Causation of traffic accidents with children from the perspective of all involved participants

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Abstract - In the year 2014 about 2,800 children between zero and 14 years got injured due to traffic accidents in Austria. More than 50% were taking part in traffic as active road users like cyclists or pedestrians. Within this study 46 real world traffic accidents between vehicles and children as pedestrians were analysed. In 39 cases, car drivers hit the crossing children. In the other cases, the collision opponents were busses, trucks or motorcycles. Most of the children got hit while crossing a road at urban sites. By analysing the traffic accidents from the perspectives of all involved participants, vehicle drivers and injured children, it is possible to identify factors for each participant, which led to the accident and factors that contributed the accident. The main task is to find patterns in the behaviour of crash victims (children and driver) before the collision. One important fact is that in more than 50% of the analysed cases sight obstructions were an important contributing factor for both, the driver and the child. From drivers view situations in which the child moved unexpected into the driven road lane were often found. For the injured child, factors like: no attention to the road traffic or no sufficient traffic observation were found to be relevant. Further it´s possible to sensitise children and adults to possible source of critical traffic situations according to the findings of this study.

INTRODUCTION

More than 650 children as pedestrians, aged zero to 14 years got injured due to traffic accidents on Austrian roads in 2014 [1]. Between the years 2002 – 2011 9,266 children got injured. About 94% of them had an accident at urban roads. This situation is quite similar to Germany. About 97% of all accidents with children as pedestrians in the year 2014 took place at urban roads in Germany [2]. Many studies attest male children a higher risk of being involved in a traffic accident than female children [3-5]. In Germany and Austria this situation is quite similar, 57% to 58% of the involved children were male [2,6]. The consequences of child accidents are not just physical; in long term monitoring often psychogenic pain is documented [7].

Pedestrian injuries to children most commonly occur when they get hit by an vehicle, keeping it´s direction, while the child is crossing a street [3]. In Austria it can be found that about 78% of the injured children were struck by an approaching vehicle keeping its direction while the children tried to cross the road [6]. Focusing on the youngest children it was found that fatal accidents with reversing cars are very likely, especially at driveways, apartment buildings or parking lots [8]. Austrian data shows that in relative terms, children between zero and five years got twice as often injured due to collisions with backwards driving cars than older children (6 – 10 and 11 – 14 years old children) [6].

Eder et al. [7] found that the most frequently accident patterns were: “hit at crosswalks”, “crossing without looking” and “sight obstructions”. Further frequent situations were identified for children using public transport (running across the road close before or behind a bus or tram) or playing at or next to the road. For children aged from six to eight crossing without taking care of the traffic was found to be the main common accident situation. Accidents caused by children crossing the road in front of or behind a public transport vehicle was frequently found in the behaviour of older children (10-13 years). [7]

Especially children older than nine years are at risk of being involved in accidents due to distractions such as using phones and the like [9]. So-called “dart out” situations describe situations in which children enter a street quickly, without thinking, to meet someone or something on the other side of the street. Situations, which were results of poor judgement on the part of the children were often found too. The children had entered the road thinking they were safe, but were not. [10]

In fact there are a lot of different factors which lead to accidents. Behaviour of children on the road is hard to manage and, of course, is age-dependant. Education and training is an important factor to prevent child accidents but there are typical steps in the child development which can´t be influenced. [11-13] Thus, it´s important not to solely focus on the mistakes the involved may have made; neither on the mistakes of the children nor on those of the drivers. It´s necessary to analyse an accident from both perspectives, drivers and injured children, to prioritise the pre-crash phase. Determining high risk situations and finding patterns in behaviour of the involved participants might lead to measure that improve safety. Showing real world accident situations in combination with providing supported trainings at test tracks is a proper method to sensitive adults to possible source of critical traffic situations. [14]

