



The Economic Burden of Road Traffic Crashes in Kazakhstan's Major Cities

Kanat Zh. Daubayev^{1*} 

¹Institute of Logistics and Business, ALT University named after Mukhamedzhan Tynyshpayev, Almaty, Kazakhstan.

Correspondence

*Kanat Zh. Daubayev – Doc. Sc. (Econ.), Institute of Logistics and Business, ALT University named after Mukhamedzhan Tynyshpayev, Almaty, Kazakhstan. Email: k.daubaev@alt.edu.kz

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Abstract

Road traffic accidents create significant losses of public welfare associated with premature deaths and injuries, which necessitates their monetary assessment when justifying transport and social policy measures. The purpose of the study is to assess and compare the economic burden of registered road crash outcomes in Almaty and Astana and to evaluate the robustness of the resulting estimates to changes in key calculation parameters. The initial data are organized as a “city–year” panel of 18 observations, based on official statistics from the Bureau of National Statistics of the Republic of Kazakhstan, the Committee on Legal Statistics and Special Accounting, and the World Bank's World Development Indicators. The methodology is based on the Value of a Statistical Life (VSL) and Willingness-to-Pay (WTP) approaches. The results showed that the total monetized burden for 2015–2023 amounted to 809.75 billion tenge in Almaty and 303.88 billion tenge in Astana, or 1.114 trillion tenge in the two cities. The estimated burden in Almaty was 2.66 times that in Astana. Depending on the scenario, the cumulative burden ranged from 776.58 billion to 1,590.08 billion tenge, while the higher losses in Almaty persisted across all robustness checks. The results confirm the importance of accounting for deaths and injuries in the economic assessment of road safety measures and in conducting a cost–benefit analysis. Thus, the city ranking remains stable across the checks, whereas the magnitudes of the decomposition depend on the initial administrative observation.

KEYWORDS

Road Safety, Welfare Burden, Welfare Economics, Transport Economics, Urbanization, Urban Development

1 | INTRODUCTION

Road traffic crashes impose losses far beyond the transport sector. Deaths and injuries reduce social welfare, generate expenditures, and constrain economic activity. Pain, diminished quality of life, and the risk of premature death have no directly observable market price. Therefore, counts of crashes and casualties alone are insufficient for economic appraisal or for selecting socially efficient interventions.

This issue is particularly relevant to Almaty and Astana, which concentrate a substantial share of Kazakhstan's population and business activity but differ in size, demographic growth, and the registered composition of road traffic injuries. Absolute crash counts largely reflect city size, while per capita rates adjust for population differences but do not capture the monetary value of crash outcomes. Moreover, a mortality-only analysis excludes a substantial share of the burden associated with nonfatal injuries.

The human capital method measures lost output or earnings and therefore captures only part of the welfare value of risk reduction. The willingness-to-pay (hereinafter – WTP) approach uses the value of a statistical life (hereinafter – VSL), which represents aggregate willingness to pay for a small reduction in mortality risk. It is consistent with welfare analysis and cost-benefit analysis, but requires a defensible VSL, appropriate updating over time, and transparent treatment of uncertainty (OECD, 2025; Robinson et al., 2019).

Kazakhstan has a stated preference estimate for road risk. Wijnen (2021) derived a VSL from a population survey and applied it in a national assessment of road crash costs. That estimate, however, refers to 2012 and to the country. The literature contains no comparable city-level series that updates the VSL for real income growth, monetizes fatalities, hospitalized casualties, and other injured persons separately, and tests whether the comparison holds under alternative assumptions.

This study evaluates Almaty and Astana over 2015–2023, excluding 2024 because the administrative definition of an injured person changed. The calculation covers the monetized burden of registered human losses; budgetary damage and reductions in gross regional product (GRP) are excluded. Mortality is valued with an updated Kazakhstan-specific VSL; hospitalization is an administrative proxy for more severe injury; and other injuries are treated separately. Values are expressed in constant 2023 prices and normalized by population and GRP.

The study updates Kazakhstan's WTP-based VSL estimate using real gross national income (GNI), distinguishes hospitalized casualties from other injuries, evaluates three integrated valuation scenarios and an alternative international transfer function, standardizes hospitalization shares, and decomposes changes in the burden into real-VSL and registered-outcomes effects.

