# Modeling the Influence of Drivers' Personal and Driving Characteristics on Traffic Sign Comprehension

## Evidence from Al-Najaf Governorate, Iraq

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**ABSTRACT**

**This study investigates the factors that influence drivers' understanding of the 30 Traffic Signs (TSs) encountered on the street network of Al-Najaf governorate, Iraq. A random sampling survey using a structured questionnaire was carried out to interview a sample of 450 drivers. The questionnaire was designed to collect data regarding drivers' personal and driving characteristics along with their TS understanding. The descriptive analysis revealed that the drivers' comprehension level of regulatory, warning, and information TSs reached 57.5%, 53.4%, and 65%, respectively. In the predictive analysis, the IBM SPSS version 28 was utilized along with two multinomial logistic regression models to identify the investigated factors. The results indicate that drivers' TS comprehension is substantially affected by personal traits, such as age, gender, and previous TS knowledge, whereas driving experience, traffic violation history, and driver's attention to TSs while driving are contributing driving characteristics. These findings stress the necessity for the development of educational schemes and training initiatives aiming to increase drivers' TS understanding.**

***Keywords-traffic control devices; questionnaire survey; traffic signs; multinomial logistic regression***

## I. INTRODUCTION

TSs are essential components of the road transportation systems. They are designed to promote safe driving practices and regulate traffic flow by conveying clear and effective messages to road users, especially drivers. Violation of traffic rules, such as TSs, is a factor linked to road accidents [1]. TSs are generally classified into three main categories: warning signs, which alert drivers to potential hazards, regulatory signs, which enforce specific rules, and guide signs, which offer directions and information [2, 3]. However, the TS effectiveness depends heavily on the drivers' ability to understand and interpret them correctly. Misinterpretation or lack of TS comprehension can lead to traffic interruptions at best and unsafe driving practices at worst [4-7]. Previous research has confirmed that TS comprehension can be influenced by various factors related to their type and design in addition to drivers' personal and driving characteristics. TS design factors include features such as design complexity, clarity, uniformity, and adequate installing and positioning [8]. Universally recognized symbols tend to enhance comprehension, whereas overly complex or ambiguous designs can confuse drivers [3]. In [9], it was demonstrated that well-designed and standardized TSs can effectively raise comprehension across diverse driver populations. In addition, personal and driving characteristics have a substantial impact on drivers TS understanding. Drivers' personal attributes related to sociodemographic and socioeconomic characteristics can influence their TS comprehension. For example, drivers at different age groups have different TS recognition and comprehension levels [10-13]. Several studies have exhibited that higher driver educational levels consistently correlate with better TS understanding [14-16]. Gender differences have also been noted as an influencing factor. Male and female drivers might display varying TS comprehension levels [12, 17, 18]. Driving characteristics, involving driving experience [10, 19, 20], driving license possession [6], previous TS knowledge [19], vehicle class [10, 18], and daily driving distance [12, 14] are potential factors that could affect drivers' understanding of TSs.

In Iraq, although there is limited research on driver TS comprehension, the three studies available have shown that the latter can be influenced by an array of personal and driving attributes. Authors in [20] found that TS comprehension is improved with higher urbanization, education level, and driving experience, while lower TS comprehension levels are associated with higher accident rates. An empirical study in Al-Najaf Governorate revealed that factors, such as drivers' profession, education, and place of residence significantly affect their TS understanding whereas variables like age, gender, and marital status were found to have no significant impact on TS comprehension [22]. Finally, a recent national study found that the average TS comprehension level was 68% and that age, gender, educational background, and driving experience could be of statistically significant impact only regarding certain TSs [23].

It is worth mentioning that the findings presented in international studies cannot be fully applied in the study area of the current paper for multiple reasons. These include the expected variations in drivers' socioeconomic characteristics, driver behavior, TS system, traffic operation, and enforcement practices. In contrast, none of the three preceding local studies has developed regression models neither considered the potential impact of the new driving license theoretical exam, recently adopted in Iraq, on drivers' comprehension extent. The current paper, therefore, aims to investigate the drivers' comprehension level of the TSs that exist on the street network of Al-Najaf governorate, and also to develop logistic regression models to explore the relative contribution of both driver's socioeconomic and driving characteristics on their TS understanding. The potential effect of the driving license exam (theoretical part) considered for the first time in this paper. The findings of this study can support local and national highway authorities in optimizing resource allocation for traffic operations and driver training programs. Additionally, the results provide actionable insights for enhancing the TS effectiveness both locally and nationally.