MATERIAL

For this study, the accident database CEDATU (Central Database for In-Depth Accident Study [15] [16]) was used. In total, 46 accidents with children were analysed by using information collected by the police (witness reports, injury data, etc.). In total 48 children as pedestrians got injured due to this accidents. All of these accidents were reconstructed using the reconstruction software PC-Crash™. Infrastructures, such as roadside furniture or trees and parking vehicles, were included. Based on the reconstructed kinematics and the additional information about the road and roadside layout, complete accident situations, from the critical situations (pre-crash phase) to the final position (post-crash phase) were analysed. To find factors that might have led to the traffic accident, the behaviour of every participant prior to the accident was analysed by determining possible causal and contributing accident factors. Each case was analysed from the perspective of the involved children as well as from the perspective of the involved drivers with the goal to find relevant and recurrent accident circumstances.
The data field basis of CEDATU compares to the STAIRS protocol (Standardization of Accident and Injury Registration System) [17] which was developed over the course of an EU project with the same name. Building on the STAIRS protocol, the data fields were extended using information from the EU projects PENDANT (Pan-European Coordinated Accident and Injury Databases) [18], RISER (Roadside Infrastructure for Safer European Roads) [19] and ROLLOVER (Improvement of rollover safety for passenger vehicles [20]). The data fields from national statistics are considered to enable a direct connection to the latter [21]. Furthermore, the data fields of CEDATU correspond to the IGLAD database [22].
At the moment CEDATU comprises of approximately 3,200 accident cases. About 70 cases are collected each year on a regular basis.

METHOD

The following example of an accident reconstruction is about a collision between a passenger car and a three-year-old boy, who was crossing a road. The child was hit by the car from the front and suffered serious injuries, especially of the lower extremities. The accident took place on a straight road with a speed limit of 30 km/h. Vehicles parked at the right and left side of the road. A 3.6 metres wide rode was given for driving vehicles. The crash occurred at daytime, the weather was bright and the road was dry. For further accident analysis, information about the damages of the involved car and pictures of the accident scene were available.

Figure 1 illustrates the parking situation at the day of the accident. The arrow marked with number one shows the driving direction of the involved driver. The arrow marked with number two shows the running direction of the child from between the parking cars at the right roadside. On the left side of the picture, the family´s house entrance can be seen. Boy's mother and his sister were exactly standing in front of the door when the accident occurred. The right picture shows an aerial

photograph of the accident scene. The shadow cast on the right side of the road approximately corresponds to the shadow cast at the time of crash.

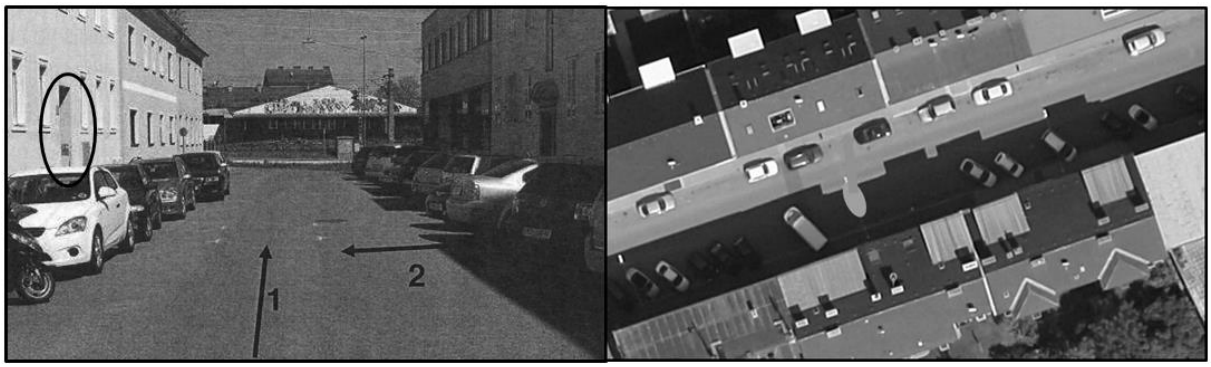

Figure 1: accident scene

The driver of the passenger car said that some metres before the accident scene, a woman at the right roadside was emptying the luggage compartment of her car, which made him drive closer to the left roadside than normally. All of a sudden, a child ran across the road from between the parking cars at the right side of the road. The driver said that he had immediately initiated an emergency braking but wasn't able to stop in time and collided with the child. The alcohol test of the driver was negative, so were the tests for other driving ability influencing substances.