The purpose of the study is to assess and compare the economic burden of registered road crash outcomes in Almaty and Astana and to evaluate the robustness of the resulting estimates to changes in key calculation parameters. The analysis constructs a city-year dataset, updates the value of a statistical life, estimates and normalizes the monetized burden, and decomposes its changes using both 2015

and 2016 as base years.

Because the study compares deterministic estimates rather than conducting statistical hypothesis tests, it addresses three research questions:

RQ1: What was the cumulative monetized burden of registered fatalities and injuries in Almaty and Astana during 2015–2023?

RQ2: Does the cross-city ranking remain robust under alternative valuation scenarios, normalization approaches, exclusion of 2015, hospitalization standardization, and a mortality-only calculation?

RQ3: How much of the change in the annual burden is attributable to changes in the real value of statistical life and to registered crash outcomes, and how sensitive is this attribution to the choice of 2015 or 2016 as the base year?

2 | LITERATURE REVIEW

Road crashes create resource costs, production losses, and human welfare losses. The last category includes mortality risk, pain, disability, psychological trauma, and diminished quality of life, while the effects of permanent injury extend to rehabilitation needs, household income, unpaid caregiving, education, employment, and social participation (Bougna et al., 2022; World Bank, 2025; Wijnen & Stipdonk, 2016). These social consequences make medical expenditure an incomplete measure of the burden. Differences in component coverage, valuation methods, severity definitions, and data completeness therefore contribute to substantial variation in estimated road crash costs (Wijnen et al., 2019).

Total social cost, public expenditure, and changes in economic output are distinct concepts. Medical treatment and vehicle repair expenditures may be reflected in measured economic activity, whereas pain, reduced quality of life, and mortality risk are not directly captured in conventional output measures. Expressing monetized welfare losses as a share of gross domestic product or gross regional product therefore provides a scale indicator without implying an equivalent reduction in output (Elvik, 2000; Wijnen, 2021).

Two principal approaches are commonly used to value the human consequences of road crashes. The human capital method estimates lost production or earnings based on age, employment status, and duration of incapacity (Chantith et al., 2021; Connelly & Supangan, 2006). Its productivity focus leaves unpaid work, quality of life, and preferences for risk reduction only partly represented. The willingness-to-pay approach values small changes in mortality risk using the VSL. The VSL represents the aggregate willingness to pay for a risk reduction that prevents one expected statistical fatality. The measure captures the welfare benefit of risk reduction; interpreting it as the price of an identifiable life or as compensation to a family would be incorrect (OECD, 2012; Robinson et al., 2019; Viscusi & Aldy, 2003). Adding a full value of a statistical life to the complete value of future earnings may double-count material well-being already reflected in willingness to pay. Without city-level microdata on income, consumption, age, and disability, a transparent alternative is to use the full value of a statistical life and report the result as a human welfare loss rather than as a total cost.

Benefit transfer is required when a current local stated-preference estimate is unavailable. The value is commonly scaled by an income ratio raised to the power of the elasticity, but empirical elasticities vary substantially across samples and income groups (Hammitt & Robinson, 2011; OECD, 2025; Viscusi & Masterman, 2017). Milligan et al. (2014) estimated an elasticity of 2.478 for developing countries, whereas the transfer model of Wijnen et al. (2026) uses a central value of 1.2 and a range of 1.0–1.4 for low- and middle-income countries. This variation supports updating Kazakhstan's own stated preference estimate as the primary approach and treating the international value-transfer function as a sensitivity check.

Evidence for Kazakhstan and Central Asia establishes both the size of the problem and the limits of available data. Wijnen (2021) combined willingness to pay for human losses with production, medical, property, and administrative costs and estimated Kazakhstan's national road crash cost at USD 6.8 billion in 2012, or 3.3% of gross domestic product. Human losses accounted for about 81% of that estimate. A World Bank (2022) assessment of Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan estimated health care costs of road traffic injuries at approximately international USD 95 million in 2016, including USD 49.3 million in Kazakhstan. That study used a cost-of-illness framework and addressed health-system and household consequences, whereas Wijnen (2021) estimated a broader national social cost. Neither provides an annual welfare-based comparison between Kazakhstan's two largest cities. The Central Asia Regional Economic Cooperation report further identifies fragmented police and medical records, inconsistent severity information, and limited record linkage as major obstacles to reliable national and regional comparisons (ADB, 2025).

