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SIMULATING INTERVENTION STRATEGIES FOR IMPROVING SEAT BELT COMPLIANCE AND MOBILE PHONE USE AMONG DRIVERS IN BAGHDAD

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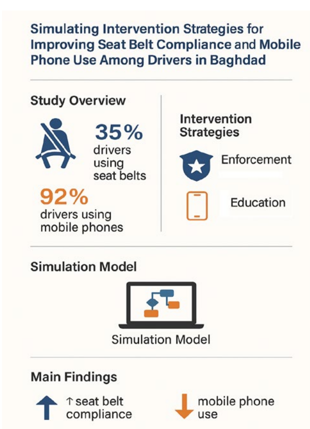
Graphical abstract



Abstract

Seat belt non-use and mobile phone use while driving pose major road safety risks in Baghdad, Iraq. A survey of 287 drivers revealed critically low seat belt compliance (35% among drivers; <4% among rear passengers) and high mobile phone use (92%). Lower compliance was significantly associated with older age and less education levels. A simulation model tested six intervention strategies over 1- and 10-year periods. The most effective strategy—combining education with enforcement—achieved a 25.2% improvement in seat belt use and a 36,343% ROI. Education-only strategies, while less effective, were highly cost-efficient (ROI: 113,695%). These findings underscore the importance of long-term, targeted interventions, especially for high-risk demographics. Combining education, enforcement, and technology-based tools can substantially enhance road safety in Baghdad and comparable urban settings.

Keywords: Road Safety, Seat Belt Compliance, Mobile Phone Use, Safety Interventions, cost-benefit.

1.0 INTRODUCTION

Seat belt and mobile phone use while driving is considered critical factors in road safety. The World Health Organization (WHO) [1] stated that seat belt compliance can lower the number of fatal and injury accidents among front seat passengers by 45-50% and rear seat passengers by 25-75%. Globally, regardless of broad legislation's efforts, the compliance with safety measures remains at low rates, especially in the Middle East and in low levels income countries. In addition to the global and regional patterns, research on metropolitan areas provides significant information regarding driver behaviors. Praveen et al (2021) revealed significant directions and risk factors correlated to non-compliance [2]. There is an essential percentage of drivers, 50%, and rear seat passengers, 94.1% did not wear seat belts. Furthermore, mobile phone use was prevalent among driver aged 26-36 in early morning hours. These actions were particularly risky on minor roads and during weekends [2].

Effective enforcement is crucial for improving compliance rates, as demonstrated by several studies that reported differences in the rate of compliance across various regions. AbdulJabbar (2022) examined seat belt compliance in Baghdad, demonstrating a low level of usage, 19.3% among drivers and a lower level among passengers [3]. On the other hand, Mahfoud et al (2015) found a higher compliance level in Doha in Qatar, 72.7% for drivers and 7.5% for mobile phones used among drivers while driving [4]. Additionally, MvCartt, Helling, and Bratiman (2006) confirmed there is significant risk associated with both hand-held and hands-free mobile phones, result from prevalent use of mobile phones while driving [5]. These statistics are consistent with a comprehensive analysis done by Kargar et al (2023), which revealed regional discrepancies in seat belt usage with a global rate of 43.94% for drivers with lower compliance in Asia, the Middle East, and Africa [6]. The results reveal the crucial need for regional intervention.

Many factors affect seat belt and mobile phone legislation. AbdulJabbar (2022), Densu and Salifu (2013), Begg & Langley

(2000), and Shaaban (2012) reported discomfort, perceived in the effectiveness of the seat belt, and weak law enforcement as obstacles. Differences between genders were observed, with females having higher compliance [3, 7, 8, 9]. Kulanthayan et al. (2004) tested factors that affected seat belt use among motorcar passengers in Selangor, Malaysia [10]. The study found that drivers with high education and travelling in urban areas were more likely to show better compliance with seat belt regulations. Attitudes towards speeding, driving at night, and traffic police presence are also significant factors that affect compliance. Since the highway traffic flow is very dynamic and uncertain environment that requires common factors indicate that behavioral factors, personal beliefs, and enforcement lack contribute to the non-compliance conditions.

Enforcement of traffic laws is required for increasing compliance with seat belt and reducing mobile phone use while driving, as illustrated by studies conducted in different regions. Mohammadi (2009) in south east Iran illustrated that firm enforcement reduced the number of fatalities and injuries, even though the benefits declined as soon as the enforcement weakened [11]. In the same way, Alghnam et al. (2018) in Riyadh, Saudi Arabia, demonstrated that setting up automated traffic cameras significantly raises the usage level from 33.9% to 75.8% and the mobile phone use from 13.8 % to 9.8%. Implementation of this intervention strategy also reduced mobile phone usage while driving, highlighting the effectiveness of technology-assisted enforcement measures [12]. Ebert et al. (2025) utilized technology to investigate the effect of telematics-based behavior interventions, showing that the respondents have a “shared pot” which is an initiative program, and a high seat belt usage rate of 91.3%. The result of this study emphasizes that teacher-based strategies could be effective tools for improving future traffic law compliance and traffic safety strategies [13]. Adaptive enforcement strategies, tailored to contextual needs and technology, effectively improve compliance [13]. These perceptions underscore the necessity of continuous enforcement strategies and integrated technology to achieve a high compliance rate.

Cultural behavior context is essential to designing effective intervention strategies. Simsekoglu and Lajunen (2009) in Turkey found that seat belt compliance is highly correlated with driving behavior rather than general health behavior, highlighting the role of driver personality and lifestyle [14]. Kweon and Kockelman (2006) reported demographic differences in seat belt usage, with males and lower-income individuals with lower income less likely to comply with traffic regulations [15]. Gender behaviors add complexity to compliance patterns. Jiménez-Mejías et al. (2014) reported significant gender variance in driving behaviors, with females typically show lesser risk behaviors compared to males [16]. These results underscore the crucial need for initiatives that consider the cultural background, beliefs, and social norms of each society.

Although enforcement and technology strategies can improve compliance significantly. Many studies concentrate on short-term strategies, often overlooking the long-term effects post-implementation. Also, the lack of comprehensive road safety intervention data arises for low- and middle-income country as an obstacle for intervention studies as underscored by Goel et al. (2024) [17]. Studies on the Baghdad environment should emphasize intervention studies, mobile phone use, and driver attitudes. These efforts could contribute effective and sustainable safety policy in Baghdad.

