Turk J Public Health
Available online at: http://dergipark.org.tr/tjph/
doi:10.20518/tjph.814830

ORIGINAL ARTICLE / ORİJİNAL MAKALE

The investigation of Turkey's road safety decisions by Haddon Matrix and 7Es

Türkiye'deki yol güvenliği kararlarının Haddon Matrisi ve 7Es ile incelenmesi

İbrahim Öztürk[a], Pınar Bıçaksız[b], Yeşim Üzümcüoğlu[c], Türker Özkan[d]

[a] PhD Student, Department of Psychology, Middle East Technical University, Ankara, Turkey.
[b] Assist. Prof., Department of Psychology, Hacettepe University, Ankara, Turkey.
[c] Assist. Prof., Department of Psychology, TOBB University of Economics and Technology, Ankara, Turkey.
[d] Prof. Dr., Department of Psychology, Middle East Technical University, Ankara, Turkey.

Received: 22.10.2020, Accepted: 08.08.2021

ABSTRACT

Objective: Road traffic crashes are one of the crucial public health problems in Turkey and all over the world. Various human, vehicle, and environment factors have been associated with road traffic crashes and different policies, strategies, and interventions have been applied to decrease adverse outcomes such as deaths. Strategies adopted and applied by authorities play a crucial role in road safety. **Methods:** In the present study, the road safety decisions taken by the Road Traffic Safety Province Coordination Board of each of the 81 provinces of Turkey were analysed by using two frameworks, the Haddon Matrix and Es of road safety. **Results:** The classification procedure resulted in 8840 decisions in different cities and 652 unique decisions across Turkey. These decisions were classified based on the Haddon Matrix and Es of road safety. The majority of the decisions focused on the pre-crash phase and education, enforcement, engineering and evaluation activities. **Conclusion:** In line with the strategic decisions, practical implications were discussed, and suggestions have been introduced for the future of road safety. The study provides both methodological and practical implications for road safety research and agenda. It is believed that the use of the Haddon Matrix and 7Es of road safety for policy development will result in significant improvements in public health interventions.

Keywords: Road safety decision, policy analysis, Haddon Matrix, policy development, public health

Correspondence: İbrahim ÖZTÜRK, PhD Student, Department of Psychology, Middle East Technical University, Ankara, Turkey. **E-mail:** ozturki@metu.edu.tr. **Tel:** +90 507 999 70 62.
Cite This Article: Öztürk İ, Bıçaksız P, Üzümcüoğlu Y, Özkan T. The investigation of Turkey's road safety decisions by Haddon Matrix and 7Es. Turk J Public Health 2021;19(3):196-210.

ÖZ

Amaç: Karayolu trafik kazaları, Türkiye'de ve tüm dünyada önemli halk sağlığı sorunlarından biridir. Çeşitli insan, araç ve çevre faktörleri karayolu trafik kazaları ile ilişkilendirilmekte ve ölümler gibi olumsuz sonuçları azaltmak amacıyla farklı politikalar, stratejiler ve müdahale programları uygulanmaktadır. Yetkililer tarafından benimsenen ve uygulanan stratejiler karayolu güvenliğinde kritik bir rol oynamaktadır. **Yöntem:** Bu çalışmada, Türkiye'nin 81 ilindeki Karayolu Trafik Güvenliği İl Koordinasyon Kurulları tarafından alınan yol güvenliği kararları, Haddon Matrisi ve yol güvenliği E'leri olmak üzere iki çerçeve kullanılarak analiz edilmiştir. **Bulgular:** Sınıflandırma prosedürü, farklı şehirlerde toplam 8840 kararla ve Türkiye genelinde 652 farklı kararla sonuçlanmıştır. Bu kararlar, Haddon Matrisi ve yol güvenliği E'lerine göre sınıflandırılmıştır. Kararların çoğunluğu kaza öncesi aşama ve eğitim, denetimler, mühendislik ve değerlendirme faaliyetlerine odaklanmıştır. **Sonuç:** Stratejik kararlar doğrultusunda, pratik uygulamalar tartışılmış ve karayolu güvenliğinin geleceği için öneriler sunulmuştur. Mevcut çalışma, karayolu güvenliği araştırmaları ve gündemi için hem yöntemsel hem de pratik çıkarımlar sağlamaktadır. Politika geliştirmede Haddon Matrisi ve yol güvenliği E'lerinin kullanımının halk sağlığı müdahalelerinde önemli iyileştirmelerle sonuçlanacağına inanılmaktadır.

Anahtar kelimeler: Karayolu güvenliği kararları, politika analizi, Haddon Matrisi, politika geliştirme, halk sağlığı

Introduction

Larsson, Dekker and Tingvall defined a road transport system as a complex socio-technical system that includes many elements as road users, vehicle and environment. Moreover, countless interactions between these elements of the system establish a complex system in which safety is a product of these interactions.[1] In this complex system, different factors have been associated with outcomes and goals.[2] For example, Scott-Parker et al. highlighted umpteen factors related to young driver crashes from road users to the social environment. From this point of view, road safety can be discussed from a systems theory point of view.[3] Larsson et al. discussed that, in this socio-technical system, governments are the management level of the organisation which are responsible for strategy and policy development and implementation.[1] Özkan and Lajunen modelled traffic regulations as a part of the origins of macro-level, and these regulations are related to crashes and fatalities.[2] In this context, it is believed to be important to examine the decisions of the top management level. With respect to this, the aim of the present study is to elaborate on the road safety decisions taken by the Road Traffic Safety Province Coordination Board of each of the 81 provinces in Turkey based on previous technical report[4] by using the Haddon Matrix and Es of road safety.