Nonfatal injuries require explicit treatment because they may produce persistent disability and large household consequences even when mortality is avoided. International practice commonly values nonfatal injuries as fractions of the VSL, although the assigned proportions vary by injury severity, valuation framework, and country (Schoeters et al., 2022; Trawén et al., 2002). For Kazakhstan, Wijnen (2021) applied values equivalent to approximately 13% of the VSL for more severe injuries and 1% for less severe injuries. The central difficulty lies in mapping a statistical category to clinical severity. The internationally used MAIS3+ threshold is not equivalent to administrative hospitalization. Admission may depend on referral pathways, bed capacity, local thresholds, and recording practice. Applying a higher weight to hospitalized casualties can therefore distort comparisons across cities if administrative practices differ.

Police registers usually capture deaths more completely than nonfatal injuries. Underreporting, inconsistent definitions, delayed outcomes, and weak linkage to health records can affect both levels and trends (WHO, 2023). Arbitrary scaling would be unjustified without city-, year-, and severity-specific correction factors. The defensible interpretation is consequently limited to registered casualties, supported by sensitivity checks that vary injury weights, standardize hospitalization shares, exclude an anomalous year, and report mortality separately.

International evidence further highlights the importance of clearly defining the

scope of economic valuation. Wisutwattanasak et al. (2024) estimated a VSL of USD 824,344 for Thailand, whereas Taniform et al. (2023) estimated the total social cost of road traffic crashes in Cameroon at USD 3.6 billion, equivalent to 3.8% of GDP. These figures cannot be compared directly with each other or with a city-level welfare measure, but they demonstrate why a locally grounded benchmark and transparent scenario analysis are necessary.

Finally, changes in monetary burden may reflect both registered outcomes and the monetary value assigned to risk. A Shapley decomposition averages the effects across possible orders of factor substitution and allocates the interaction term symmetrically, producing an exact, residual-free attribution (Shorrocks, 2013). Its result can nevertheless depend on the selected endpoints when the starting observation is administratively unusual. To the best of our knowledge, the literature reviewed here does not provide an annual city-level series for Kazakhstan based on an updated local VSL, an urban comparison that explicitly tests sensitivity to hospitalization classification, or an endpoint-sensitivity analysis of the decomposition between valuation and registered-outcomes effects.

3 | METHODOLOGY

This comparative retrospective study uses 18 city-year observations for Almaty and Astana covering the period 2015–2023. The study period begins with the first consistent regional data series and ends in 2023 because Kazakhstan's administrative definition of an injured person changed in 2024 (Prosecutor General of the Republic of Kazakhstan, 2024).

Data on fatalities, injured persons, and hospitalized casualties were obtained from the Bureau of National Statistics of Kazakhstan, which identifies the Committee on Legal Statistics and Special Records of the Prosecutor General's Office as the primary data source (Bureau of National Statistics, 2025). Population and gross regional product (GRP) data were obtained from the Bureau's regional statistical series (Bureau of National Statistics, 2025). Gross national income (hereinafter – GNI) per capita, the consumer price index (hereinafter – CPI), and the annual average exchange rate were obtained from the World Development Indicators (World Bank, 2025). All data series were downloaded and cross-checked on July 17, 2026.

Hospitalization is used as an administrative proxy for injury severity. Other injured persons were calculated as the difference between the total number of registered injured persons and hospitalized casualties. No adjustment for underreporting was applied because city-, year-, and severity-specific correction factors are unavailable. Consequently, the estimates refer exclusively to registered cases. Table 1 presents the variables, their definitions, units of measurement, data sources, and roles in the analysis.

Table 1. Study variables and parameters

Variable	Definition / unit		Source	Role in the analysis
Registered fatalities	persons		Bureau of National Statistics; primary source: Committee on Legal Statistics and Special Records	Fatal outcomes
Registered injured persons	persons		Bureau of National Statistics; primary source: Committee on Legal Statistics and Special Records	Nonfatal outcomes
Hospitalized casualties	persons		Bureau of National Statistics; primary source: Committee on Legal Statistics and Special Records	Administrative proxy for injury severity
Other injured persons	persons		Author's calculations	Other nonfatal outcomes
Mid-year population	persons		Bureau of National Statistics	Per capita normalization
Gross regional product	KZT million		Bureau of National Statistics	Normalization by economic scale
Gross national income per capita	constant USD	2020	World Bank, World Development Indicators	Income-based VSL updating
Consumer price index	index		World Bank, World Development Indicators	Conversion to a common price base
Annual average exchange rate	KZT per USD		World Bank, World Development Indicators	Currency conversion
Value of a statistical life	constant KZT	2023	Calculated from Wijnen (2021)	Unit value of mortality risk

Subscripts *c* and *t* denote city and year, respectively.
Registered vehicle counts are excluded because they do not measure distance traveled, through traffic, or actual transport exposure.