Another main contributor of the dangerous state of the roads in Baghdad is the use of cell phones! This is often looked at as a necessity, and it is embedded in the culture despite the known risk to driver attention and response time . This is coupled with a general apathy towards punishment, as a result of lax law enforcement, with which such activities continue with impunity.

In light of socio-political instability, limited research infrastructure, and enforcement limitations, Baghdad provides a unique setting to examine low-cost and scalable tools to influence driver behavior. However, conventional experimental or longitudinal study designs are not always feasible in these settings, for logistical and ethical reasons. In this setting, simulation modeling can be a useful tool, because it allows researchers to simulate the long-term impact of various interventions given existing demographic, behavioural, and economic information. This study aims to explore simulation intervention strategies for short-term and long-term periods to improve seat belt compliance and reduce mobile phone use among Baghdad drivers based on the current compliance evaluation. Through examination environment with socio-political challenges and limited resources, the study is intended to contribute practical knowledge to policymakers aiming to implement evidence-based road safety programs within the constraints of real-world demands.

2.0 METHODOLOGY

2.1 Theoretical Framework: Theory of Planned Behavior TPB

This study utilizes the Theory of Planned Behavior (TPB) to explore driver compliance with seat belt use and mobile phone regulations. According to TPB, behavior is affected by three main factors: i.e. attitudes towards the behavior, subjective norms, and perception of behavioral control [18], [19], [20]. In the case of traffic safety, these appear like: drivers' beliefs about the outcome of safety behaviors (e. g., “seat belts save lives”); social expectation (e.g., peer or family attitudes); and their perceived ability to comply (e.g., feeling able to resist use of a mobile phone while driving). Adopting TPB makes it possible to systematically investigate the behavioral motivations and barriers in the survey data. Each TPB domain was represented by a set of items on the questionnaire to facilitate data collection**.**

2.2 Study Area and Sampling

The study was conducted in Baghdad, the capital of Iraq, selected due to its high population density, traffic congestion, and elevated accident rates [21]. A structured questionnaire was used to capture the data from 400 drivers who were randomly selected from September to December 2024. A computer-generated random number file was used to sample from a stratified list of licensed drivers drawn from public transportation registries that accurately represent the demographic population by age, gender, and vehicle type.

The inclusion criteria were drivers aged 18 years or older, holders of current driving licenses and currently driving within Baghdad. Participants with cognition or physical impairments that were likely to affect the accuracy of reporting were ineligible. One hundred thirteen individuals with incomplete and unreturned questionnaires were excluded, and the final sample size was 287; thus, the response rate was 83.5%.

2.3 Questionnaire Design and Validation

The survey instrument was based on validated tools, particularly the WHO Global Road Safety Survey and other regional road safety instruments [1, 7]. It included closed-ended and Likert-scale questions covering demographics, seat belt use, mobile phone use, and behavioral motivations.

The questionnaire underwent pretesting with 30 drivers in Baghdad to ensure reliability. Feedback from pretesting contributed to revisions in question phrasing and structure, particularly for items assessing behavioral intent and perceptions of enforcement.

2.4 Ethical Considerations

All participants were informed about the objectives of the study, its voluntary nature, and that the collected data used for study purposes only, and responses were collected discreetly to ensure participant anonymity, where no identifiable information was recorded.

2.5 Composite Safety Score Weighting

A composite safety score was constructed to reflect individual compliance behavior, ranging from 0 (non-compliant) to 100 (fully compliant). The score assigned a 60% weight to seat belt use and a 40% weight to mobile phone avoidance is supported by established evidence on the differential impact of behaviors on traffic safety results. According to WHO assessments and global crash data, have demonstrated that compliance with the use of seat belts, as a single measure, can reduce the risk of fatal injury by about 50% for both drivers and front-seat passengers [22]. In contrast, mobile phone use during driving—although having a similar effect on crash risk—would lead to at most a four-fold increase for hand-held phones and a 23-fold increase for texting, but usually to lower proportions of fatal injuries than do unrestrained occupants [23]. Composite indicator studies, such as the study by Grdinić-Rakonjac et al. (2021), further justify differential behavioral weighting by demonstrating that seat belt violations receive higher relational weights in risk models than phone use due to their stronger correlation with fatality statistics. Therefore, the 60/40 distribution reflects a risk-proportional weighting that reflects the real-world fatality impact in urban traffic environments [24].

2.6 Data Analysis

The data collected was analyzed with Excel software and the Python programming language. The primary analysis processes were:

- Descriptive Statistics: For summarizing participant demographics and overall compliance rates.
- Chi-square Analyses: To examine the relationships between demographic factors and compliance behaviors (i.e., seat belt use and mobile phone use).
- Violation Coding: Binary coding was used (1 = use; 0 = non-use) for seat belt and mobile phone behavior.
- Safety Score Calculation: A combined safety score ranging from 0 (least safe) to 100 (safest) was computed with a 60% weighting for seat belt usage and a 40% weighting for mobile phone avoidance, reflecting their relative contribution to safety.
- Identification of High-Risk Group: Safety scores were stratified by age and level of education to determine the groups with the lowest scores. Chi-square tests were employed to determine statistical significance ($p < 0.05$).

2.7 Simulation of Intervention Strategies

To evaluate potential safety improvements, simulation models were developed using the Python programming language to examine the effects of six intervention strategies over short-term (1 year) and long-term (10 years) periods:

1. Control (no intervention)
2. Education-only
3. Camera setup
4. Enforcement-only
5. Combined Education with Enforcement
6. Combined Education with Camera

The model was structured with the following components:

- Input Parameters:
  - Baseline compliance rates from the field survey
  - Demographic segmentation by education level and age
  - Intervention effectiveness derived from published studies and WHO guidelines
  - Cost inputs for each intervention scenario
  - Population distribution per 100,000 drivers
- Output Parameters:
  - Projected change in seat belt usage
  - Economic benefit (accident cost savings)
  - Return on Investment (ROI) and Net Benefit
- Behavioral segmentation was based on education level:
  - University-educated drivers: higher baseline compliance (28%) and higher response coefficient (1.3)
  - School-educated drivers: lower baseline compliance (7%) and lower responsiveness (0.8)