1.1. The Haddon Matrix

The Haddon matrix is a tool for analysing existing information about any public health problem such as road traffic crashes and used to develop future countermeasures.[5-6] It is one of the models for injury prevention and has been used in many public health-related areas such as public health readiness and response planning,[7] floods,[8] children falling on playgrounds[6] and investigation of road traffic crashes and injuries.[5, 9] Moreover, it has also been used as a general perspective of road traffic safety.[10-12]

The Haddon Matrix consists of two dimensions (see Table 1.); phases and factors. Any event or crash is divided into three phases; pre-event, event, and post-event; and four factors, namely human, vehicle/equipment, physical environment and socio-economic environment. For

Table 1. *The Haddon Matrix*[10]

		Factors			
		Human	Vehicle and Equipment	Physical Environment	Socio-Economic Environment
Phases	Pre-Crash				
	Crash				
	Post-Crash				

road traffic crashes, the phases are named as pre-crash, crash, and post-crash.[5,10,13-14] The phases approach a crash as a continuum of an event from preventing a crash to preventing injuries and deaths and sustaining life. The phase structure of the matrix enables the applications of particular interventions to decrease road traffic crashes and outcomes of these crashes at different phases.[8-9,11-12,15]

Human factors represent different groups of road users involved in a crash as drivers, passengers, pedestrians, motorcyclists, bicyclists or others. Vehicle/equipment factors as physical characteristics, movement, and location are the channels or agents of impact. Physical environment factors constitute the setting of a crash. Finally, socio-economic factors are the factors related to the social environment.[10-11]

The matrix provides theoretical knowledge and practical applications by determining the contributory factors that could be used to develop preventive public strategies.[8-12] For example, changes in the vehicle/equipment factors could reduce the risk of a crash or the consequences of a crash by focusing on different phases.[16] Moreover, emergency response is one of the factors affecting the post-crash stage. In the literature review conducted by Üzümcüoğlu et al., it has been found that emergency response can significantly reduce the number of seriously injured people in a road traffic crash.[17] (For an example of a road traffic crash investigation, please see Albertsson et al.[3] and pedestrian injury due to automobiles, please see Barnett et al.[7]).

In addition to being used as an investigation tool for road traffic crashes, the Haddon Matrix could also be used to evaluate the effectiveness of particular national-level agents such as the health department. The public health system could be examined for readiness for certain types of public health problems. The matrix could identify areas that need improvements and serve as a tool for policy and emergency response development.[7] Moreover, Short et al. suggested that interventions related to road traffic crashes should focus on different factors of the Haddon Matrix, and evaluations should be done for each factor. The intervention programs should involve different agents from the community level and national level.[18] In light of these, the Haddon Matrix is used to evaluate road safety decisions in Turkey.

1.2. Es of Road Safety

In addition to determining phases and factors using the Haddon Matrix, it would also be important to identify the scope of road safety decisions and interventions by using Es of road safety. The earliest versions discussed three Es; education, enforcement, and engineering.[19] Groeger classified factors of road safety into 7 Es; education, enforcement, engineering, exposure, examination of competence and fitness, emergency response, and evaluation. According to their definitions from the road safety perspective, *education* aims to transfer knowledge and skills as a means of driver education or public education.[19] The content and structure of road safety educations are also crucial for their effectiveness. It is also stated that even though education does not provide quick results, it is necessary to have a comprehensive road safety policy.[20]

Enforcement, including traditional and electronic traffic controls such as speed or alcohol controls, was evaluated as one of the most critical factors affecting undesired behaviours.[21] *Engineerin*g focuses on vehicle, road, and environment design. Road and environment-related factors such as curvature, infrastructure, and roundabout design are found to be important engineering related factors for road safety.[21] *Exposure* is related to the interaction of road users with traffic (risk) based on certain variables such as time of the day or amount of travel.[19, 22] *Examination of competence and fitness* aims to control competence related structures such as driver license. *Emergency response* focuses on the response after a crash occurred, such as delivering necessary first aid. Finally, the last one is *evaluation* which focuses on reviewing interventions based on outcomes such as decreasing the number of crashes.[19]

1.3. The Aim of the Present Study

In the literature, various studies have used the Haddon Matrix and Es in order the evaluate different aspects of road safety interventions. For example, Bui et al. reviewed the intervention programs towards emergency service vehicle incidents from other sectors. Vehicle and environmental- and policy-related interventions were the leading types of intervention, and driver training and educations were also effective, indicating the importance of different Es of road safety in the post-crash phase.[23] In another study, Scholtes et al. addressed that, out of 27 interventions for road safety targeting children, 17 of them were related to pre-crash, 9 of them were related to crash, and one of them was related to the post-crash phase.[24]

Considering the significance of the Haddon Matrix and Es for road safety, in the current study, the road safety decisions taken by the Road Traffic Safety Province Coordination Board of each province in Turkey were analysed by using the Haddon Matrix and Es of road safety. The Haddon Matrix is used to classify the decisions based on the targeted phase and factor. In addition to that, the decisions were also differentiated based on the method corresponding Es of road safety.[19] In this way, the Haddon Matrix and Es of road safety were used to categorise the road safety decisions of Turkey into factors, phases, and methods.

To the authors' best knowledge, the study is the first study analysing the national road safety decisions by using the Haddon Matrix and Es of road safety. The two methods complement each other both methodologically and contextually. By using these methods, it is expected that researchers and policymakers will be able to evaluate at which stages of a crash (phases of the Haddon Matrix) a decision will intervene in which elements of the traffic (factors of the Haddon Matrix) by using which methods (Es of road safety).

