Global Road Traffic Fatality Estimate for 2060: The Effect of Increased Vehicle Automation

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I. INTRODUCTION

The number of road vehicles and road traffic fatalities continues to rise globally. By 2060, it is estimated that 2.26 million traffic-related fatalities will occur [1], in spite of the explicit target to halve the number of road traffic fatalities and injuries in the UN Sustainable Development Goal 3. Autonomous driving (AD) and advance driver assistance systems (ADAS) are being introduced to the market to reduce human error and support drivers during the decision-making process, increasing safety and reducing traffic fatalities. Estimates of the safety benefits of existing and upcoming ADAS and AD are available in the literature. The reductions in road traffic fatalities due to ADAS and improved in-crash protection in India have been estimated based on in-depth information from the Road Accident Sampling System India (RASSI) [2]. A similar study using the German In-Depth Accident Database (GIDAS) shows a fatality reduction not only from ADAS technologies in combination with improved in-crash protection, but also due to an AD concept [3].

The aim of our present study is twofold: (1) to obtain the estimated safety benefit of different in-crash, ADAS and AD technologies available in the literature, and scale them to the world in order to estimate the potential number of lives saved globally for 2060; and (2) to highlight which road user groups are expected to benefit the least from progress in vehicle automation, thus requiring additional attention in the future research and development of safety systems.

II. METHODS

The World Health Organization (WHO) estimated that there were 1.4 million traffic-related fatalities globally in 2016 [1]. That number is expected to reach 2.26 million by 2060: 2.2 million fatalities in low- and middle-income countries and 64 000 in high-income countries [1]. The Global Burden of Disease study reports the road users making up these fatalities in 2016 by country [4], as shown in Table I.

Assuming the distribution remains unchanged, we can estimate the distribution of road traffic fatalities by country income level and road user distribution in 2060 in a baseline (business as usual) scenario (Table II).

TABLE I
DISTRIBUTION OF ROAD TRAFFIC FATALITIES ACROSS ROAD USER TYPES

		Occupant[1]	Pedestrian	Cyclist	Motorcyclist[2]	Other[3]	Total
2016	*Low+middle*	53%	26%	6%	13%	2%	100%
	High	34%	41%	5%	19%	1%	100%

[1]Vehicle occupants; [2]Riders of motorized 2 and 3 wheelers; [3]mainly unspecified.

To calculate the life-saving effect of ADAS for low- and middle-income countries, we applied the estimates from [2] of fatality reductions due to standard ADAS together with improved in-crash protection by road user group in India to the 2060 baseline fatalities. For high-income countries we applied the (standard ADAS with improved in-crash protection) estimates from [3].

To calculate the effect of AD, we applied the (cautious driving) estimates from [3] to all income levels, since estimates specific to low- and middle-income countries were unavailable. In line with previous research [3] we have assumed that AD vehicles will include ADAS technology and improved in-crash protection, hence increasing automation will save more lives. Notably, however, the AD's effectiveness estimates from [3] is lower than the estimate from [2] regarding the ADAS' occupant protection. This may be due to differences between

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the two papers in the data and modelling of ADAS functions. For consistency, we have assumed that AD for low and middle-income countries is as effective as ADAS at 96.5%.

TABLE II
CURRENT (2016) AND FUTURE (2060) ROAD TRAFFIC FATALITY DISTRIBUTION

		Occupant	Pedestrian	Cyclist	Motorcyclist	Other	Total
2016	*Low+middle*	693 554	340 234	78 516	170 117	26 172	1 308 593
	High	31 861	38 421	4 685	17 805	937	93 709
	Total	725 415	378 655	83 201	187 922	27 109	1 402 302
2060	*Low+middle*	*1 163 716*	*570 880*	*131 741*	*285 440*	*43 914*	2 195 691
	High	*21 868*	*26 370*	*3 216*	*12 220*	*643*	64 318
	Total	1 185 584	597 250	134 957	297 660	44 557	2 260 009

Data from WHO except data in italics, based on assumptions described in the text

Both studies [2-3] defined technology bundles consisting of several ADAS and AD features. For each feature, the effectiveness was calculated by two simplified rulesets based on the effect of the feature, resulting in an optimistic and a conservative estimate. For example, AEB rear-end was defined by an optimistic ruleset, *M1 vehicle & opponent is a vehicle & relative speed <= 100km/h & relevant accident types* and a conservative ruleset *M1 vehicle & opponent is a vehicle & driving speed difference <= 70km/h & no ice or snow on road & no poor road condition & no unstable vehicle condition & fine weather & relevant accident types* [3]. The ranges of effectiveness given in the literature (optimistic to conservative) were simplified to point estimates using the average between lower and upper estimates, as summarised in Table III.

Furthermore, effectiveness estimates for passenger car occupants were applied to the entire road user group of vehicle occupants, assuming that most vehicles are passenger cars and that similar advancements in occupant protection will be made for other types of vehicles.