The effectiveness of the intervention was measured through projected changes in seat belt compliance, and its economic feasibility was assessed using Return on Investment (ROI) and Net Benefit metrics. Inflation, population education trends, and annual operational costs were factored into the long-term model. The ROI was calculated using the following equation:

$$ROI = ((\text{Total Benefit} - \text{Total Cost}) / \text{Total Cost}) \times 100\% \quad \text{eq. 1}$$

3.0 RESULTS AND DISCUSSIONS

3.1 Population Characteristics

The study sample comprised 55.1% males and 44.9% females. Participants' ages spanned from 18 to 70 years, with the majority falling into two age brackets: 30.3% between 31-40 years and 31.4% between 41-50 years, as illustrated in table 1. Educational attainment varied from primary school (11.8%) to doctoral degrees (12%), with bachelor's degree holders constituting the largest group at 46%. Regarding marital status, 69.7% were married, 23.7% were single, and a small percentage were either divorced or widowed. The majority of participants (81.9%) were employed, and 77.4% possessed valid driving licenses. Driving experience varied among participants between 5 years or less and 10 years or more. Most drivers operated either salon cars or passenger vehicles (4 seats) at 69.7%, followed by SUVs (sport utility vehicles, 7 seats) at 21%. The remaining 9.1% drove other vehicle types, including buses, minibuses, and pickup trucks, as shown in Table 1.

Table 1 Population Characteristics for the Participants

Properties		No.	%
Gender	Male	158	55.1
	Female	129	44.9
Age (years)	(18-24)	32	11.0
	(25-30)	46	16.0
	(31-40)	87	30.3
	(41-50)	90	41.4
	+ 50	32	11.1
Education Level	Primary school	34	11.8
	Secondary school	51	17.8
	BSc.	132	46.0
	MSc.	33	11.5
	PhD.	37	12.9
Marital Status	Single	68	23.7
	Married	200	69.7
	Divorced & Widows	19	6.6
Licenses	Yes	222	77.4
	No	65	22.6
Car Type	Saloon	200	69.7
	SUV	61	21.3
	Other	26	9.1

3.2 Seat Belt Use Patterns

Among 287 participants, seat belt usage rates were critically low, with only 35.2% of drivers, 16% of front seat occupants, and a mere 3.8% of back seat passengers regularly using seat belts, as detailed in Table 2. These statistics underscore a concerning trend in seat belt compliance, especially among passengers. This pattern reveals a critical safety issue for passengers, especially in the back seat, and interventions should be targeted at all vehicle occupants, not only the driver. To explore potential disparities in seat belt usage between genders, a Chi-square test was performed. The results, yielding a Chi-square statistic of 1.1938 and a P-value of 0.2745, indicated no significant difference in seat belt usage between male and female drivers at the 0.05 confidence level. This lack of significant gender difference was also observed among front seat occupants, with a Chi-square statistic of 2.2875 and a P-value of 0.1304, reinforcing the uniformity in behavior across genders.

Additionally, the study examined seat belt usage across various age groups (as presented in Table 1), revealing no statistically significant differences with a Chi-square value of 6.4505 and a P-value of 0.16793 for the same confidence level. However, educational attainment emerged as a significant factor influencing seat belt use. A Chi-square test comparing seat belt usage between individuals with school-level education and those with university education showed significant disparities. Only 7% of participants with school-level education used seat belts, compared to 28% of university-educated individuals. This significant difference, indicated by a Chi-square value of 6.8091 and a P-value of 0.00907 (as shown in Table 3), highlights the impact of educational level on safety behavior. The important effect of education on seat belt usage, with university-educated drivers being four times more likely to use seat belts, emphasizes the urgent need for education programs specifically designed for varying educational backgrounds. This targeted approach could significantly enhance seat belt compliance across different population groups.

Table 2 Usage of Seat Belt according to the Position of the Seat

Position	Male		Female		Total	
	Yes	No	Yes	No	Yes	No
As driver	60 (38%)	98 (62%)	41 (32 %)	88 (68 %)	101 **(35.2%)**	186 (65 %)
As Passenger in the front seat	30 (19%)	128 (81%)	16 (12 %)	113 (88%)	46 **(16%)**	241 (84%)
As Passenger in the Back Seat	5 (3 %)	153 (97%)	6 (2 %)	126 (98%)	11 **(3.8 %)**	279 (96 %)

Table 3 Seat Belt Use Statistics

Properties	**Use seat belt Yes**	**Use seat belt No**	**Chi²**	**P value**	**Result**
Gender:					
Male	60 (21%)	98 (34 %)	1.193	0.274	Not significant
Female	41 (14 %)	88 (31 %)			
Age					
(18-24)	16 (6%)	16 (6%)	6.450	0.168	Not significant
(25-30)	24 (8%)	2 (7%)			
(31-40)	54 (19%)	34 (12%)			
(41-50)	58 (20%)	32 (11%)			
+ 50	23 (8%)	8 (3%)			
Education					
School	20 (7%)	65 (22 %)	6.809	0.009	**Significant**
University	80 (28 %)	122 (43 %)			

3.3 Reasons for Seat Belt Usage and Non-Usage

Participants in the study provided varied reasons for their decisions to wear or not wear seat belts, as depicted in Figure 1. Among those who use seat belts, a minority cited reasons such as car alarm systems (4.5%), habitual use (8%), and family pressure (1%). The predominant motivations, however, were the belief in seat belts' life-saving capabilities (22.3%), the desire to avoid traffic fines (21.6%), and adherence to traffic laws (18.8%). Notably, 14.6% of participants indicated that they never use seat belts.

Conversely, Figure 2 details the reasons given by respondents for not wearing seat belts. The most frequently cited explanation was discomfort, reported by 40.4% of participants, followed by the fear of being trapped in the event of an accident (13.2%). Additional factors included driving at low speeds (13.9%), reliance on other safety features such as airbags (7.3%), a lack of belief in the effectiveness of seat belts (1.7%), the size of the vehicle (1%), and perceived insufficient law enforcement (0.3%). Despite these concerns, 22% of participants reported consistent seat belt usage, highlighting a complex interplay of factors influencing this crucial safety behavior.

