role of the GOMAAPS in the prehospital phase.

## Conclusion

Applying a lot of strategies and tools to evaluate the patients precisely, developing prevention programs, improving quality of provided services, and ultimately improving patient health must be concerns of researchers, policy-makers and managers of health care system. GO MAAPS tool can considered as a tool to determine the severity of trauma in traumatic patients to improve the quality of services provided to these patients and save the lives of them. In this study, the predictive ability of this tool in traumatic patients admitted to the hospital as well as the score ability to prevent ambulance transportation in mild traumatic patients were studied. Using obtained results of the study and similar studies in policy-making and management of health system as well as utilizing this tool in surveillance system can have key role in patient's situation evaluation in pre-hospital and hospital phase, appropriate planning for right and timely providing hospitalization services for patients (secondary level of prevention), and reduced hospital costs.

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### Conflicts of interest

There are no conflicts of interest.

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