Methods

2.1. Procedure

In the scope of the Road Traffic Safety Strategy and Action Plan, Road Traffic Safety Province Coordination Boards hold regular meetings. The governor chaired the board, which involves different agents such as mayors, administrative chiefs, decision-makers, and non-governmental organisation representatives. Based on the former report[4], the 8840 decisions taken at the meetings from 81 provinces were analysed by using the Haddon Matrix and Es of Road Safety. Before placing the decisions into the Haddon Matrix and Es of road safety, a list of decisions taken in 545 meetings between 2012 and 2015 was prepared. The number of meetings per province ranged between 0 to 22 (M = 6.73, SD = 5.79). Decisions including more than one action plan (such as public education and planning new campaigns) were divided into sub-decisions that include only one action plan (for details, please see the former report[4]). In this way, each decision was organised to fall into only one cell in the Haddon Matrix and contains only one dimension from the road safety Es.

A total of 8840 decisions and 654 different decisions were determined. In the results sections, first, the distributions of the total number of decisions were presented. Secondly, 654 different decisions were determined by removing repeated decisions

from the 8840 decisions. Two decisions were excluded from the further classifications because of not being directly related to road safety, such as protecting catchment basins. After the final forms of decisions were set (8840 total and 652 different decisions), each decision was associated with one factor and one phase of the Haddon Matrix and one E of road safety. For example, traffic training for drivers and pedestrians concerns only the pre-crash phase and human factors in the Haddon Matrix and education in Es of road safety. The distributions of the decisions were discussed concerning the combined version of the Haddon Matrix and 7Es of road safety at the country level. All examination and distribution of decisions were carried out by authors separately.[4]

Then, group discussion sessions were held to reach a consensus on the classifications of the itemised decisions (for sample decisions for each classification, please see Table 2).

The majority of the researchers (at least three out of four votes) have sought a consensus on the final forms of each item and classification of decisions.Moreover, examples of decisions based on Es of road safety could be listed as followed:

- Education: "traffic education for public transportation drivers".
- Enforcement: "speed controls".
- Engineering: "road maintenance".
- Exposure: "regulation of certain groups such as truck in city traffic".
- Examination of competence and fitness: "education of driver educators and examiners".
- Emergency response: "establishing first-aid centres in institutions".
- Evaluation: "preparation and follow-up of road safety action plans".

Results

3.1. The Distributions of Total Number of Decisions

3.1.1. Total Decisions based on the Haddon Matrix

In this section, the distributions of 8840 decisions were presented based on the Haddon Matrix (see Table 3).

Table 2. *Sample Decisions based on the Haddon Matrix*

	Human Factors	**Vehicle/Equipment Factors**	**Physical Environment Factors**	**Socio-Economic Environment Factors**
Pre-Crash Phase	General traffic educations, speed and alcohol control	Control of school services and tires	Road and roadway elements' maintenance	Regular meetings and workshops
Crash Phase	Seat belt and helmet use	Control of seat belt and child-restraints	Safety rails and barriers	Seat belt at official cars, Seat belt and helmet projects
Post-Crash Phase	First-aid educations	Increasing numbers of ambulances and control of ambulances	Control of emergency roads and meeting places	Sub-commissions about ambulance services

Table 3. *Distribution of Total Decisions on the Haddon Matrix*

		Factors				
		Human	Vehicle and Equipment	Physical Environment	Socio-Economic Environment	*Total*
Phases	Pre-Crash	2545	646	2539	2135	7865
	Crash	404	36	29	60	529
	Post-Crash	167	14	88	177	446
	Total	3116	696	2656	2372	8840

The 8840 decisions were divided into the factors of the Haddon Matrix as 3116 to human factors (35.25%), 696 to vehicle/equipment factors (7.87%), 2656 to physical environment factors (30.05%) and 2372 to socio-economic environment factors (26.83%). In terms of the Haddon Matrix's phases, out of 8840 decisions, 7865 of them (88.97%) were related to the pre-crash phase, 529 of them (5.98%) were related to the crash phase, and 446 of them (5.05%) were associated with the post-crash phase.

Finally, 8840 decisions distributed into the cells of Haddon Matrix as 2545 (28.79%) human/pre-crash, 404 (4.57%) human/crash, 167 (1.89%) human/post-crash 646 (7.31%) vehicle-equipment/pre-crash, 36 (0.41%) vehicle-equipment/crash, 14 (0.16%) vehicle-equipment/post-crash, 2539 (28.72%) physical environment/pre-crash, 29 (0.33%) physical environment/crash, 88 (1.00%) physical environment/post-crash, 2135 (24.15%) socio-economic/pre-crash, 60 (0.68%) socio-economic/crash, and 177 (2%) socio-economic/post-crash decisions.

3.1.2. The Distributions of Total Decisions based on the Es of Road Safety

A total of 8840 road safety decisions were classified based on the Es of road safety. The distribution showed that, 1941 decisions (21.96%) for education, 2313 decisions (26.17%) for enforcement, 2204 decisions (24.93%) for engineering, 127 decisions (1.44%) for exposure, 131 decisions (1.48%) for examination of competence and fitness, 193 decisions (2.18%) for emergency response, and finally 1931 decisions (21.84%) for evaluation were identified (see Figure 1).

3.2. The Distribution of Different Decisions

The distribution of 652 decisions over the Haddon Matrix and Es of road safety were presented in Table 4.

3.2.1. The Distributions based on the Haddon Matrix

The 652 different decisions were differentiated into the cells of the Haddon Matrix (see Table 5).

Total 652 decisions included 165 human factors (25.31%), 69 vehicle/equipment factors (10.58%), 189 physical environment factors (28.99%) and 229 socio-economic environment factors (35.12%) decisions. Moreover, the decisions were distributed into the phases as followed, 586 for pre-crash (89.88%), 17 for crash (2.61%) and 49 for post-crash (7.51%) phases.

Out of 165 human factors decisions, 143 decisions (86.67%) were related to pre-crash, eight decisions (4.85%) were related to crash, and 14 decisions (8.48%) were related to post-crash phases.