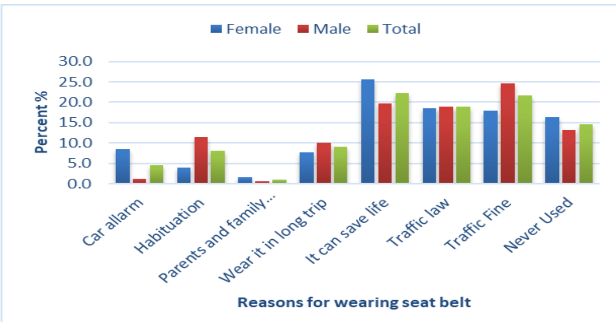


Figure 1 Reasons for Wearing the Seat Belt

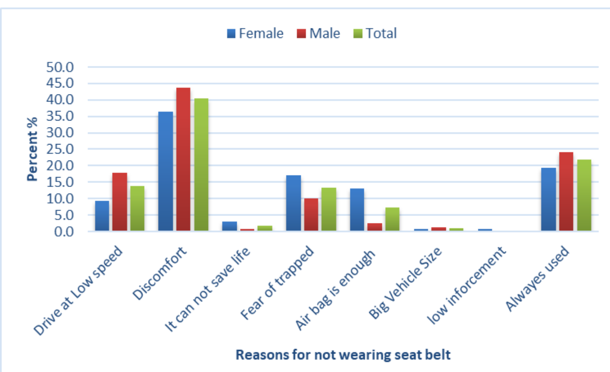


Figure 2 Reasons for not Wearing Seat Belt

The results reveal that seat belt usage is driven mainly by external motivations—fear of fines (21.6%) and belief in legal obligation (18.8%)—rather than intrinsic safety beliefs (22.3%). This reflects a dominance of subjective norms and weak internalization of attitudes toward the behavior, as consistent with concepts of the Theory of Planned Behavior [18], [19], [20].

Notably, 14.6% of participants never wear seat belts, with the leading barrier being discomfort (40.4%). This indicates a low perceived behavioral control, highlighting the importance of enforcement or technological reminders (e.g., alarms) to compensate for poor self-regulation. These findings align with those of Simsekoglu & Lajunen (2009) who found that seat belt use is driven more by situational and behavioral factors than general safety attitudes [14].

3.4 Mobile Phone Usage

The use of mobile phones while driving has become a significant concern in road safety discussions, particularly given its varied implications across different demographics. Surveys indicate that a high percentage of drivers, 92%, engage in mobile phone use while driving. Although it appears that male drivers have a slightly higher tendency to use mobile phones, with 55% reporting habitual use compared to 45% of female drivers, a Chi-square test (χ^2 = 1.3536, P-value = 0.24465) reveals that this difference is not statistically significant. This finding suggests that gender does not play a decisive role in mobile phone usage while driving. Despite the lack of a significant gender difference, the concern about mobile phone distractions is universally acknowledged among drivers [5] [12]. A notable 94% of surveyed drivers expressed worries that mobile phone usage could negatively affect their attention and reaction times. However, 6% of drivers believe that mobile phone use is ubiquitous among all drivers. Interestingly, 56% of drivers hesitate to answer the phone while driving, indicating a cautious approach by a majority.

The primary reasons drivers use their mobile phones include the need for connectivity, such as making urgent calls or responding to important messages, which accounts for 58% of the usage. Additionally, 31% use their phones for emergencies. A smaller percentage, 2%, use their phones to pass the time during traffic jams. Notably, the use of Bluetooth technology, which allows drivers to use their phones hands-free, was mentioned as a common method for staying connected without significant distraction. These findings underscore the complex factors influencing mobile phone use while driving and highlight the need for targeted interventions and educational campaigns. Such initiatives should aim to mitigate the risks associated with mobile phone use by promoting safer driving practices and enhancing awareness of the potential dangers. The motivations behind mobile phone usage, as detailed in Table 4, reveal that the most common reasons are important calls and emergency situations. This data supports the need for continued efforts to educate drivers on the importance of focusing on the road and utilizing hands-free options when necessary.

Table 4 Results for Motivation for Mobile Phone Usage During Driving

`Motivation	Male	Female	Total No.	Total %
Important call	95	71	166	58 %
Emergency Situation	46	43	89	31%
Spend Time during a Traffic Jam	4	3	7	2.4%
Never used	10	9	19	2.1%
Other reasons	3	3	6	6.6%
Total	158	129	287	100%

The reasons drivers choose to refrain from using mobile phones while operating a vehicle are detailed in Table 5. The data reveals a significant awareness of safety and legal responsibilities among the participants: 20 % of drivers abstain from mobile phone use to comply with traffic laws.39 % avoid using their phones due to fears of becoming involved in a traffic accident. 36 % recognize that mobile phones can significantly distract their attention from driving. An additional 5% cite personal habits or intrinsic preferences as reasons for not using their phones while driving. These findings highlight the predominant safety concerns that influence drivers' decisions to avoid mobile phone use, underscoring the importance of continued public education and enforcement of traffic laws to reinforce these safe driving behaviors.

The high prevalence of mobile phone use (92%) while driving—despite most drivers (94%) acknowledging its danger—suggests a clear intention-behavior gap, where drivers are aware of risks but unable or unwilling to change behavior. This gap is well-explained by TPB: although drivers hold negative attitudes toward distracted driving, weak enforcement and social normalization of phone use undermine compliance.

Similar findings were reported by McCartt et al. (2006) [5] and Alghnam et al. (2018) [12], who noted that even in regions with public awareness campaigns, usage persists unless enforcement is visible and sustained.

Table 5 Results for Motivation for Mobile Phone not Using During Driving

Reasons	Male	Female	Total No.	Total %
Traffic Law	31	27	58	20%
Afraid of accident involvement	51	62	113	39%
Distract attention	65	37	102	36%
Other reasons	11	3	14	5%
Total	158	129	287	100%

3.5 Identify High-Risk Groups Based on Safety Behaviors

To identify high-risk groups, the full dataset's safety scores were analyzed and broken down by demographic features such as age, education, gender, and marital status. High-risk groups will be those with the lowest average safety scores, indicating frequent risky behaviors (not using seat belts and/or using phones while driving). Figure 3 shows the distribution of safety scores across the entire sample.