## II. SURVEY DESIGN AND ANALYTIC METHOD

### A. Study Area

The study area is Al-Najaf governorate, Iraq, with spatial coordinates of 32° 00' 23" N (latitude) and 44° 20' 50 E (longitude). Al-Najaf is located in the Iraq's central region about 160 km to the south-west of Baghdad and with a 2021-based estimated population of about 1,500,000 [24]. Figure 1 portrays a GIS-based map of the study area [29].

### B. Sample Frame and Sample Size

The sample frame for this study constitutes the total number of active drivers in Al Najaf Al Ashraf governorate. Determining the appropriate sample size is a crucial step in statistical studies. Researchers must consider factors such as budget, time limits, nature of the study, desired precision and confidence levels, and population variability. A well-defined sample, along with high-quality data collection, may lead to more reliable and generalizable results. According to the statistics obtained from the Al-Najaf Directorate regarding traffic, the total number of drivers registered formally up to the end of 2023 is more than 500,000 [25], statistically considered a large population, since it surpasses 100,000 individuals. Given that the minimum sample size is 385 with ±5% margin error and 95% confidence level [26-28], in the current study, a decent sample size of 450 drivers was investigated.

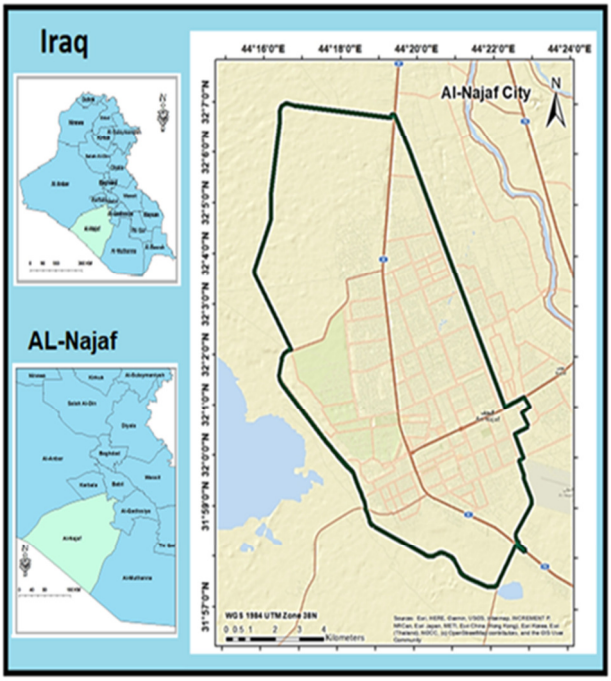


Fig. 1. A GIS-based map of the study area.

### C. PArticipant Approaching and Survey Administration

The in-person interview strategy was selected as the most feasible and effective method for recruiting and engaging potential respondents. A systematic paper-based questionnaire was developed as the survey tool. The sampling technique necessitates that the driving sample would be selected in a predominantly random manner. Proper probability-based sampling improves the representativeness of the sample data concerning the population (drivers in the research region) and increases their credibility [28]. Furthermore, sufficient sampling facilitates the extrapolation of the study results to the broader population [26]. A traffic police officer was designated to assist in the random sampling of drivers through interviews performed on selected roadways within the street network of the study area.

### D. Survey Instrument Design and Validity

The questionnaire was divided into three sections. The first consisted of short-answer questions designed to collect detailed information about drivers' demographic characteristics, such as age, gender, place of residence, and educational level. The second section entailed gathering information about driving characteristics, namely driving experience, driving license, previous TS knowledge, driving distance, driving frequency, traffic violations, and crash frequency. The third section was designed to assess driver TS comprehension based on their previous TS knowledge. It included 30 multiple choice questions about the right meaning of 30 different TSs, 17

regulatory signs (A1-A17), nine warning signs (B1-B9), and four guide signs (C1-C4), as demonstrated in Table I. For each question, five answers were available for the driver – one right answer, three wrong answers, and one "I don't know" answer.