Out of 69 vehicle and equipment factors, 58 pre-crash (84.06%), two crash (2.9%) phase, and nine post-crash (13.04%) phases were found. Out of 189 physical environment decisions, 181 decisions to pre-crash (95.76%), one decision to crash (0.53%), and seven decisions to post-crash (3.70%) phases were determined. Two hundred twenty-nine socio-economic environment decisions were categorised as 204 decisions to pre-crash (89.08%), six decisions to crash (3.17%), and 19 decisions to post-crash (10.05%) phases.

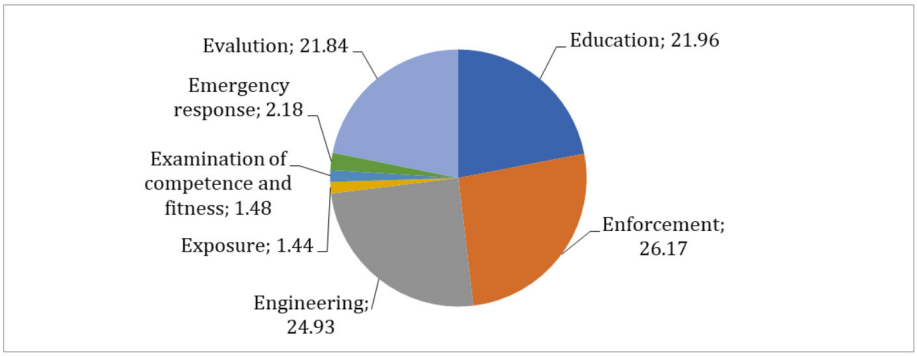

Figure 1. Es Distribution of Road Safety Decisions in Turkey (as percentages)

Table 4. *Distribution of Different Decisions on the Haddon Matrix and Es of the Road Safety*

	Human			Vehicle and Equipment			Physical Environment			Socio-Economic Environment		
	Pre-Crash	Crash	Post-Crash	Pre-Crash	Crash	Post-Crash	Pre-Crash	Crash	Post-Crash	Pre-Crash	Crash	Post-Crash
E1	76	3	10	3	0	0	6	0	0	22	2	0
E2	47	2	0	42	2	1	17	0	0	37	1	1
E3	3	0	0	10	0	0	129	1	3	1	0	0
E4	8	0	0	1	0	0	9	0	0	9	0	0
E5	5	0	0	0	0	0	0	0	0	6	0	1
E6	0	0	3	0	0	8	0	0	3	2	0	12
E7	4	3	1	2	0	0	20	0	1	127	3	5
Total	143	8	14	58	2	9	181	1	7	204	6	19

Note: E1: Education, E2: Enforcement, E3: Engineering, E4: Exposure, E5: Examination of competence and fitness, E6: Emergency response, E7: Evaluation

Table 5. *Distribution of Different Decisions on the Haddon Matrix*

		Factors				
		Human	Vehicle and Equipment	Physical Environment	Socio-Economic Environment	*Total*
Phases	Pre-Crash	143	58	181	204	586
	Crash	8	2	1	6	17
	Post-Crash	14	9	7	19	49
	Total	165	69	189	229	652

3.2.2. The Distributions based on the Es of Road Safety

Each different road safety decision was classified based on the Es of road safety. The distribution showed that, 122 decisions (18.71%) for education, 150 decisions (23.01%) for enforcement, 147 decisions (22.55%) for engineering, 27 decisions (4.14%) for exposure, 12 decisions (1.84%) for examination of competence and fitness, 28 decisions (4.29%) for emergency response, and finally 166 decisions (25.46%) for evaluation were identified (see Figure 2).

3.2.3. The Distributions based on the Haddon Matrix Factors and Es of Road Safety

In the following section, the distribution of decisions over the factors of the Haddon matrix and Es of road safety were investigated (see Table 6). In terms of the classification of 165 human factors related decisions based on 7Es of road safety, 89 decisions for education (53.94%), 49 decisions for enforcement (29.7%), three decisions for engineering (1.82%), eight decisions for exposure (4.85%), five decisions for examination of competence and fitness (3.03%), three decisions for emergency response (1.82%), and eight decisions for evaluation (4.85%) were identified. In terms of the classification of vehicle/equipment factors related decisions based on 7Es of road safety, three decisions for education (4.35%), 45 decisions for enforcement (65.22%), ten decisions for engineering (14.49%), one decision for exposure (1.45%), no decision for examination of competence and fitness, eight decisions for emergency response (11.59%), and two decisions for evaluation (2.9%) were determined.

In terms of the classification of physical environment factors related decisions based on 7Es of road safety, six decisions for education (3.17%), 17 decisions for enforcement (8.99%), 133 decisions for engineering (70.37%), nine decisions for exposure (4.76%), no decision for examination of competence and fitness, three decisions for emergency response

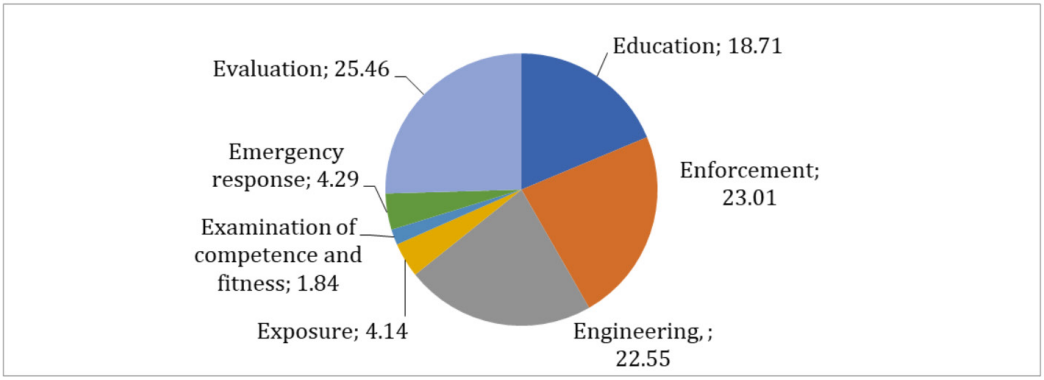

Figure 2. Es Distribution of Road Safety Decisions in Turkey (as percentages)