The majority of the participants have extremely low safety scores, with an average of about 14% and a median score of 0%. This indicates that a significant number of the sample rarely wear seat belts and/or use mobiles while driving quite often.

Next, demographic groups which most likely to be high-risk (lowest safety scores) were analyzed. Table 6 presents the top 10 highest-risk demographic combinations by age and education.

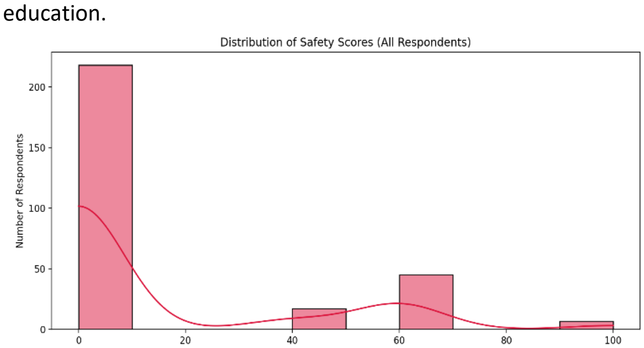


Figure 3 Safety Scores for all Respondents

It can be seen from the table 6 that individuals with primary or secondary education only, especially those aged 31 to 70 years, are most vulnerable. For example, 100% of 31–40-year-olds with primary education only are high-risk, as are 94% of 51–70-year-olds with secondary education.

To confirm these findings, a statistical analysis was performed to investigate how demographic factors relate to risky driving behaviors. It revealed that both age and education level have a significant role in determining high-risk classifications. The Chi-square tests showed strong links for age ($\chi^2 = 11.78$, $p = 0.0082$) and education ($\chi^2 = 15.19$, $p = 0.0017$). Specifically, older adults aged 51 to 70 had a high-risk classification rate of 88.4%, while those with only a primary education were even more at risk, with 89.7% classified as high-risk. Conversely, other demographic factors such as gender ($\chi^2 = 0.04$, $p = 0.8514$) and marital status ($\chi^2 = 2.78$, $p = 0.2486$) show an insignificant correlation to high-risk behaviors in this study. These findings support Kulanthayan et al. (2004) [10], who observed that educational attainment is a significant predictor of compliance.

Behaviorally, this group may experience lower perceived behavioral control and lack exposure to risk education, suggesting the need for tailored interventions. This aligns with TPB theory, where demographic variables influence beliefs and perceived ease of adopting safe behaviors.

Table 6 Top 10 Highest-Risk Demographic Combinations

Age Group	Education	Mean Safety Score	Group Size	Percent High Risk
31-40	Primary	0	6	100
51-70	Primary	0	2	100
51-70	Secondary	2.5	16	93.75
41-50	Primary	3.3	12	91.67
31-40	Secondary	5.7	35	91.43
51-70	Bachelor	10	22	86.36
41-50	Doctoral	16	10	80
41-50	Secondary	10.7	30	80
18-30	Secondary	12.2	23	78.26
18-30	Primary	11.1	9	77.78

3.6 Intervention Effectiveness Project

Different intervention strategies to improve seat belt usage over the short-term for one year and long-term periods for ten years were investigated. The six strategies, control (no intervention), education alone, camera setup, enforcement only, combined education with enforcement, and education with camera setup, were tested. Table 7 display Simulation Model Assumptions.

3.7 Cost-Benefit Components

The approximate costs of each intervention within the model are based on typical road safety literature [25] [26] [27], international (e.g., WHO and World Bank) reports [1] [28]. Each cost component was determined, and what it represents:

1. Control
    - No intervention, so all costs are $0.
2. Education Campaigns
    - Initial cost: $50,000 per 100,000 drivers (covers campaign design, materials, media, and staff training)
    - Annual cost: $30,000 (ongoing outreach, school programs, refresher campaigns)
    - Maintenance: $5,000 (updating materials, retraining staff)
    - These figures are in line with WHO and World Bank estimates for public health and road safety campaigns in urban areas [1].
3. Camera Setup
    - Initial cost: $200,000 per 100,000 drivers (purchase and installation of automated enforcement cameras, IT infrastructure)
    - Annual cost: $50,000 (data management, monitoring staff)
    - Maintenance: $30,000 (camera servicing, software updates)
    - These numbers are based on published costs for red-light and speed camera programs in urban cities like Barcelona, and London, adjusted for scale per 100000 drivers [29] [30].
4.Enforcement Only
    - Initial cost: $150,000 per 100,000 drivers (recruitment, training, and equipment for additional traffic police)
    - Annual cost: $100,000 (salaries, patrol vehicles, fuel, administrative overhead)
    - Maintenance: $20,000 (equipment, uniforms, ongoing training)
5. Combined Education with Enforcement
    - Initial cost: $180,000 (reflects some cost savings from shared resources)
    - Annual cost: $120,000
    - Maintenance: $25,000
    - This combines the above, with a discount for overlapping activities (e.g., joint training, shared outreach).
6. Combined Education with Camera
    - Initial cost: $230,000
    - Annual cost: $70,000
    - Maintenance: $35,000
    - This combines education and camera setup, with some efficiency savings.

Table 7 Simulation Model Assumptions

Parameter	Value / Assumption	Data Source
Baseline driver seat belt compliance	35.2% (drivers), 16% (front passengers), 3.8% (rear passengers)	Field Survey
Baseline mobile phone use while driving	92% overall usage rate	Field Survey
Response factor for university-educated drivers	1.3 (higher intervention sensitivity)	Derived from behavioral segmentation
Response factor for school-educated drivers	0.8 (lower intervention sensitivity)	Derived from behavioral segmentation
Seat belt fatality risk reduction	45–50%	WHO (2023)
Annual inflation rate	3%	World Bank Estimates
Population education shift	+2% annual increase in university-educated group	Iraq Central Statistical Office (2023)
Accident cost per 100,000 drivers	$35 million per year	WHO & Bishai & Hyder (2006) [26]
ROI calculation formula	ROI = (Total Benefit – Total Cost) / Total Cost × 100%	Standard economic evaluation

These costs are considered an approximate estimation to represent costs in Baghdad for simulation modeling purposes. A summary of the cost structure used in the model is shown in Table 8. In the 10-year model, these costs are adjusted for the inflation rate and are per 100,000 drivers.