TABLE I. TSs INCLUDED IN THE QUESTIONNAIRE

| | | | |
|---|---|---|---|
|  A1 |  A2 |  A3 |  A4 |
|  A5 |  A6 |  A7 |  A8 |
|  A9 |  A10 |  A11 |  A12 |
|  A13 |  A14 |  A15 |  A16 |
|  A17 |  B1 |  B2 |  B3 |
|  B4 |  B5 |  B6 |  B7 |
|  B8 |  B9 |  C1 |  C2 |
|  C3 |  C4 | | |

Regarding questionnaire validity, questionnaires with adequate validity yield precise information. Content validity is vital as it guarantees that the questionnaire items accurately represent the traits they are intended to evaluate. This validity can be attained through two methodologies [30, 31]. The initial method involves administering a pilot test (pilot survey) prior to executing the primary survey. The second one entails employing questions that are theoretically endorsed and prevalent in the relevant literature. Both methodologies were employed in this research. In the pilot survey, replies and comments from 30 drivers were recorded and analyzed. Rational feedback was taken into account, leading to questionnaire modifications to improve its appropriateness and efficacy. Selected questions were accordingly rephrased. For example, the seat belt wearing status question was omitted due to lack of variation, and age was replaced with year of birth. Moreover, the questionnaire design underwent minor modifications. For instance, some sign photos were replaced with clearer ones. It should be noted that most questions have already been utilized by prior scholars.

### *E. Conducting Survey and Response Coding*

The distribution of the questionnaires commenced in November 2023 and continued until April 2024. The survey form was translated into Arabic to ensure its full understanding by the drivers. A total of 450 properly filled forms were acquired. The questions were encoded and digitized to establish a database suitable for the planned quantitative statistical analysis. The scoring system that was employed to measure driver TS understanding level is the following: +1 for complete and correct responses, +0.5 for correct but incomplete responses (partially correct), 0 for "I don't know" responses, -0.5 for wrong responses, and -1 for responses opposite to the correct meaning. This rating is rigorous and has been utilized in prior relevant studies [7, 32, 33]. The understanding level for each respondent was calculated by having divided the total score of a driver by the score that could be achieved if all questions were answered correctly. The overall comprehension level for the sample is the mean of all respondents' comprehension levels.

### *F. Statistical Analysis*

The IBM SPSS software (version 28) was deployed to carry out both descriptive and predictive analyses [34]. The SPSS is frequently used in empirical studies due to its user-friendly interface and high capability in handling various statistical analyses, from basic frequency distributions to advanced techniques, such as Generalized Linear Models (GZLM) and Artificial Neural Networks (ANN).

In the current work, descriptive statistics were used to investigate respondents' characteristics, their overall TS understanding level, and the comprehension levels for regulatory, warning, and guide TS, individually. The inferential statistics, in contrast, were employed by implementing two multinomial logistic regression models to predict drivers TS comprehension. The first model included drivers' socioeconomic attributes as predictors, whereas the set of explanatory variables in the second model constituted a group of motorists' driving characteristics. Such models are members of a regression model group, typically designated as GZLM [35, 36]. In such models, to accomplish the linearity between the discrete Dependent Variable (DV) and the set of Independent Variables (IVs), otherwise predictors, a specific link function should be utilized. For the case of binomial, multinomial, and ordinal regressions, this function is called the "logit" function. Equations (1)-(3) show the specification of the estimated logistic regression model based on a sample of population data [35]:

$$Logit\ (Y) = a + B1X1 + B2X2 + \ldots + BkXk \quad (1)$$

$$Logit\ (Y) = ln\ (Odds\ (Y)) \quad (2)$$

$$Odds\ (Y) = p\ (Y) / 1 - P(Y) \quad (3)$$

where *Y* is the outcome variable, *X1* to *Xk* are the set of predictors, *a* and *B1* to *Bk* are the regression coefficients, and *P* is the probability. The Odd Ratio (OR) is the ratio of the odds of the event for one value of the IV divided by the odds for a different value of the IV, usually a value one unit lower. The OR specifies the amount of change in the odds and the direction of the relationship between IV and DV. The Maximum Likelihood Estimation procedure was utilized to estimate the model parameters.

## III. RESULTS AND DISCUSSION

### A. Descriptive Analysis

#### 1) Analysis of Personal Characteristics

Table II depicts the personal and driving characteristics of the 450 interviewed drivers that were considered in building the two comprehension regression models. Table II demonstrates that the majority of the interviewed drivers are male 412 (91.6%), within the 26-35 age group, and with a university education. Furthermore, most drivers were from Al Najaf city. About 295 (66%) of the drivers had previous TS knowledge obtained from self-education, while 92 (20%) reported having participated in relevant training courses. The rest (14%) drivers had no wide TS knowledge. Regarding drivers' experience (i.e. years of driving), 43% started driving within the last 10 years. Regarding TS attention, 41% reported that they always pay attention to TSs while driving, 24% most of the time, 29% sometimes, and 7% reported that they pay no attention to TSs. Considering traffic violations, 78% of the drivers had committed up to four traffic violations and 2% of them had more than 12 violations. The driving license frequency analysis showed that most drivers (86%) had a driving license. Finally, regarding the driving license exam (with a TS-related theoretical part), 48% of the drivers were not involved in such a theoretical exam either because their exam did not include a theoretical part or because they did not have a driving license at all. It should be noted that according to the carried out interview with a former officer in the Traffic Directorate of Al-Najaf Al-Ashraf, the theoretical exam began in 2019 [25].