TABLE III
EFFECTIVENESS OF ADAS AND AD PER ROAD USER TYPE AND COUNTRY INCOME LEVEL

		Occupant	Pedestrian	Cyclist	Motorcyclist	Other
2060 ADAS	*Low+middle*	96.5%	14.5%	15%	7%	0%
	High	53%	23%	30%	12%	16%
2060 AD	*Low+middle*	96.5%	35.5%	49%	32%	20%
	High	73%	35.5%	49%	32%	20%

III. INITIAL FINDINGS

We applied effectiveness estimates from Table III to the 2060 baseline scenario from Table II, thereby obtaining an estimate of lives saved by ADAS and AD per road user group and country income level. Subtracting these from the baseline, we obtained an estimate of the remaining road traffic fatalities, as shown in Table IV.

TABLE IV
ESTIMATED FUTURE (2060) ROAD TRAFFIC FATALITIES FOR ADAS AND AD SCENARIOS

		Occupant	Pedestrian	Cyclist	Motorcyclist	Other	Total
2060 ADAS	*Low+middle*	40 730	488 102	111 980	265 459	43 914	950 185
	High	10 278	18 459	2 251	10 754	540	42 283
	Total	51 008	506 561	114 231	276 213	44 454	992 468
2060 AD	*Low+middle*	40 730	368 217	67 847	194 099	35 131	706 024
	High	5 904	17 009	1 656	8 310	515	33 394
	Total	46 634	385 226	69 503	202 409	35 646	739 418

In the ADAS scenario, assuming a passenger car fleet with improved in-crash protection and 100% ADAS implementation, road traffic fatalities are estimated to decrease to 1.0 million. Notably, car occupant fatalities are almost extinct. It is a logical consequence of the 96.5% effectiveness of ADAS at protecting car occupants in India [3] applied to the dominating proportion of low- and middle-income fatalities. Pedestrian, cyclist and motorcyclist fatalities are estimated to increase, both in actual numbers and proportions, compared to 2016. Pedestrians account for over 50% of all road traffic fatalities.

In the AD scenario, assuming a passenger car fleet with improved in-crash protection and 100% AD technology implementation, road traffic fatalities are estimated to decrease further to 0.7 million. Again, pedestrians dominate the remaining fatalities with 52%, followed by motorcyclists with 27%.

IV. DISCUSSION

Our results are in line with the general expectation that all safety technologies, be they in-crash protection, ADAS or AD, have an impact on reducing world road traffic fatalities. This is quantified with the number of lives saved around the world for different types of road users.

Uncertainties were not formally calculated in the study but are expected to be large. The effectiveness estimates from the literature are only approximate and were further simplified for ease of use in further studies on the impact of safety technologies. A logical inconsistency, AD having lower effectiveness than ADAS when applying a GIDAS AD estimate to low and middle-income countries, was dealt with by assuming equal effectiveness for AD and ADAS in low and middle-income countries. More accurate estimates for AD vehicles in low and middle-income countries are needed.

In addition, road user type distributions are hard to estimate. We used the Global Burden of Disease estimates [4], which for example, report a higher share of pedestrian fatalities than another often-used source, the WHO Global Status Report on Road Safety [5].

The WHO fatality prognoses for 2060 are based on current assumptions and might be revised. Previously, WHO predicted that traffic fatalities would continue to increase, reaching 1.85 million by 2030 [6]. However, based on the 2018 report [1], that number will reach only 1.49 million. This difference is due to a re-estimation of the Smeed's law parameters used for mortality projection as well as the introduction of a time parameter to compensate for a higher-than-expected rate of decline in vehicle ownership observed in high-income countries [7]. As the traffic fatalities estimated by WHO do not account for the potentially drastic changes in vehicle technology and road safety, the results of our study (in spite of its limitations) can fill in the gaps and show the positive effect of vehicle technologies on the number of road traffic fatalities by road user groups on a global scale.

Similarly, predicted effectiveness in reducing fatalities by ADAS and AD might change. This study used estimates from literature based on historical in-depth accident data, determining which of the recorded crashes are expected to be avoided and which ones are expected to remain. This approach has been shown to deliver reasonable predictions over a 10-year horizon in Sweden [8]. However, over a period of 40 years from now, societal and infrastructural changes influencing the road traffic situation may substantially change ADAS and AD effectiveness. Future studies modelling such changes, perhaps based on historical data of the development path of current high-income countries, are needed.

We affirm that, while the exact numbers might not be accurate, our general observations hold true: Vehicle automation will reduce road traffic fatalities substantially, but given the increase in motorisation, will not bring them down to zero. Further efforts in infrastructure, education and enforcement, as well as technology implementation are needed. Particular emphasis must be placed on protecting pedestrians, cyclists and motorcyclists better, as these road users are expected to benefit the least from vehicle automation.

V. REFERENCES

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