Table 6. *Distribution of Different Decisions on the Haddon Matrix Factors and Es of Road Safety*

Factors of the Haddon Matrix						
		Human	Vehicle and Equipment	Physical Environment	Socio-Economic Environment	*Total*
Es of Road Safety	Education	89	3	6	24	122
	Enforcement	49	45	17	39	150
	Engineering	3	10	133	1	147
	Exposure	8	1	9	9	27
	Examination of competence and fitness	5	0	0	7	12
	Emergency response	3	8	3	14	28
	Evaluation	8	2	21	135	166
	Total	165	69	189	229	652

(1.59%), and 21 decisions for evaluation (11.11%) were established. In terms of the classification of socio-economic environment factors related decisions based on 7es of road safety, 229 decisions were grouped as followed: 24 decisions to education (10.48%), 39 decisions to enforcement (17.03%), one decision to engineering (0.44%), nine decisions to exposure (3.93%), seven decisions to examination of competence and fitness (3.06%), 14 decisions to emergency response (6.11%), and 135 decisions to evaluation (58.95%).

A total of 122 decisions were determined as being related to education and distributed as followed; 89 decisions for human factors (72.95%), three decisions for vehicle/equipment factors (2.46%), six decisions for physical environment factors (4.92%), and 24 decisions for socio-economic environment factors (19.67%). For enforcement, 150 decisions were determined and distributed as followed; 49 decisions for human factors (32.67%), 45 decisions for vehicle/equipment factors (30%), 17 decisions for physical environment factors (11.33%), and 39 decisions for socio-economic environment factors (26%). For engineering, 147 decisions were determined, and three decisions for human factors (2.04%), ten decisions for vehicle/equipment factors (6.8%), 133 decisions for physical environment factors (90.48%), and one decision for socio-economic environment factors (0.68%) were found.

Out of 27 decisions for exposure, eight decisions for human factors (29.63%), one decision for vehicle/equipment factors (3.7%), nine decisions for physical environment factors (33.33%), and nine

decisions for socio-economic environment factors (33.33%) were determined. For examination of competence and fitness, 12 decisions were determined and distributed: five decisions for human factors (41.67%), and seven decisions for socio-economic environment factors (58.33%). A total of 28 decisions were determined for emergency response and differentiated as three decisions for human factors (10.71%), eight decisions for vehicle/equipment factors (28.57%), three decisions for physical environment factors (10.71%), and 14 decisions for socio-economic environment factors (50%). For evaluation, 166 decisions were determined and distributed as followed; eight decisions for human factors (4.82%), two decisions for vehicle/equipment factors (1.2%), 21 for physical environment factors (12.65%), and 135 for socio-economic environment factors (81.32%).

engineering decisions were classified as 143 pre-crash (97.28%), one crash (0.68%) and three post-crash (2.04%) decisions.

All of the 27 exposure-related decisions were associated with pre-crash phase (100%). Out of 12 examinations of competence and fitness decisions, 11 decisions for pre-crash (91.67%) and one decision for post-crash (8.33%) phases were determined. The 28 emergency response decisions were differentiated as two pre-crash (7.14%) and 26 post-crash (92.86%) phases. Finally, 153 pre-crash (92.17%), six crash (3.61%) and seven post-crash (4.22%) decisions composed 166 evaluation related decisions.

Discussion

Hughes et al. suggested that using a framework based on the policy tools and components of road safety strategies is useful for developing and evaluating road safety strategies.[25] In light of this, the present study investigates the content of national road safety decisions in Turkey based on the Haddon Matrix and 7Es of road safety. For this reason, each road safety decision taken by the Road Traffic Safety Province Coordination Boards was systematically analysed and placed into related dimensions of the Haddon Matrix and Es of road safety.

Table 7*. Distribution of Different Decisions based on the Haddon Matrix Phases and Es of Road Safety*

		Phases of the Haddon Matrix			
		Pre-Crash	Crash	Post-Crash	*Total*
Es of Road Safety	Education	107	5	10	122
	Enforcement	143	5	2	150
	Engineering	143	1	3	147
	Exposure	27	0	0	27
	Examination of competence and fitness	11	0	1	12
	Emergency response	2	0	26	28
	Evaluation	153	6	7	166
	Total	586	17	49	652

3.2.4. The Distributions based on the Haddon Matrix Phases and Es of Road Safety

Finally, the distribution of Es of road safety on the phases of the Haddon Matrix was examined (see Table 7). The 122 education-related decisions were distributed into phases as 107 decision for pre-crash (87.70%), five decisions for crash (4.1%) and ten decisions for post-crash (8.2%) phases. A total of 150 enforcement-related decisions were differentiated as 143 pre-crash (95.33%), five crash (3.33%) and two post-crash (1.33%) decisions. The 147

The distribution of the total number of decisions and different decisions in terms of factors of the Haddon Matrix showed that human, physical environment, and socio-

economic environment factors correspond to 25-35% of decisions in the meetings. Similar to the variety in the characteristics of road traffic crashes[11-12], there was a wide range of decisions across different factors. Even though the majority of the decisions were related to human factors in total decisions (35%), the highest diversity for different decisions was found to be socio-economic environment factors (35%). Considering the variety in the decisions and differences in the number of meetings between provinces proven in the previous report[4], it could be discussed that, even within a country, regions may have different priorities regarding road safety.