3.8 Short Term Analysis

The simulation model was developed to evaluate the effectiveness and economic effects of various seat belt compliance interventions in Baghdad. The model includes demographic segmentation by level of education, with those having university education (representing 28% of the population) assuming a baseline compliance level of 28% and a higher response factor of 1.3 (more responsive to interventions) to interventions. Concerning those with schooling education only (representing 72% of the population), they show a lower baseline compliance level of 7% and a lower response factor of 0.8 (less responsive to interventions) as depicted in Figure 4.

Table 8 Model Cost Structure

Intervention	Initial Cost per 100000 drivers	Annual Cost 100000 drivers	Maintenance Cost 100000 drivers
Control	$0	$0	$0
Education	$50,000	$30,000	$5,000
Camera Setup	$200,000	$50,000	$30,000
Enforcement Only	$150,000	$100,000	$20,000
Education with Enforcement	$180,000	$120,000	$25,000
Education with Camera	$230,000	$70,000	$35,000

One year analysis shows that education + enforcement strategy attain the highest compliance rate at 19.9%, followed by education + camera at 18.0%and camera setup at 17.8%. The control group maintains a relatively stable compliance rate of 11.7%, indicating the requirement for active intervention.

Cost-benefit analysis displays adequate returns on investment for all strategies, which shows the highest ROI with education despite the lowest full compliance rates at 69,941%. This high ROI is attributed to a relatively low implementation cost ($ 50,000) compared to significant benefits in the prevention of accidents ($ 35 million). Education + enforcement strategy, high early investment ($ 180,000) requires, produces the largest net benefit of approximately $ 41.3 million, which demonstrates its better effectiveness in preventing accidents and related costs as illustrated in Figure 4.

3.9 Long Term Analysis

The ten-year simulation model includes additional factors such as demographic changes, inflation rate, and long-term maintenance costs for each intervention. The model reflects the 2% annual increase in the university-educated ratio of the population and the same reduction in the school-educated section, which reflects gradual social changes. Cost calculations include initial setup costs, annual operational expenditure, and maintenance requirements; all 3% have been adjusted for annual inflation.

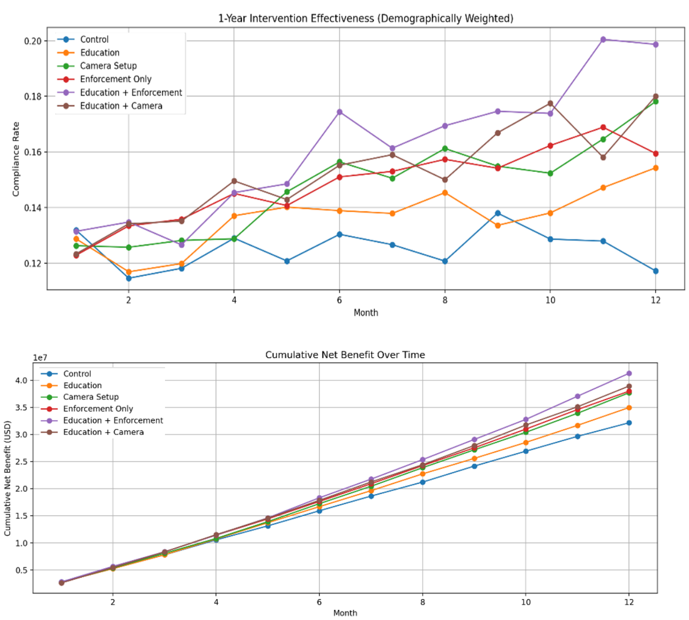


Figure 4 Intervention Effectiveness Project for One Year

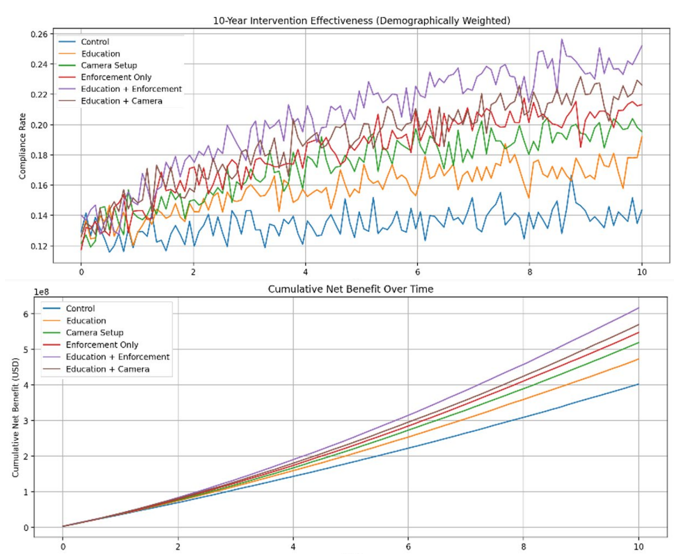
After ten years, the combined education with enforcement strategy maintains its superiority, receives a 25.2% compliance rate, followed by education + camera at 22.6% and enforcement at only 21.3%. The control strategy shows minimum improvement, reaching only 14.4%. The average annual growth in compliance ranges from 0.1% (control) to 1.1% (education + enforcement), which demonstrates the continuous impact of intervention over time. Long-term cost-benefit analysis reveals sufficient cumulative benefits in all strategies. The education shows the highest ROI at 113,694.8% with a total benefit of $ 473.7 million against the cost of $ 416,236. Combined education with enforcement strategy produces a net profit of $ 616.8 million and ROI of 36,343%, producing the biggest full profit of $ 618.5 million as shown in Figure 5.

The results of the model show that while all interventions are economically appropriate, the combined strategies are the most effective approach to improving seat belt compliance, especially education with enforcement. Analysis suggests that the initial investment costs are recovered within the first year, and even when there is accounting for inflation and maintenance costs, benefits are accumulated over ten years. Demographic division reveals the importance of designing interventions for individual population sections, while long-term analysis highlights the continuous impact of systematic intervention strategies on public safety results.

These findings provide strong support for implementing wide seat belt compliance programs, especially those that combine educational and enforcement components. The model suggests that such programs can achieve significant improvements in compliance rates by generating adequate economic benefits through low accident costs and can improve public safety results.