TABLE II. RESPONDENT CHARACTERISTICS

| Factor | Statistics | Categories | Frequency | Percentage % |
|---|---|---|---|---|
| Age | n = 450<br>x =37.39<br>Sd = 10.625 | 16-25<br>26-35<br>36-45<br>46-55<br>>55 | 42<br>188<br>122<br>72<br>26 | 9.3<br>41.8<br>27.1<br>16<br>5.8 |
| Gender | n = 450 | Male<br>Female | 412<br>38 | 91.6<br>8.4 |
| Place of residence | n = 450 | Kufa city<br>Najaf city<br>Other | 110<br>241<br>99 | 24.4<br>53.6<br>22 |
| Highest education level | n = 450 | -Primary school or less<br>-Intermediate school<br>-High school<br>-University<br>-Higher studies | 121<br>96<br>54<br>138<br>41 | 27<br>21<br>12<br>31<br>9 |
| Previous TS knowledge | n = 450 | Self-education<br>Training course<br>No | 295<br>92<br>63 | 66<br>20<br>14 |
| Driving experience (years) | n =450<br>x = 14.89 | 0-5<br>5-10<br>10-15<br>15-20<br>20-25<br>>25 | 89<br>104<br>91<br>61<br>27<br>74 | 20<br>23.3<br>20.4<br>13.7<br>6.1<br>16.6 |
| TS attention during driving | n = 450 | No<br>Sometimes<br>Most times<br>Always | 31<br>130<br>106<br>183 | 7<br>29<br>23<br>41 |
| No. of traffic violations | n = 450<br>x = 2.67 | 0-4<br>4-8<br>8-12<br>≥ 12 | 351<br>67<br>23<br>9 | 78<br>14.9<br>5.1<br>2 |
| Driving license ownership | n = 450 | Yes<br>No | 378<br>72 | 84<br>16 |
| Driving license exam | n = 450 | Yes<br>No | 234<br>216 | 52<br>48 |

#### 2) Comprehension Level Analysis

##### a) Total Comprehension Level

The total TS comprehension score for each driver was computed based on the correctness of their answers regarding the meaning of the 30 TSs listed in the questionnaire. The average total score was 56.7%, which is moderately low. According to [37], the International Standardization Organization report (ISO-3864) entitled "Design principles for safety signs and safety markings" stated that for a TS to be acceptable, it should have a comprehension level of at least 67%.

##### b) Driver Comprehension Level By Sign Type

- Comprehension of regulatory signs

These signs include two types: prohibitive signs and mandatory signs. The results concerning the understanding of the 12 prohibitive regulatory TSs (A1-A12) are presented in Table III. The total comprehension level of these TSs was just over 54%. Signs A3 and A8 reached the highest percentages of totally correct answers, about 85.8% and 79.6%, respectively. Signs A1 and A12 were the least familiar to the respondents, with just 10.2% and 33.6% totally correct answers, respectively. The results also demonstrate that A10 and A9 are the signs with the most opposite answers. Another important point is TS design clarity and uniformity. Adding the inclined banning bar can aid in increasing this understanding level. For instance, the comprehension level for the A3, A7 and A8 signs increased remarkably when the banning bar was added. Five mandatory regulatory TSs were used in this study's questionnaire (A13-A17), and their analysis results are listed in Table III. According to the results, the drivers' comprehension of the mandatory signs (totally correct answers) reached 61.3%.

Among the five signs, A15 was more familiar to drivers, with a total correct comprehension rate of 76.4%. In contrast, 16.4% of drivers were not familiar with A16 whereas 17.6% had wrongly understood it. The mean score of the correct answers for the 17 regulatory TSs was about 57.7%.