At the time of the accident, mother and sister of the injured child were at the opposite side of the road, in front of the house entrance. Neither of them had observed the accident as they were standing with the back to the road. Before the accident happened, the boy was with his uncle on the other roadside next to his parking car, the mother said.

The uncle told the police that he had shown the boy damages at the car caused by him when all of a sudden, the child started running across the road.

The woman who was standing behind her car, emptying the luggage compartment told the police that she hadn´t observed the accident. However, she said that the woman on the left and the man on the right roadside were talking in a very loud manner with each other, but she didn't understand their language. A few minutes before the collision, the child had crossed the road several times, she added.

Based on the detailed accident investigation, the following happening is very likely:

At the time the child's uncle started reprimanding him to be more careful with the car, the boy started running diagonally across the road towards his mother. The crossing velocity of the boy was reconstructed to about six km/h. He got hit by the right corner of the car on his left body side. In the course of the collision, the boy was thrown six metres forward and two metres to the right. The rest position of the boy was beneath a parking car. The collision velocity of the involved car could be reconstructed to 32 km/h. At the time of collision, the driver had already initiated an emergency braking; the starting velocity of the car was reconstructed to about 37 km/h.

Now, the accident pre-crash phase will be analysed in all of its details, from the perspective of the driver as well as from the perspective of the child. The photo spread (Figure 2) shows the accident occurrence right before the accident from the perspective of the driver, Figure 3 illustrates it from the perspective of the child. Each sequence starts 5.0 seconds before t_0.

Pre-crash phase from the perspective of the driver:

When the driver turned into the road, the following view (Figure 2) was given. On the first picture – 5.0 seconds before the collision – the driver was about 52 metres away from the accident scene. He drove with a velocity of about 37 km/h. To his left and his right, parking cars were visible. At the right side of the road, he noticed a woman emptying her car's luggage compartment. There was no oncoming traffic.

About 4.0 seconds before the collision, he steered his car more to the left side of the road to increase the distance between his car and the woman on the right. From his perspective, there were no children or other people visible.

3.0 seconds before the collision, he was 30 metres away from the point of collision. He had almost finished his steering process. From the driver's view, the child subsequently injured was still invisible. He still drove with a velocity of 37 km/h.

2.0 seconds (20 metres) before the collision, the crossing child would had been visible but the driver didn't notice it. The child had started crossing the road from the right shadowed side. The driver's attention was still focused at the woman to his right, who was now in his immediate proximity. The side distance between the car and the woman was about 1.3 metres.
If the driver had reacted at this very moment (exactly 2.1 seconds before t_0) and done an emergency braking, he would have been able to stop in time (reaction time of 0.8 seconds, 0.2 seconds lag time [23] included and 1.1 seconds emergency brake).

1.0 second (10 metres) before the collision, the driver had passed the woman at the right and noticed the child. He immediately initiated an emergency braking.

0.5 seconds before the collision, the distance between the car's front and the child was about 5 metres. Yet, the initiated emergency braking hadn't been effective. The driver was still in the phase of reaction. Shortly before the collision occurred, the driver was able to reduce his speed by 5 km/h and collided with the child with a velocity of 32 km/h.

Figure 2: pre-crash phase from the perspective of the car driver

Pre-crash phase from child´s perspective:

The first picture (Figure 3) shows the perspective of the child 5.0 seconds before the collision. His uncle was rebuking him to be more careful with his car and was showing him the damages he was allegedly responsible for. At this time his mother and sister were standing in front of their house entrance on the other side of the road.

About 4.0 seconds before the collision, the child was looking for his mother and found her standing at the other side of the road. His uncle, still instructing him to be careful with his car, had a look at the child, who still had been next to him. Both were standing next to the right back door of the car.