The study showed critically low rate of seat belt compliance among Baghdad drivers and passengers, with 35% for drivers, 16% for front-seat, and less than 4% for back-seat passengers. Mobile phone usage while driving was alarmingly commonly, with 92% of drivers inform using for important call or emergencies. These results align with previous research in Baghdad and Middle east region, that also reported low compliance rate and high mobile phone use [3] [4]. the observed significant effect for education level on compliance consistent with the studies that proved education as a primary factor for determining safety behaviors [10, 16].

High risk group specified in the study partially ager 31 to 70 years with school education, clarify the urgent need for targeted interventions. older age with less education shows significant indicator of risky behavior, on the other hand gender and marital status reveal no meaningful effect. understanding these demographic differences permit to design imitative policies to achieve maximum impact and efficiency of resources.



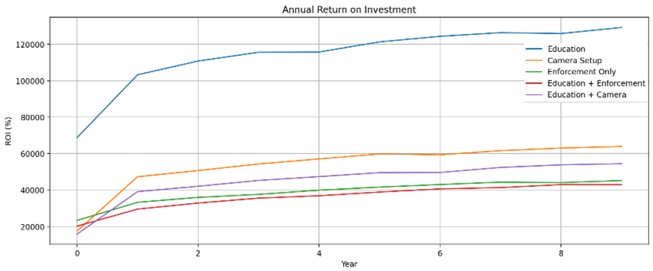


Figure 5 Intervention Effectiveness Project for ten years

Simulation modeling of intervention strategies has shown that combined education and enforcement interventions yielded the highest improvements in seat belt compliance for both short (one year) term and long-term strategy (ten years). This effective result is likely presented because education encourage drivers to change their behaviors and awareness, while enforcement make them aware to accountability and consequences to break traffic regulations. However, education only strategy result in lower raise in compliance, but it is the more cost-effective one due to lower implementation costs, providing a practical solution at limited resources.

The relative stable compliance rate under control scenario (with no intervention) reveals that voluntary behavior change alone is insufficient. Results of this study confirm that sustainable, systematic intervention and combined strategies like education, enforcement, and technology-based approaches, such as automated cameras, could improve traffic regulation compliance. these results have been proven in different environments [12, 13]. These results confirm Goel et al. (2024) [17], who emphasized that multi-component interventions, especially those combining enforcement and education, are the most effective in LMICs. Moreover, the long-term ROI and demographic responsiveness to education suggest that social norms and perceived behavioral control can be gradually shifted over time—a critical insight from TPB.

3.10 Limitations

There are some limitations in this study to consider. Limitations include the cross-sectional design, self-reported data which may cause response bias and restrict causal inference also lack of observational data. The simulation model relies on inputs of intervention effectiveness taken from literature due to lack information in Bagdad Context, these results could not be reflective of real situation of implementation in a specific setting. The sample, while of reasonable size and various in demographics backgrounds, may not completely represent all Baghdad drivers.

Further studies should adopt a longitudinal design to investigate real changes of behaviors after the intervention and to integrate observational data that confirm reported compliance. Broadening the consideration of cultural and attitudinal barriers would strengthen the interventions for further development. Moreover, given its wide availability, there is a need for specific investigations on mitigation techniques feasible to be implemented for both emergency and routine mobile phone use.

In summary, the need of comprehensive education and enforcement combined programs to increase the seat belt compliance and decrease use mobile phone use while driving in Baghdad and longitudinal study. Targeted, high-risk demographically specific interventions, along with ongoing surveillance and adaptation, will be crucial to the progress of road safety and reduction in traffic related injury and death in urban environments.

4.0 CONCLUSIONS AND RECOMMENDATIONS

This study highlights a critical public safety concern in Baghdad, where seat belt compliance remains exceptionally low—only 35% among drivers, 16% for front-seat passengers, and less than 4% for rear-seat passengers—while mobile phone use while driving is highly prevalent at 92%. Educational level emerged as a significant predictor of compliance, with university graduates over twice as likely to adhere to safety behaviors compared to those with lower education. These findings are consistent with regional patterns and global data but underscore the unique challenges in the Baghdad context.

The simulation results demonstrate that combined interventions—specifically education with enforcement—yield the greatest improvements in seat belt compliance in both the short- and long-term. Education-only strategies, while less effective in behavioral change, proved to be highly cost-effective due to their low implementation costs. These outcomes provide strong evidence that multi-pronged approaches are the most sustainable and scalable solution for urban settings like Baghdad.

4.1 Policy Recommendations Specific to Baghdad

Targeted Education Campaigns: Develop low-cost, mass-media, and community-based campaigns focused on older drivers with low educational attainment, identified as the highest-risk group. Messages should be culturally sensitive and emphasize personal and family safety, not just legal compliance.

4.2 Integration into Licensing & School Programs

Embed road safety education into driver licensing procedures and secondary school curricula, leveraging Baghdad's centralized education system to institutionalize safety awareness early.

4.3 Technology-Assisted Enforcement

Pilot the deployment of automated seat belt and phone-use detection cameras in high-traffic areas. Use existing traffic infrastructure and stagger implementation in coordination with law enforcement to ensure feasibility in Baghdad's budget-constrained and politically dynamic environment.

4.4 Community-Based Monitoring & Incentives

Partner with local organizations, taxi unions, and ride-hailing services to introduce community-led compliance reporting and non-financial incentives (e.g., public recognition, fuel discounts) to promote safer driving norms.

4.5 Gradual Scaling & ROI Tracking

Begin with pilot interventions in high-risk districts (e.g., areas with high accident density), and monitor ROI and compliance shifts annually. This adaptive model allows for policy adjustments based on real-time evidence and resource availability

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Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper

References

[1] World Health Organization (WHO). 2023. *Road Safety. [Online]. Available: https://www.who.int/health-topics/road-safety* Retrieved on 25 December, 2023

[2] Praveen, B., Ramesh, A., & Kumar, M. 2021. Drivers Perspective on Wearing Seat Belt and Use of Mobile Phone While Driving in Metropolitan City. In Advances in Civil Engineering: *Select Proceedings of ARICE 2019. Springer Singapore. 413–426.*

[3] Abduljabbar, A. S. 2022. Assessment of Drivers and Passengers Seat Belt Compliances in Baghdad City. *Jurnal Kejuruteraan.* 34(5): 935–940.