TABLE III. COMPREHENSION ANALYSIS

| Signs | Totally correct % | Partially correct % | Don't know % | Wrong % | Opposite % |
|---|---|---|---|---|---|
| A1 | 10.2 | 83.3 | 4.0 | 0.9 | 1.6 |
| A2 | 52.4 | 12.7 | 18.9 | 6.7 | 9.3 |
| A3 | 85.8 | 3.8 | 2.9 | 2.9 | 4.7 |
| A4 | 49.3 | 27.8 | 3.1 | 9.8 | 10.0 |
| A5 | 43.3 | 20.2 | 6.7 | 13.1 | 16.7 |
| A6 | 62.4 | 9.1 | 10.7 | 10.2 | 7.6 |
| A7 | 59.1 | 8.4 | 6.2 | 23.8 | 2.4 |
| A8 | 79.6 | 6.4 | 5.3 | 6.0 | 2.7 |
| A9 | 63.8 | 4.4 | 4.7 | 4.0 | 23.1 |
| A10 | 52.6 | 1.6 | 3.4 | 7.5 | 34.9 |
| A11 | 56.7 | 8.7 | 6.2 | 8.9 | 19.6 |
| A12 | 33.6 | 28.7 | 9.1 | 9.6 | 19.1 |
| A13 | 68.0 | 8.4 | 2.9 | 18.4 | 2.2 |
| A14 | 63.3 | 9.8 | 13.6 | 10.4 | 2.9 |
| A15 | 76.4 | 2.4 | 4.7 | 12.2 | 4.2 |
| A16 | 47.6 | 17.8 | 16.4 | 0.7 | 17.6 |
| A17 | 51.3 | 35.6 | 2.9 | 6.2 | 4.0 |
| B1 | 66.4 | 9.3 | 4.2 | 16.0 | 4.0 |
| B2 | 46.4 | 10.2 | 22.2 | 6.2 | 14.9 |
| B3 | 67.3 | 16.4 | 3.8 | 1.3 | 11.1 |
| B4 | 66.4 | 4.9 | 1.8 | 2.7 | 24.2 |
| B5 | 39.8 | 15.6 | 15.1 | 5.6 | 24.0 |
| B6 | 39.3 | 11.3 | 7.3 | 36.7 | 5.3 |
| B7 | 50.6 | 7.5 | 12.7 | 1.4 | 27.9 |
| B8 | 57.6 | 4.3 | 9.1 | 1.8 | 27.2 |
| B9 | 47.2 | 21.5 | 24.9 | 3.2 | 3.2 |
| C1 | 51.3 | 9.8 | 20.4 | 16.0 | 2.4 |
| C2 | 34.2 | 36.9 | 14.0 | 6.4 | 8.4 |
| C3 | 94.0 | 1.3 | 1.1 | 1.8 | 1.8 |
| C4 | 83.2 | 10.2 | 1.4 | 1.8 | 3.4 |

- Comprehension of Warning Signs

Table III shows the results of drivers' comprehension regarding the warning signs (B1-B9) evaluated in this study. The average percentage of totally correct answers was 53.4%. The analysis revealed that drivers' understanding of certain warning signs should be enhanced for road safety purposes, as some drivers had understood these signs' meaning completely wrong (i.e. opposite meaning). Relevant examples are signs B4, B5, B7, and B8. In contrast, B3 was well-known with a 67.3% total correct comprehension score.

- Comprehension of Information TS

The total comprehension level of guide signs was fairly high, 65%. Among the four signs, C3 and C4 had the highest totally correct answer scores of 94% and 83.2%, respectively, as can be seen in Table III. This finding complies with that of [6]. C1, had the highest percentage of don't know responses, while C2 was the least known by the participants.

### *B. Multivariate Regression Models*

Two logit regression models were developed to identify the driver's sociodemographic and driving characteristic predictors that affect driver TS comprehension levels. The outcome variable constituted the driver comprehension level, and was coded as a 3-level ordinal variable based on the obtained scores: good knowledge (>0.66-1.0), moderate knowledge (>0.33-0.66), and poor knowledge (0.0-0.33). Considering the two models, although ordinal regression was initially chosen to build the former, the relevant assumption of parallel line test was found violated (p-value = 0.010 <5%), and hence the most proper alternative was the multinominal logistic regression analysis [38].

#### *1) Sociodemographic Model*

The driver TS comprehension level was divided into the three aforementioned categories. The set of predictors (IVs) used in the sociodemographic model were: place of residence, age, gender, educational levels, and driver previous TS knowledge. In Table IV, column B represents the coefficient of IVs (logit), S.E. is the standard error, Sig. is the P-value at 5% LOS, Wald represents the test used to find out if the explanatory variables in a model are significant, and Exp (B) is the OR.