About 3.0 seconds before the collision, the uncle had closed the back door of the car. At this very moment, the boy had initiated his run towards his mother. From his position and perspective, his view of the road to his left was limited, which is why he had not seen the oncoming car.

About 2.0 seconds (3 metres) before the collision, the child was already running. His crossing velocity was about 6 km/h, focusing his mother at the other side of the road. He still hadn’t noticed the oncoming car.

About 1.0 seconds before the collision, the car was only about 9 metres away from the boy. Theoretically, the boy could have stopped at this moment but kept running towards his mother.

About 0.5 seconds before the collision, the boy still kept running undeterred. Shortly before the collision, the uncle shouted: “Stop, a car!”, but the boy obviously hadn’t heard him.
Irrespective of his uncle´s warning, the boy wouldn´t have been able to stop in the very short time before the collision.

Figure 3: pre-crash phase from child´s perspective

Relevant “human accident factors” associated to the driver:

Based on the accident analysis, the driver’s reaction was too late and leads to the causative factor “reaction time delay”. A reason for his delayed reaction might be the fact that the driver was concentrating on the woman “external distraction” was thus a contributing factor to the accident.
The driver had increased the lateral distance to the woman and continued driving with a constant velocity of 37 km/h, not decelerating. The maximum allowed speed was 30 km/h. However, the accident couldn’t have been avoided, even if the driver had adhered to the speed limit of 30 km/h and reacted at exactly the same point as he did in the actual situation. In this case, another contributing factor was “high velocity/speed”.

Last but not least, the factor “expectance of a certain behaviour of other road users – pedestrian crossing unexpected” was determined as another contributing factor. The driver hadn’t seen any indications for a critical situation, which is why to him the crossing child appeared unexpected.

Relevant human accident factors associated to the crossing child:

Causative for this accident was the circumstance that the child hadn’t observed the traffic carefully enough; the causative factor of the accident being “inattentive – no sufficient traffic observation”. As

a reason for this and as a contributing factor, his uncle's rebuke while his mother had already been at the other side of the road could be considered as "psychological stress".

In addition, the fact that the child was very familiar with the surroundings at the accident scene should be taken into account. It is very likely that the child had already played in the street, just like it did minutes before the collision occurred. This factor can be termed "habitually stretching rules".
It´s a possibility that the boy either had never learned the general rule not to play on the streets or he had simply ignored it.

Last but not least the fact that the child had started to run from between two parking cars should be mentioned. In this case, a "wrong behaviour of the pedestrian – due to sudden emergence from view restricted area" was chosen.

Another contributing factor relating to both, child and driver, was the fact of temporary obstructions of view. The parking vehicles next to the road restricted their view so they couldn't see each other in the key moment when the child had initiated its movement to cross the road. In fact, the earliest possible moment for both was about 2.5 seconds before the collision happened.

RESULTS

Within this analysis of 46 accidents, in which 48 children got injured (nine slight, 22 serious, 17 fatal) it was found that in just 16 cases the driver reacted with a deceleration of its car. 10 accidents took place in the immediate area of public transport stops and another 10 accidents happened at crosswalks. According to the road layout and infrastructure, the most important contributing accident factor for both, children and vehicle drivers, were found to be obstructions of view.
Permanent obstructions caused by bushes, fences or similar objects in the road layout as well as temporary obstructions like parking vehicles were found to be relevant sight obstructions especially for smaller children. In more than 52% of the analysed accidents sight obstructions at or beside the roadway had a significant contribution.

Especially in relation to the involved children, the following causal human accident factors were found frequently:

- No or no sufficient traffic observation
- Sudden emerge from view restricted areas
- Wrong behaviour in traffic situations regulated by traffic lights
- Playing on or besides the road

These factors could also be found frequently as contributing factors (Figure 4); factors that contribute to the accident e.g. playing children next to the road:

A child crosses the road to chase a ball and gets hit by an oncoming vehicle. The cause for this accident might be the fact, that the child hadn't payed attention to the road traffic. A possible contributing factor might be the location they had chosen. If the game had taken place at another location than the road, the child wouldn't have had to chase the ball across the street.
A detailed list of factors ascribed to children as pedestrians can be found in the appendix (Table 1).