According to the energy-damage phenomena, as discussed by Haddon, the essential point of developing effective countermeasures is not only decreasing the number of crashes by focusing on just causes but also reducing the results such as deaths and injuries by identifying all factors through the crash process.[10,13] In the scope of road safety, the focus of effective countermeasures should be both preventing crashes from occurring and decreasing the number of deaths and injuries in the event of a crash. The results of the study showed that approximately 90% of all total or different decisions taken for road safety focuses on the pre-crash phase, where the main focus is to prevent crashes from occurring. The cells of the Haddon Matrix show that majority of the road safety decisions taken in Turkey were related to pre-crash phase, human, physical environment, and socio-economic environment factors. Additionally, education, enforcement, engineering, and evaluation were the most varied Es. That could be interpreted as the main focus in Turkey is preventing crashes from occurring through different Es. With respect to the distribution of decisions, it could also be discussed that there could be a need for interventions in the crash and post-crash phases, such as public first-aid interventions involving different Es of road safety.

Haddon explained road traffic crashes as an energy exchange and also proposed ten main countermeasure strategies that could be used to decrease loss after a crash. It is also suggested that any intervention regarding road safety will reflect these strategies. These strategies are "*1) preventing the initial marshalling of the form of energy, 2) reducing the amount of energy marshalled, 3) preventing the release of the energy, 4) modifying the rate of spatial distribution of release of the energy from its source, 5) separating in time or space the energy being released from the susceptible structure, 6) separating the energy being released from the susceptible structure by interposition of a material barrier, 7) modifying the contact surface, subsurface or basic structure which can be impacted, 8) strengthening the living or non-living structure which might be damaged by the energy transfer, 9) moving rapidly in detection and evaluation of damage and to counter its continuation and extension, and 10) all those measures which fall between the emergency period following the damaging energy exchange and the final stabilization of process.*" Evaluating possible interventions based on individual and combined strategies will show which part of the energy exchange process is interfered.[10, 26]

Rustagi et al. and Short et al. suggested that the Haddon Matrix provides major possible intervention program areas for road safety. Besides, future intervention programs should focus on different factors such as engineering and be supported by community and national level agencies.[9,18] For the Road Traffic Safety Province Coordination Boards in Turkey, various agencies from different levels of the society participated in the decision-making process. However, the results show that the decisions mainly focused on specific areas of road safety, such as education and pre-crash. As discussed earlier, the combined use of the Haddon Matrix and Es of road safety might provide effective intervention programs that address the needs of society. Different strategies planned to achieve the same outcome, such as decreasing crashes,

may require various components[3,26]. For example, suppose that a country aims to reduce crashes, and policymakers develop two countermeasures. Even if two countermeasures focus on the post-crash phase of the Haddon Matrix, one of them may use only one E, such as education, and the other one uses three Es, such as education, enforcement, and emergency response.

As highlighted earlier, the Haddon Matrix can be used to assess national level readiness for public health problems and evaluate and develop strategies effectively using public health resources.[7] Since road traffic crashes are one of the major public health problems worldwide and have a significant impact on the national income of a country[27], and it is essential to conduct road traffic intervention programs that are adequately analysed and planned. Moreover, it is also proposed that if potential or actual hazard, in this case, road traffic crashes, exceeds nations, it is necessary to apply international actions.[27] WHO states that road traffic crashes are not only regional or national problems but also global problem.[27] In recent years, the application of international programs shows the importance and effectiveness of these programs.[29-30] It has been found that the examination of road traffic crashes by using the Haddon Matrix provides detailed information about a specific crash, and future suggestions might be developed based on that crash.[5] However, it should be noted that the multidimensionality of factors affecting a road traffic crash would result in many combinations, so the generalisability of suggestions would be limited. As discussed by Albertsson et al., the Haddon Matrix could be divided and used as different factors since the matrix provides flexibility.[5] The current report shows that the matrix could also be used to investigate national level road safety decisions. Additional dimensions related to regional and country-level might provide detailed inside for road traffic safety problems and result in more effective countermeasure programs.

In addition to the results coming from the Haddon Matrix, the distributions related to 7Es of road safety showed four major areas; education, enforcement, engineering, and evaluation. Additionally, while evaluation was mainly associated with the pre-crash phase and socio-economic environment, engineering was mostly related to the pre-crash phase and physical environment. The majority of the education and enforcement decisions were also associated with the pre-crash phase. The earliest version of three Es of road safety[19], namely education, enforcement, and engineering, also have an essential share in the road safety decisions in Turkey. However, critical factors that as exposure and emergency response did not report as much as other decisions. As discussed by Hughes et al., using a more limited scope of road safety strategies involving a limited number of Es of road safety might affect the effectiveness of these applications.[25]

Based on the current findings, a few theoretical and practical implications could be suggested. First of all, the Haddon Matrix and Es of road safety were found to be valuable tools to evaluate road safety decisions. It has been found that each sub decision had been successfully associated with one of the factors, phases and Es of road safety. Besides, it could also be suggested that the matrix and Es of road safety provide a snapshot of road safety interventions in Turkey. For this reason, it could be recommended that the two methods could provide a more detailed approach to road safety interventions at the country level. Following this exploration, previous interventions could be evaluated, and new intervention programs could be developed. Following this, secondly, the distributions of decisions showed that there are specific points that get more attention than others, such as pre-crash human factors while taking road safety decisions. The fact that there is a wide range of decisions in these areas shows the richness of the intervention programs that could be implemented. However, future studies should also investigate whether the lower number of decisions in specific areas is due to the nature of that category (i.e. lack of different interventions) or indicates a lack of focus on that area.