As illustrated in Table IV, four predictors were found to have statistically significant influence on driver TS comprehension, namely driver age, gender, education level, and previous TS knowledge. Age was found to have a positive B-regression coefficient: The odds of drivers to be with good knowledge increases by a factor of 1.084 as their age increases by one year, probably due to the increased experience that comes with driving years. Authors in [39] also observed this association. The gender variable was found to have a negative B-regression coefficient. Female drivers are less probable to be in the good knowledge category than male drivers by a factor of 0.018 (OR). Several earlier studies on gender revealed that males had a generally better TS comprehension level than females [15, 18, 21]. Concerning education, drivers with primary school or lower, intermediate school, and high school education levels had good knowledge but lower than those belonging to the higher education group. This implies that drivers' TS comprehension increases with an increased education level. These results are consistent with those listed in [16, 21, 39]. Finally, regarding previous TS knowledge, drivers who had no previous knowledge were less expected to be in the good knowledge category than those who were in the training course category. This indicates the positive role of training schemes in increasing TS understanding among drivers. This result is consistent with the findings reported in [4, 40].

The evaluating statistics of the multinomial logistic model are summarized in Table IV. Regarding Model fitting information statistics, the chi square test had a p-value of < 0.001 (less than 5%), indicating the statistical effectiveness of the whole model against the intercept only (null) model. The Pearson chi-square test, which is useful for quantifying model validity in fitting the data, obtained a p-value of 1.00 (> 5%), indicating an unremarkable deviation between the observed and predicted probabilities. Finally, Nagelkerke pseudo-R-square was 0.27, exhibiting a good explanatory power for the developed model. The Nagelkerke R-square values, which were between 0.2 and 0.3, are considered favorable in logistic regression [5].

TABLE IV. PARAMETER ESTIMATE RESULTS OF MULTINOMIAL LOGISTIC REGRESSION FOR THE COMPREHENSION-DEMOGRAPHIC MODEL (MODEL NO. 1)

| Comprehension level | | B | S.E. | Wald | Sig. | Exp(B) |
|---|---|---|---|---|---|---|
| Good knowledge | Intercept | 5.718 | 2.326 | 6.045 | 0.014 | |
| | Q1 Age | 0.080 | 0.039 | 4.294 | **0.038**** | 1.084 |
| | Q2 Gender (0=Female) | -3.994 | 1.102 | 13.13 | **0.000**** | 0.018 |
| | Q2 Gender (Ref. Cat. = Male) | 0 | __ | __ | __ | __ |
| | Q3 Place of residence (0=Other) | -0.092 | 0.958 | 0.009 | 0.923 | 0.912 |
| | Q3 Place of residence (1=Kufa city) | -0.887 | 0.749 | 1.404 | 0.236 | 0.412 |
| | Q3 Place of residence (Ref. Cat. = Najaf city) | 0 | __ | __ | __ | __ |
| | Q4 Highest Education Level (0=Primary school or less) | -4.366 | 1.632 | 7.157 | **0.007**** | 0.013 |
| | Q4 Highest Education Level (1=Intermediate school) | -3.845 | 1.590 | 5.851 | **0.016**** | 0.021 |
| | Q4 Highest Education Level (2=High school) | -3.558 | 1.677 | 4.501 | **0.034**** | 0.028 |
| | Q4 Highest Education Level (3=University) | -0.642 | 1.441 | 0.198 | 0.656 | 0.526 |
| | Q4 Highest Education Level (Ref. Cat. =Higher studies) | 0 | __ | __ | __ | __ |
| | Q5 Previous knowledge in TS (0=No) | -4.059 | 1.192 | 11.60 | **0.001**** | 0.017 |
| | Q5 Previous knowledge in TS (1=Self education) | -0.724 | 1.244 | 0.339 | 0.621 | 0.561 |
| | Q5 Previous knowledge in TS (Ref. Cat. = Training course) | 0 | __ | __ | __ | __ |
| Moderate knowledge | Intercept | 4.598 | 2.297 | 4.006 | 0.045 | |
| | Q1 Age | 0.065 | 0.038 | 2.915 | **0.088*** | 1.067 |
| | Q2 Gender (0=Female) | -2.880 | 1.048 | 7.548 | **0.006**** | 0.056 |
| | Q2 Gender (Ref. Cat. =Male) | 0[b] | __ | __ | __ | __ |
| | Q3 Place of residence(0=Other) | 0.674 | 0.934 | 0.521 | 0.470 | 1.962 |
| | Q3 Place of residence (1=Kufa city) | -0.929 | 0.732 | 1.608 | 0.205 | 0.395 |
| | Q3 Place of residence (Ref. Cat. =Najaf city) | 0 | __ | __ | __ | __ |
| | Q4 Highest Education Level (0=Primary school or less) | -2.994 | 1.605 | 3.477 | **0.047**** | 0.050 |
| | Q4 Highest Education Level (1=Intermediate school) | -2.758 | 1.562 | 3.118 | **0.049**** | 0.063 |
| | Q4 Highest Education Level (2=High school) | -1.964 | 1.634 | 1.446 | 0.229 | 0.140 |
| | Q4 Highest Education Level(3=University) | -0.138 | 1.416 | 0.010 | 0.922 | 0.871 |
| | Q4 Highest Education Level (Ref. Cat. =Higher studies) | 0 | __ | __ | __ | __ |
| | Q5 Previous knowledge in TS (0=No) | -2.678 | 1.168 | 5.261 | **0.022**** | 0.069 |
| | Q5 Previous knowledge in TS (1=Self education) | -0.077 | 1.242 | 0.004 | 0.950 | 0.926 |
| | Q5 Previous knowledge in TS (Ref. Cat. =Training course) | 0 | __ | __ | __ | __ |