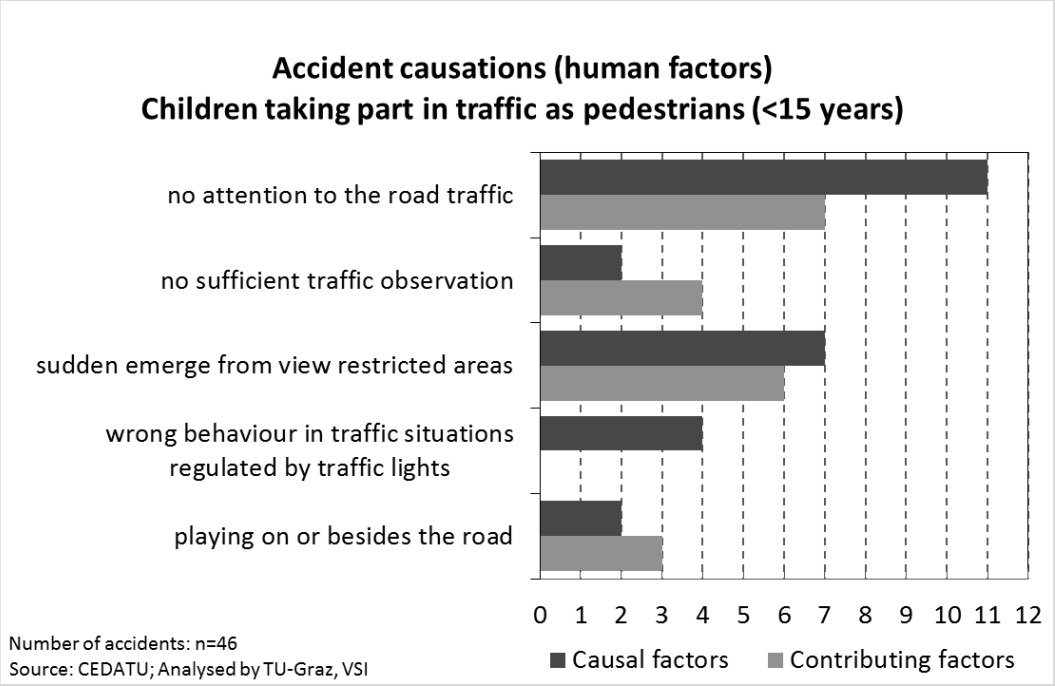

Figure 4: human accident factors ascribed to the involved children

In relation to the involved drivers, it was found that the unexpected movement of children into the driving lane and wrong behaviours towards children at pedestrian crossings were the most frequently found causal factors. External and internal distraction, too high or not adjusted speed were found to be the most common contributing factors too. (Figure 5) The detailed list of factors ascribed to the car driver can be found in the appendix (Table 2).