Additionally, future decisions could be taken by considering these tools as a basic structure and focus on the needs of different parts of the country by examining these needs again based on these tools. Moreover, investigating road traffic crashes that represent the crash profile of different regions or a country and developing countermeasures based on these might provide better road traffic safety policies. As discussed by Rustagi et al., road traffic crashes and crash data involve multiple agencies such as hospitals and police using their own reporting systems and parameters.[9] Using a single crash reporting system that is developed in a way that provides information for cells for the Haddon Matrix and 7Es of road safety might result in a more systematic and efficient system for national-level road safety. Collecting representative and detailed information might result in better outcomes for national road safety programs.[29]

Moreover, Scott-Parker et al. criticised the lack of knowledge about the effects of higher-level contributory factors to young driver crashes, such as government policy and regulatory bodies and interactions between countermeasures from different levels on the road safety.[3] Furthermore, Larsson et al. also suggested that effective road safety should not focus on only one dimension.[1] The general diversity in factors, phases, and Es in Turkey supports the multidimensionality and could be evaluated as good promises for Turkey's future of road safety. The present paper also draws a general picture regarding the variety and distribution of road safety decisions. However, the application and outcomes of these decisions were not the subjects of the current paper. It should also be noted that even though the decisions had been analysed based on the Haddon Matrix and 7Es of road safety, it is not known how the decisions had been applied and what their outcomes are. Because of this, it was not possible to study the applied decisions and their consequences. However, road safety decisions may involve various interventions. Evaluations of these would also have great importance. In future studies, considering the OECD/DAC evaluation criteria for interventions, it would be important also to analyse road safety agenda and interventions based on the relevance, coherence, effectiveness, efficiency, impact and sustainability.[31] Runyan also added the third dimension that will help to choose the best interventions based on certain criteria. The third dimension, named as decision criteria, included several elements from cost to feasibility.[6] By following specific steps, evaluation of different interventions would also be possible.

As discussed by Larsson et al., systems theory has certain aspects associated with safety that enable applying the theory into the road safety context. For instance, systems are viewed as hierarchical structures, and road safety approaches such as Vision Zero emphasise the shared responsibility between elements in a hierarchical structure.[1] Scott-Parker et al. also highlighted the importance of a systems approach in road safety. In the study, the actors associated with young driver road safety were examined, and multiple actors with various responsibilities were determined.[3] Similarly, the current study also supports the notion that a systems approach is necessary for road safety research. The participants of these meetings and the content of the decisions taken in Turkey also support the complex hierarchical structure of road safety. The decisions by the authorities showed immense differences covering many aspects of road safety from drivers to road infrastructure and from education to examination of competence and fitness.

It should also be mentioned that the findings of the current study are the general overview of road safety decisions in Turkey. With respect to that, the present study proposes an example of an investigation of road safety decisions. In the model of Özkan and Lajunen, traffic regulations were the distal factors directly related to road traffic crashes and fatalities at the macro level.[2] From this point of view, the findings of the current study could be regarded as a guideline for road safety researchers and policymakers.

Additionally, using different models (Haddon Matrix and Es of road safety in the current study) proposes a new approach to policy development in public health.

In the near future, the meaning and content of human factors might change with the development of new technologies such as Intelligent Transportation Systems (ITS). Because of these changes, it might be essential to consider the interaction of human factors with other factors such as vehicle and environment while using the Haddon Matrix.[32] In the future, it might be important to consider ITS as a new factor that combines human, vehicle and environment factors. Moreover, it should also be highlighted that the decisions were most likely to be influenced by many factors associated with Turkey, such as demographics or cultural characteristics. As stated by McIlroy et al., the same actors might have different roles across countries, so it might be important to investigate different countries with the same methodology.[33]

A few limitations should be mentioned regarding the present study. One of the most crucial issues while considering the findings of the present study is that the study focuses on the variety of road safety decisions rather than the frequency. The total number of decisions should be interpreted by taking into consideration this. For instance, considering salient points such as education or socio-economic factors, it is unknown whether these decisions and variety represent a wide range of unsolved problems or continuation of successful practices. For this reason, the present study focuses on the presentation of the variety of decisions from the perspective of two frameworks. In future studies, following up on the benefits and efficiency of these decisions would be beneficial for the future of road safety. The other one is related to the decisions and distribution of the decisions. Some decisions were divided into simple forms to be able to classify them. For this reason, although the initial numbers of decisions were large, in the application, some of the decisions were combined to result in one intervention.

In conclusion, for the first time in the literature, the decisions of road safety at a country level were analysed by using the Haddon Matrix and 7Es of road safety. The results show that both methods add valuable theoretical and practical implications for road safety decisions. The use of the Haddon Matrix and 7Es of road safety for policymaking might significantly improve public health interventions. The differentiation of road safety decisions in Turkey showed that the main focus was on the pre-crash phase and education, enforcement, engineering and evaluation activities, highlighting the importance given to different interventions such as educating road users and preventing crashes. It is also believed that the current methodology provides important descriptive of road safety strategies, and results could be used in many areas of road safety from research to policy implementation. Overall, from a systems theory point of view, the present study provides some information that is believed to be valuable for the future of road safety. The study presents a new approach for road safety research by showing that the road safety decisions taken at the top level of the hierarchical structure in a complex socio-technical system can be analysed using different models and theories (the Haddon Matrix and Es of road safety in the present study).

Acknowledgement

Ethical Declaration: This study was supported by the General Directorate of Security in Turkey and does not require ethical approval as it is based on meeting reports.
Financial Support: No funding was received for this study.
Conflict of Interest: The authors declare no conflict of interest.