Note: compiled by the author

The value used to monetize mortality risk is based on the Kazakhstan-specific stated-preference estimate reported by Wijnen (2021). The low and high VSL estimates for 2012 are USD 595,633 and USD 871,790, respectively, with a mean of USD 733,711 used as the baseline. Real gross national income (GNI) per capita is expressed in constant 2020 USD, as shown in Equation (1):

$$Y_t = GNIpc_t^{KZT} \frac{CPI_{2020}}{CPI_t} \div ER_{2020} \tag{1}$$

where:

- Y_t – the real GNI per capita in year, expressed in constant 2020 USD;
- $GNIpc_t^{KZT}$ – the nominal gross national income per capita in KZT;
- CPI_t – the consumer price index in year;
- CPI_{2020} – the consumer price index in the base year 2020;
- ER_{2020} – the average KZT/USD exchange rate in 2020.

The 2012 VSL is then updated according to real income growth and converted into constant 2023 KZT using Equation (2):

$$VSL_{t,s}^{2023KZT} = \left[VSL_s^{2012USD} ER_{2012} \frac{CPI_{2020}}{CPI_{2012}} \div ER_{2020} \right] \left(\frac{Y_t}{Y_{2012}} \right)^{\varepsilon_s} ER_{2020} \frac{CPI_{2023}}{CPI_{2020}} \tag{2}$$

where:

- $VSL_{t,s}^{2023KZT}$ – the value of a statistical life in year under scenario, expressed in constant 2023 KZT;
- $VSL_s^{2012USD}$ – the Kazakhstan VSL estimate for 2012 in USD;
- ER_{2012} – the corresponding average KZT/USD exchange rates;
- ε_s – the income elasticity of the VSL under scenario s .

The same national VSL is applied to both cities in each year so that an identical reduction in mortality risk is assigned the same monetary value. City-specific preferences may nevertheless differ. The annual baseline burden is calculated as shown in Equation (3):

$$B_{ct} = D_{ct}VSL_t + H_{ct} (0.13 VSL_t) + (I_{ct} - H_{ct}) (0.01 VSL_t)$$

(3)

where:

- B_{ct} – the annual monetized burden in city c and year t ;
- D_{ct} –the number of registered fatalities;
- I_{ct} – the total number of registered injured persons;
- H_{ct} – the number of hospitalized casualties;
- VSL_t – the value of a statistical life in year t .

The baseline injury weights are set at 13% of the VSL for hospitalized casualties and 1% for other injured persons, following the values previously applied to Kazakhstan by Wijnen (2021). Hospitalization is used as an administrative proxy for injury severity and is not equivalent to a clinical MAIS3+ classification. Table 2 presents three integrated valuation scenarios.

Table 2. Parameters of the integrated valuation scenarios

Parameter	Low	Baseline	High
Kazakhstan VSL, 2012, USD	595,633	733,711	871,790
Income elasticity of VSL	1.0	1.2	1.4
Hospitalized injury, share of VSL	10%	13%	16%
Other injuries, share of VSL	0.9%	1.0%	1.5%

Note: compiled by the author

The low and high scenarios represent alternative parameter assumptions and should not be interpreted as statistical confidence intervals. As an additional robustness check, the analysis applies the international VSL transfer function proposed by Wijnen et al. (2026), as specified in Equation (4):

$$VSL_t^{BT} = 404\,000 \left(\frac{Y_t}{5\,726} \right)^{1.2}$$

(4)

where:

- VSL_t^{BT} – the VSL obtained using the international benefit-transfer specification;
- Y_t – the real GNI per capita in year, expressed in constant 2020 USD.

Following Shorrocks (2013), the change in the monetized burden between the base year and 2023 is decomposed into two components: (1) the effect of changes in the VSL and (2) the effect of changes in registered fatalities and injuries. First, the number of registered casualties is converted into a weighted indicator (5):

$$Q_t = D_t + 0.13 H_t + 0.01 L_t \quad (5)$$

where:

Q_t – the weighted number of registered casualties in city c and year t ;

D_t – the number of fatalities;

H_t – the number of hospitalized casualties;

L_t – the number of other injured persons.