- Predicted variable is the comprehension levels (Good knowledge, Moderate knowledge, Poor knowledge).
- Reference category (Poor knowledge).
- Model fitting information: Final model Chi-Square is significant (sig. < 0.001).
- Goodness of fit based on Pearson's Chi-Square (sig. = 1.00).
- Pseudo Nagelkerke R -Square = 0.274.

*2) Driving Characteristics Model*

The predictor variables used in this model are: driving experience, traffic violation, driving license (theoretical exam), driving license, and TS attention. As depicted in Table V, four factors were found to have a significant contribution to estimating the outcome variable at 5% LOS. These are the driving experience, traffic violation, TS attention, and TS exam. Taking into account the driving years, the relationship between driver experience and good TS knowledge is positive. The odds of drivers to be in the good knowledge category increased by a factor of 1.109 as their experience increased by one year. The results show that experienced drivers can better understand TSs. This finding agrees with the results of [10, 19, 20, 21].

Traffic violation was found to have a negative B regression coefficient. A one-unit increase in traffic violations decreases the odds of being in the good knowledge category by a factor of 0.855, indicating that higher violation rates are associated with lower knowledge levels. This may be due to the driver's ignorance of these signs' importance. Additionally, repeated violations might reflect a behavioral pattern of risk-taking or diminished respect for the traffic laws. This demonstrates the urgent need to enhance TS awareness and implement traffic education programs to improve driving behavior and reduce accidents on the roads.

Regarding the responses of drivers to the question "Do you pay attention to the traffic signs on the road?", the analysis results revealed that those who responded "no" will possibly be in the good knowledge category, by a factor of as low as 0.085, compared to the drivers who responded "always". This suggests that drivers who pay attention to recognize TSs are aware of their significance and realize the necessity of understanding their meaning. Boosting TS recognition can enhance road safety and traffic operation [41].

Considering the driving license exam, the findings exhibited that the latter had a significant impact on the DV. Drivers who did not take the TS exam were with odds of being in the good knowledge group (0.059) compared to those who took the exam. This stresses the exam importance as a recent addition to the driving license approval procedures. The same effect was noticed when running the multinomial regression between the moderate knowledge and poor knowledge categories. This suggests that the driving license exam can be considered a valuable addition to the licensing procedures.

TABLE V. MULTINOMIAL LOGISTIC REGRESSION OUTPUTS FOR COMPREHENSION-DRIVING CHARACTERISTIC MODEL (MODEL NO. 2)