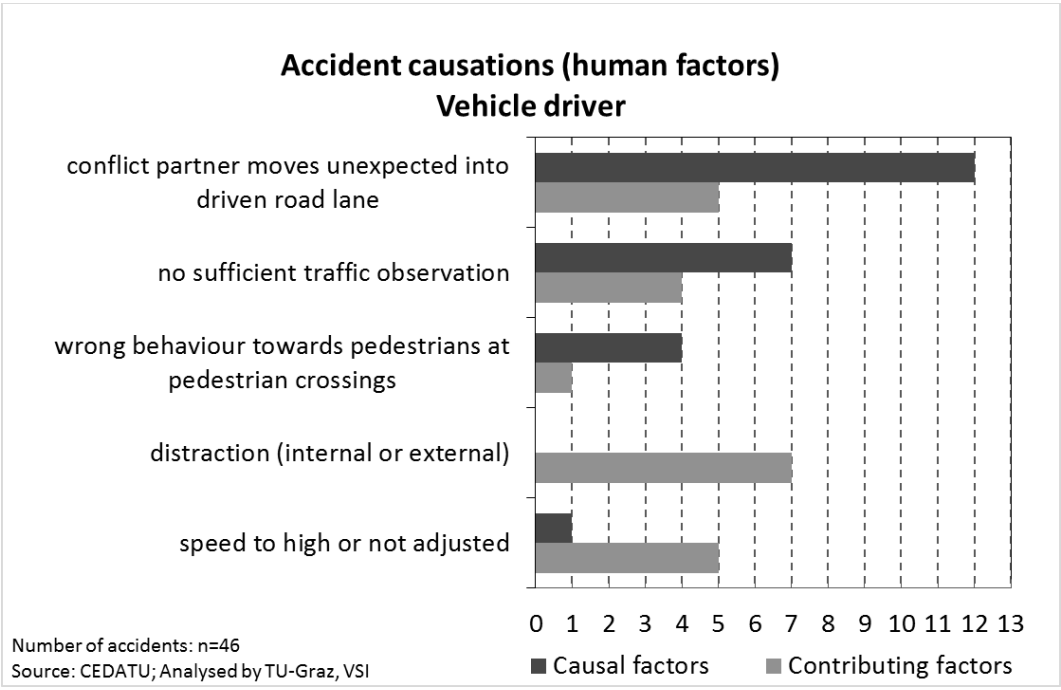

Figure 5: human accident factors ascribed to the involved driver

Another, not less important factor is that most of the injured children crossed the road running before they got hit by the vehicle. In fact it was found that more than 60% of the children were in a running movement when the accident occurred. Figure 6 shows the speed the children obtained according to the accident reconstructions. Typical “normal walking” velocities for children aged three

to 14 years are between four and six km/h [24]. Figure 6 shows that only about 30% of the crossing children moved with velocities of six km/h or less.