References

1. Larsson P, Dekker SW, Tingvall C. The need for a systems theory approach to road safety. Saf Sci 2010;48(9):1167-1174.
2. Özkan T, Lajunen T. A general traffic (safety) culture system (G-TraSaCu-S). TraSaCu project, European Commission, RISE Programme. 2015;1–47.
3. Scott-Parker B, Goode N, Salmon P. The driver, the road, the rules . . . and the rest? A systems-based approach to young driver road safety. Accid Anal Prev 2015;74:297–305.
4. Özkan T, Öztürk İ, Üzümcüoğlu Y, Bıçaksız P, Yıldırım E, Vursavaş F, Daşkın O, Turgut S, Sayı İE, Battal Ö, Söylemez M, Kurban S. Trafik Kurul Kararlarının Analizi – Türkiye Değerlendirmesi. Emniyet Genel Müdürlüğü. Available at: http://www.trafik.gov.tr/kurumlar/trafik.gov.tr/06-Yayinlar/Diger/TKKA_TurkiyeDegerlendirmesi.pdf. 2015.
5. Albertsson P, Björnstig U, Falkmer T. The Haddon Matrix, a tool for investigating severe bus and coach crashes. International Journal of Disaster Medicine 2003;2:109–119.
6. Runyan CW. Introduction: Back to the Future—Revisiting Haddon's Conceptualization of Injury Epidemiology and Prevention. Epidemiol Rev 2003;25:60–64.
7. Barnett DJ, Balicer RD, Blodgett D, Fews AL, Parker, CL, Links JM. The Application of the Haddon Matrix to Public Health Readiness and Response Planning. Environ Health Perspect 2005;113(5):561–566.
8. Zhong S, Clark M, Hou XY, Zang YL, FitzGerald G. 2010–2011 Queensland floods: Using Haddon's Matrix to define and categorise public safety strategies. Emerg Med Australas 2013;25:345–352.
9. Rustagi N, Kumar A, Norbu L, Vyas D. Applying Haddon Matrix for Evaluation of Road Crash Victims in Delhi, India. Indian J Surg 2017;80(5):479–487.
10. Haddon WJr. A logical framework for categorising highway safety phenomena and activity. J Trauma 1972;12(3):193–207.
11. Baru A, Azazh A, Beza L. Injury severity levels and associated factors among road traffic collision victims referred to emergency departments of selected public hospitals in Addis Ababa, Ethiopia: The study based on the Haddon matrix. BMC Emerg Med. 2019;19(2):1–10.
12. Yaacob NFF, Rusli N, Bohari SN. A review analysis of accident factor on road accident cases using Haddon Matrix approach. Proceedings of the Second International Conference on the Future of ASEAN (ICoFA) 2017;2.
13. Haddon WJr. The changing approach to the epidemiology, prevention, and amelioration of trauma: The transition to approaches etiologically rather than descriptively based. Am J Public Health Nations Health 1968;58(8):1431–1438.
14. Haddon WJr. Advances in the epidemiology of injuries as a basis for public policy. Public Health Rep 1980;95(5):411–421.
15. Goniewicz K, Goniewicz M, Pawlowski W, Fiedor P. Road accident rates: strategies and programmes for improving road traffic safety. Eur J Trauma Emerg Surg 2015;42(4);433–438.
16. Oster CVJr, Strong JS. Analyzing road safety in the United States. Research in Transportation Economics 2013;43:98–111.
17. Üzümcüoğlu Y, Özkan T, Lajunen T, Morandi A, Orsi C, Papadakaki M, Chliaoutakis J. Life quality and rehabilitation after a road traffic crash: A literature review. Transp Res Part F Traffic Psychol Behav 2016;40:1–13.
18. Short MM, Mushquash CJ, Bédard, M. Interventions for motor vehicle crashes among Indigenous communities: Strategies to inform Canadian initiatives. Can J Public Health 2014;105(4):296–305.

19. Groeger JA. How many e's in road safety. In B. E. Porter (Ed.), Handbook of Traffic Psychology (pp.3–12). San Diego, CA: Elsevier.
20. Assailly JP. Road safety education: What works? Patient Educ Couns 2017;100S:S24–S29.
21. Wang C, Quddus MA, Ison SG. The effect of traffic and road characteristics on road safety: A review and future research direction. Saf Sci 2013;57:264–275.
22. Elvik R, Høye A, Vaa T, Sørensen, M. The handbook of road safety measures. 2nd ed. Bingley, UK: Emerald; 2009.
23. Bui DP, Balland S, Giblin C, Jung AM, Kramer S, Peng A, Aquino MCP, Griffin S, French DD, Porter KP, Crothers S, Burgess JL. Interventions and controls to prevent emergency service vehicle incidents: A mixed methods review. Accid Anal Prev 2018;115:189–201.
24. Scholtes B, Schröder-Bäck P, Mackay M, Vincenten J, Brand H. (2017). Child safety reference frameworks: A policy tool for child injury prevention at the sub-national level. Cent Eur J Public Health 2017;25(2):120–128.
25. Hughes BP, Anund A, Falkmer T. A comprehensive conceptual framework for road safety strategies. Accid Anal Prev 2016;90:13–28.
26. Haddon WJr. Energy damage and the 10 countermeasure strategies. Inj Prev 1995;1:40–44.
27. World Health Organization. Global status report on road safety. Available at: https://www.who.int/violence_injury_prevention/road_safety_status/2018/en/. 2018.
28. Haddon WJr. On the escape of tigers: an ecologic note. Am J Public Health Nations Health, 1970;60(12):2229–2234.
29. Siegrist S. Towards a method to forecast the effectiveness of national road safety programmes. Saf Sci 2010;48(9):1106–1110.
30. Gupta S, Hoe C, Özkan T, Lajunen TJ, Vursavas F, Sener S, Hyder AA. Evaluation of a five-year Bloomberg Global Road Safety Program in Turkey. Public Health 2017;144:S45–S56.
31. OECD. Evaluation Criteria. Available at: https://www.oecd.org/dac/evaluation/daccriteriaforevaluatingde
32. Noy YI. Human factors in modern traffic systems. Ergonomics 1997;40(10):1016–1024.
33. McIlroy RC, Plant KA, Hoque MS, Wu J, Kokwaro GO, Nam VH, Stanton NA. Who is responsible for global road safety? A cross-cultural comparison of Actor Maps. Accid Anal Prev 2019;122:8–18.