| Comprehension level [a] | | B | S.E. | Wald | Sig. | Exp(B) |
|---|---|---|---|---|---|---|
| Good knowledge | Intercept | 2.601 | 0.746 | 12.170 | 0.000 | |
| | Q1 Driving experience | 0.104 | 0.037 | 8.043 | **0.005**** | 1.109 |
| | Q2 Traffic violations | -0.156 | 0.044 | 12.332 | **0.000**** | 0.855 |
| | Q3 TS attention (0=No) | -2.464 | 1.020 | 5.841 | **0.016**** | 0.085 |
| | Q3 TS attention(1=Sometimes) | 1.386 | 0.728 | 3.619 | **0.057*** | 3.997 |
| | Q3TS attention (2=Most times) | -0.330 | 0.598 | 0.306 | 0.580 | 0.719 |
| | Q3TS attention (Ref. Cat. = Always) | 0[b] | __ | __ | __ | __ |
| | Q4 TS exam (0=No) | -2.836 | 0.618 | 21.044 | **0.000**** | 0.059 |
| | Q4 TS exam (Ref. Cat. =Yes) | 0[b] | __ | __ | __ | __ |
| | Q5 Driving license(0=No) | -1.025 | 0.608 | 2.843 | 0.092 | 0.359 |
| | Q5 Driving license (Ref. Cat. =Yes) | 0[b] | __ | __ | __ | __ |
| Moderate knowledge | Intercept | 3.200 | 0.719 | 19.786 | 0.000 | |
| | Q1 Driving experience | 0.097 | 0.036 | 7.307 | **0.007**** | 1.102 |
| | Q2 Traffic violations | -0.096 | 0.031 | 9.258 | **0.002**** | 0.909 |
| | Q3 TS attention(0=No) | -0.829 | 0.741 | 1.253 | 0.263 | 0.436 |
| | Q3 TS attention(1=Sometimes) | 1.183 | 0.705 | 2.817 | **0.093*** | 3.264 |
| | Q3 TS attention (2=Most times) | -0.425 | 0.562 | 0.571 | 0.450 | 0.654 |
| | Q3TS attention (Ref. Cat. = Always) | 0[b] | __ | __ | __ | __ |
| | Q4 TS exam (0=No) | -2.633 | 0.582 | 20.469 | **0.000**** | 0.072 |
| | Q4 TS exam (Ref. Cat. = Yes) | 0[b] | __ | __ | __ | __ |
| | Q5 Driving license(0=No) | -0.198 | 0.511 | 0.150 | 0.698 | 0.821 |
| | Q5 Driving license (Ref. Cat. = Yes) | 0[b] | __ | __ | __ | __ |

- Predicted variable is the comprehension levels (Good knowledge, Moderate knowledge, Poor knowledge).
- (a). The reference category is: poor knowledge.
- (b) . This parameter is set to zero because it is redundant.
- Model fitting information: Final model Chi-Square is significant (sig. = 0.000).
- Goodness of fit based on Pearson's Chi-Square (sig. = 0.965).
-Pseudo Nagelkerke R -Square = 0.250.

As displayed in Table V, the Model fitting information test proves that the final model added a significant improvement over the null model [$x^2$ (14) = 101.09, p = 0.000 < 0.05]. For the Goodness of fit statistics, the person's chi-square test does indicate a valid model that fit the data well [$x^2$ (708) = 641.524, p = 0.965 > 0.05]. Furthermore, the pseudo Nagelkerke R-square is 0.250, which reflects an acceptable ability for the adopted driver set of characteristics (predictors) in explaining the variation in TS comprehension level (predicted variable).

## IV. CONCLUSIONS

The current paper evaluated driver Traffic Sign (TS) comprehension, taking into account the potential effects of certain personal and driving attributes of the drivers on this comprehension. A decent sample of 450 drivers was interviewed and their understanding level of 30 TSs was analyzed.

The frequency analysis revealed a hardly acceptable overall level (56.7%) of TS comprehension among the interviewed drivers. The individual average comprehension level for regulatory, warning, and guide signs were around 58%, 53.5%, and 65%, respectively. The findings emphasize the need to enhance TS comprehension using different and effective schemes of awareness-raising and educational programs related to TSs. The findings of the multivariate logistic regression analyses revealed that among drivers' characteristics, age, gender, education, driving experience, traffic violation frequency, and TS attention had significant influence on TS comprehension. Interestingly, the TS exam and previous TS knowledge were found to have a positive impact on driver's TS understanding. Accordingly, the renewal process for the driving license is proposed to include a theoretical exam that will involve questions regarding the right meaning of several TSs. Finally, adding an inclined banning bar to prohibitive regulatory signs can significantly assist in increasing their clarity, and hence their understanding level among drivers. Such signs include "U-turn is prohibited", "Trucks are prohibited", and "Passing is prohibited". National and local roads and traffic agencies are highly advised to consider this modification. Further research regarding TS design uniformity is also proposed.

The geographical context of the current study makes it questionable to generalize its findings nationally. Thus, conducting national-level studies is proposed. Furthermore, sign-related factors that could influence driver TS recognition and understanding, such as sign design, placement, and clarity should be also investigated and analyzed sufficiently.

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