[4] Mahfoud, Z. R., Cheema, S., Alrouh, H., Al-Thani, M. H., Al-Thani, A. A. M., & Mamtani, R. 2015. Seat belt and mobile phone use among vehicle drivers in the city of Doha, Qatar: an observational study. *BMC Public Health.* 15: 937.

[5] McCartt, A. T., Hellinga, L. A., & Bratiman, K. A. 2006. Cell phones and driving: review of research. *Traffic Injury Prevention. 7(2): 89–106.* DOI: 10.1080/15389580500465273

[6] S., Ansari-Moghaddam, A., & Ansari, H. 2023. The prevalence of seat belt use among drivers and passengers: a systematic review and meta-analysis. *Journal of the Egyptian Public Health Association.* 98(1): 14.

[7] Densu, S. N., & Salifu, M. 2013. Attitudes Towards Seatbelts Use in Kumasi, Ghana. *International Journal of Structural and Civil Engineering Research.* 2(1): 82–94.

[8] Begg, D. J., & Langley, J. D. 2000. Seat-belt use and related behaviors among young adults. *Journal of Safety Research.* 31(4): 211–220.

[9] Shaaban, K. 2012. Young Drivers' Attitude Regarding Seat Belt Use in Qatar. *International Conference on Civil, Electrical and Electronics Engineering (ICCEEE'2012). December 21–22, Bangkok, Thailand.*

[10] Kulanthayan, S., Raha, A. R., Law, T. H., & Radin Umar, R. S. 2004. Seat Belt Use Among Car Users in Malaysia. *IATSS Research. 2*8(1): 19–25.

[11] Mohammadi, G. 2009. Mobile phone and seat belt usage and its impact on road accident fatalities and injuries in southeast Iran. *International Journal of Crashworthiness.* 14(4): 309–314.

[12] Alghnam, S., Towhari, J., Alkelya, M., Binahmad, A., & Bell, T. M. 2018. The effectiveness of introducing detection cameras on compliance with mobile phone and seatbelt laws: a before-after study among drivers in Riyadh, Saudi Arabia. *Injury Epidemiology.* 5(1): 1–6.

[13] Ebert, J. P., Yan, R., Friday, S., Small, D., McDonald, C. C., Bartolozzi, K., & Delgado, M. K. 2025. Behavioral Interventions for Increasing Seat Belt Use and Decreasing Distracted Driving Using Telematics: A National Randomized Trial. *American Journal of Public Health.* 115(5): 758–768.

[14] imsekoglu, Ö., & Lajunen, T. 2009. Relationship of seat belt use to health and driver behaviors. *Transportation Research Part F: Traffic Psychology and Behaviour.* 12(3): 235–241.

[15] Kweon, Y. J., & Kockelman, K. M. 2006. Driver attitudes and choices: speed limits, seat belt use, and drinking-and-driving. *Journal of the Transportation Research Forum.* 45(3): 39–56.

[16] Jiménez-Mejías, E., Prieto, C. A., Martínez-Ruiz, V., del Castillo, J. D. D. L., Lardelli-Claret, P., & Jiménez-Moleón, J. J. 2014. Gender-related differences in distances travelled, driving behaviour and traffic accidents among university students. *Transportation Research Part F: Traffic Psychology and Behaviour.* 27: 81–89.

[17] Goel, R., Tiwari, G., Varghese, M., Bhalla, K., Agrawal, G., Saini, G., ... & Mohan, D. 2024. Effectiveness of road safety interventions: An evidence and gap map. *Campbell Systematic Reviews.* 20(1): e1367.

[18] Somoray, K., White, K. M., Watson, B., & Lewis, I. 2024. Predicting risky driving behaviours using the theory of planned behaviour: A meta-analysis. *Accident Analysis & Prevention,* 208: 107797.

[19] Eijigu, T. D. (2021). Mobile phone use intention while driving among public service vehicle drivers: Magnitude and its social and cognitive determinants. *PLoS one,* 16(4): e0251007.

[20] Keffane, S. 2021. Theory of planned behavior as a model of limit mobile phone use while driving. *Advanced in Educational and Technology and Psychology, 5: 6-12.*

[21] Iraqi Ministry of Planning, 2023. *Central Statistical Organization.* [Online]. Available: http://cosit.gov.iq/en/home Retrieved on 27 December, 2023

[22] World Health Organization. 2013. *Strengthening road safety legislation: a practice and resource manual for countries.* World Health Organization.

[23] McEvoy, S. P., Stevenson, M. R., McCartt, A. T., Woodward, M., Haworth, C., Palamara, P., & Cercarelli, R. 2005. Role of mobile phones in motor vehicle crashes resulting in hospital attendance: a case-crossover study. *BMJ (Clinical research ed.),* 331(7514): 428. DOI: https://doi.org/10.1136/bmj.38537.397512.55

[24] Grdinić-Rakonjac, M., Antić, B., Pešić, D., & Pajković, V. 2021. Construction of road safety composite indicator using grey relational analysis. *Promet-Traffic&Transportation, 33(1): 103-116.*

[25] Harris, G. T., & Olukoga, I. A. 2005. A cost benefit analysis of an enhanced seat belt enforcement program in South Africa. *Injury Prevention.* 11(2): 102–105.

[26] Bishai, D. M., & Hyder, A. A. 2006. Modeling the cost effectiveness of injury interventions in lower- and middle-income countries: opportunities and challenges. *Cost Effectiveness and Resource Allocation.* 4: 1–11.

[27] World Health Organization (WHO). 2018. *Global status report on road safety 2018.* Geneva: World Health Organization.

[28] Mendivil, J., García-Altés, A., Pérez, C., Marí-Dell'Olmo, M., & Tobias, A. 2011. Speed cameras in an urban setting: A cost-benefit analysis. *Injury Prevention.* 18(2): 75–80.

[29] Hooke, A., Knox, J., & Portas, D. 1996. *Cost benefit analysis of traffic light & speed cameras. London, UK: Home Office,* Police Research Group.

[30] Simsekoglu, Ö., & Lajunen, T. 2009. Relationship of seat belt use to health and driver behaviors. *Transportation Research Part F: Traffic Psychology and Behaviour.* 12(3): 235–241.