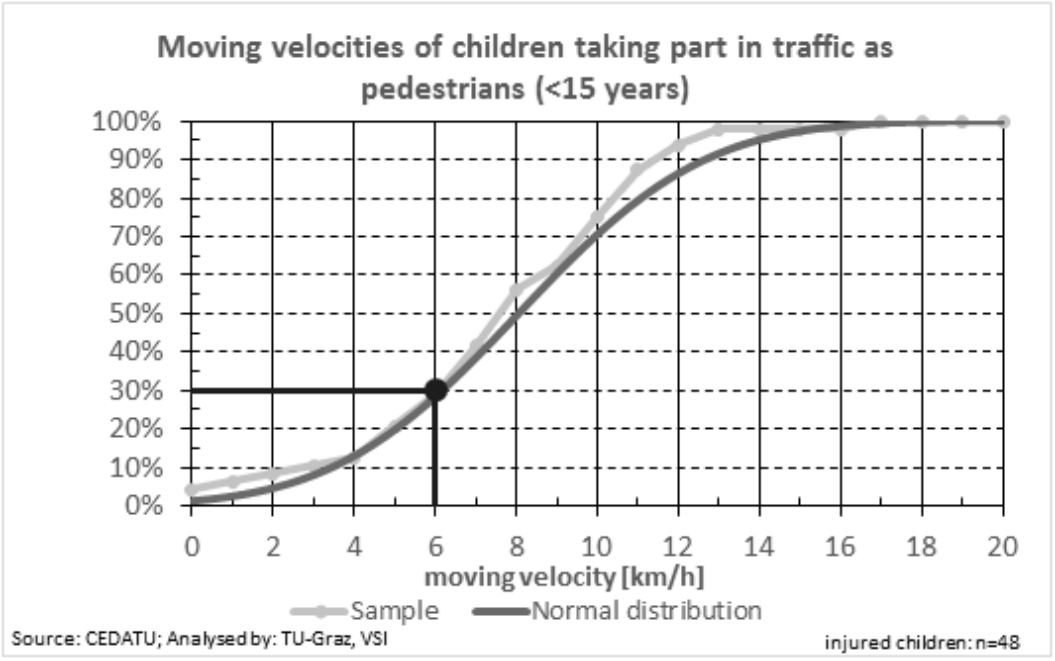

Figure 6: moving velocities of children taking part in traffic as pedestrians

CONCLUSION

For children the possibility to avoid an accident often would have been given abiding by simple rules like: “Do not cross the road when pedestrian traffic lights show red.” In the analysed dataset of 46 accidents more than 60% of the children got hit by oncoming cars while they tried to cross the road by running. Slowly moving towards the road, stopping at the road edge and carefully observation would probably avoid many accidents. But in practice it´s not that simple. The psychomotor development of children is an important factor, we can´t deny in accident researches. Children are more distractible than adults are. It´s harder for them to concentrate on safety relevant incidents on the road, especially when they are with other children.

A screening, of actual and appropriated Austrian schoolbooks showed that the cover ratio between the content of these books and accident patterns in real world scenarios is by about 20% - 50%. Sequently analysing an accident from the perspective of children can bring a better understanding of the occurrence of such accidents and critical scenes in road traffic. These findings can be used in education. Detailed knowing about the risks for children in road traffic makes it possible to teach and train such situations.

From the perspective of the driver, the sensitisation to pay particular attention towards children in road traffic is important. Especially at bus stops, school starting and ending time special care is required. In the analysed cases in which children got injured especially at crosswalks, drivers often mentioned that they saw the children at the road layout before the collision but didn´t think of the possibility that it might cross. In general, a safety effort might be carefulness of the driver when children are in the close range to the road.

Due to analysing accidents case by case from the perspective of all involved participants, sampling accident patterns, causal factors and contributing ones, improvements in road safety can be done. Especially due to integration of the findings in education (for children and adults too), in theoretical and practical manner.

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APPENDIX

Table 1: detailed list of accident factors ascribed to the injured children

Accident causations (all factors) Children taking part in traffic as pedestrians (<15 years)				
Maingroup	Subgroup	Description	Number of causal factors	number of contributing factors
Human factors	Wrong behavior of the pedestrian	wrong behavior of the pedestrian in traffic situations regulated by traffic lights or police officers	4	0
Human factors	Wrong behavior of the pedestrian	wrong behavior of the pedestrian at crossings without regulation by traffic lights or police officers	2	0
Human factors	Wrong behavior of the pedestrian	wrong behavior of the pedestrian due to sudden emergence from view restricted areas	7	6
Human factors	Wrong behavior of the pedestrian	wrong behavior of the pedestrian (ignoring the road traffic)	11	7
Human factors	Wrong behavior of the pedestrian	other wrong behavior of the pedestrian	2	0
Human factors	Wrong behavior of the pedestrian	wrong behavior of the pedestrian due to playing on or besides the road	2	3
Human factors	Wrong behavior of the pedestrian	wrong behavior of the pedestrian due to other mistakes	0	1
Human factors	Inattentive / distraction	no sufficient traffic observation	2	4
Human factors	Inattentive / distraction	other	0	1
Human factors	Inattentive / distraction	habitually stretching rules	0	1
Human factors	Safety distance / Time delay	no reaction of the driver/pedestrian	0	2
Human factors	Constitution	Ageing	0	4
Human factors	Experience	Experience	4	2
Human factors	Psychological stress	Stressful life event	0	1
Human factors	Human other	Human other	1	2
Infrastructure	Road condition	Wet road	0	2
Infrastructure	Road condition	Snow, snow slush	0	1
Infrastructure	Road geometry and road guidance	Uphill	0	1
Infrastructure	Visibility/visibility limitation	Visibility	1	1
Infrastructure	Visibility/visibility limitation	Permanent obstruction of view	0	2
Infrastructure	Visibility/visibility limitation	Temporary obstruction of view	0	4
Weather and Lightning conditions	Lightning conditions	Twilight	0	1
Weather and Lightning conditions	Lightning conditions	Darkness	0	3
Weather and Lightning conditions	Lightning conditions	Artificial light	0	2
Weather and Lightning conditions	Precipitate	Rain/drizzle	0	1
Weather and Lightning conditions	Precipitate	Snowing	0	1
Weather and Lightning conditions	Weather	Fog/Mist	1	0
Infrastructure	Road geometry and road guidance	Bend to left	0	1

Table 2: detailed list of accident factors ascribed to the vehicle drivers

Accident causations (all factors) Vehicle driver				
Maingroup	Subgroup	Description	Number of causal factors	number of contributing factors
Human factors	Wrong behavior of the pedestrian	wrong behavior of the pedestrian in traffic situations regulated by traffic lights or police officers	0	1
Human factors	Wrong behavior of the pedestrian	wrong behavior of the pedestrian due to sudden emergence from view restricted areas	0	2
Human factors	Wrong behavior of the pedestrian	wrong behavior of the pedestrian (ignoring the road traffic)	1	0
Human factors	Overtaking	overtaking though traffic situation is not clear	0	1
Human factors	Turning off, Turning, Reversing	mistake during u-turn or reversing	1	0
Human factors	Wrong behavior against pedestrians	wrong behavior towards pedestrians at pedestrian crossings	4	1
Human factors	Wrong behavior against pedestrians	wrong behavior towards pedestrians at other places	0	1
Human factors	Wrong behavior of Driver, Road Usage	Driving on/over given line (w/o further information)	1	0
Human factors	Inattentive / distraction	Internal	0	2
Human factors	Inattentive / distraction	External	0	5
Human factors	Inattentive / distraction	no sufficient traffic observation	7	4
Human factors	Inattentive / distraction	other	1	2
Human factors	Safety distance / Time delay	Safety distance	0	1
Human factors	Safety distance / Time delay	Reaction-time delay	1	4
Human factors	Safety distance / Time delay	no reaction of the driver/pedestrian	1	6
Human factors	Speed	High	1	2
Human factors	Speed	not Adjusted	0	3
Human factors	Constitution	Ageing	0	1
Human factors	Constitution	Handicapped driver	0	0
Human factors	Experience	Experience	0	1
Human factors	Expectance of certain behaviour of other road users	Skidding into driven road lane	4	1
Human factors	Expectance of certain behaviour of other road users	Conflict partner moves unexpected into driven road lane	12	5
Vehicle	Vehicle visibilty limitation	Vehicle visibility limitation	1	3
Infrastructure	Road condition	Wet road	0	2
Infrastructure	Road condition	Snow, snow slush	0	1
Infrastructure	Road geometry and road guidance	Uphill	0	3
Infrastructure	Road geometry and road guidance	Summit of a hill	0	1
Infrastructure	Visibility/visibility limitation	Visibility	2	1
Infrastructure	Visibility/visibility limitation	Permanent obstruction of view	0	5
Infrastructure	Visibility/visibility limitation	Temporary obstruction of view	0	8
Infrastructure	Traffic condition	Slow moving traffic	0	2
Infrastructure	Pedestrian crossing/cycle path	Pedestrian crossing	0	2
Infrastructure	Speed limit	Speed limit inappropriate	0	1
Weather and Lightning conditions	Lightning conditions	Sun glare	0	2
Weather and Lightning conditions	Lightning conditions	Twilight	0	2
Weather and Lightning conditions	Lightning conditions	Darkness	0	4
Weather and Lightning conditions	Lightning conditions	Artificial light	0	2
Weather and Lightning conditions	Precipitate	Rain/drizzle	0	2
Weather and Lightning conditions	Precipitate	Snowing	0	1
Weather and Lightning conditions	Weather	Fog/Mist	1	0
Further factors	Surprisedly obstacle	Surprisedly obstacle(s) ahead (traversable)	1	0
Infrastructure	Road geometry and road guidance	Bend to left	0	2