The weights correspond to 100% of the VSL for a fatality, 13% for a hospitalized casualty, and 1% for another injured person. The effect associated with changes in the VSL is calculated as (6):

$$E_{VSL} = (VSL_{2023} - VSL_b) \frac{Q_b + Q_{2023}}{2} \quad (6)$$

where:

E_{VSL} – the valuation effect;

Q_b – the equivalent statistical casualties in the corresponding years;

b – the base year, either 2015 or 2016.

Equation (6) shows how the monetized burden changed due to changes in real VSL between the base year and 2023, while the level of registered casualties is represented by their average over the two years. The effect associated with changes in registered fatalities and injuries is calculated as (7):

$$E_Q = (Q_{2023} - Q_b) \frac{VSL_b + VSL_{2023}}{2} \quad (7)$$

where:

E_Q – the registered-outcomes effect and the remaining notation is defined above.

The identity $E_{VSL} + E_Q = B_{2023} - B_b$ holds exactly. The decomposition is performed separately using 2015 and 2016 as base years because the hospitalization share in Almaty was unusually high in 2015. Comparing the two base years therefore provides a direct test of the sensitivity of the decomposition results to this initial observation.

The annual city-level data used in the calculations cover registered fatalities, injured persons, hospitalized casualties, population, gross regional product, and the estimated VSL for 2015–2023. The complete dataset, calculation procedures, source links, and access dates are provided in the supplementary materials (Appendix A).

4 | RESULTS

In Almaty, the number of injured persons fell from 6,559 in 2015 to 4,012 in 2023, a reduction of 38.8%, while fatalities declined from 159 to 142, or by 10.7%. Fatalities reached their lowest level in 2020 and 2021, at 84 in each year. In Astana, the number of injured persons increased from 761 to 907, or by 19.2%, while fatalities declined from 57 to 35. These absolute figures should be considered in the context of demographic change: Almaty's population increased from 1.68 million to 2.20 million over the period, while Astana's population grew from 0.87 million to 1.39 million.

Population-normalized indicators declined in both cities. In Almaty, fatalities decreased from 9.48 to 6.47 per 100,000 residents, while injuries declined from 391.16 to 182.76 per 100,000 residents. In Astana, the corresponding rates decreased from 6.56 to 2.51 for fatalities and from 87.57 to 65.14 for injuries. However, population-based rates do not account for transport exposure; exposure-based indicators, such as rates per vehicle-kilometer travelled, would provide a more appropriate measure of road traffic risk.

Hospitalization shares differed markedly between the two cities. In Almaty, the share was 28.6% in 2015 and ranged from 10.3% to 14.4% thereafter. In Astana, it ranged from 69.9% to 73.7% during 2015–2019 and from 54.0% to 58.5% during 2020–2023. The abrupt shift in Almaty between 2015 and 2016 may reflect changes in referral pathways, admission thresholds, or reporting practices, although the available data do not allow these potential administrative explanations to be distinguished. The influence of the 2015 observation is therefore assessed through a separate calculation for 2016–2023 rather than by excluding it from the baseline calculation.

The baseline VSL, expressed in constant 2023 prices, increased from KZT 319.91 million in 2015 to KZT 396.45 million in 2023. The trend was not monotonic, with declines observed in 2016 and 2020 following decreases in real GNI per capita. In 2023, the low, baseline, and high VSL estimates were KZT 302.94 million, KZT 396.45 million, and KZT 500.44 million, respectively.

Table 3 reports the annual monetized burden, its ratio to GRP, and the corresponding per capita values.

In Almaty, the baseline burden declined from KZT 143.87 billion in 2015 to a low of KZT 59.39 billion in 2020, before rising to KZT 91.90 billion in 2023. The minimum coincided with pandemic mobility restrictions, but the descriptive design cannot identify a causal effect of COVID-19 or separate it from other factors. The 2023 value remained 36.1% below the 2015 level. On a per capita basis, the decline was 51.2%, and the ratio to GRP fell from 0.757% to 0.364%. The elevated official count of hospitalized casualties materially affects the 2015 estimate, so the initial level should not be interpreted solely as evidence of a change in the underlying severity of crashes.

Table 3. Annual baseline burden and normalized indicators

Year	Almaty, KZT billion	Almaty, % of GRP	Almaty, KZT per capita	Astana, KZT billion	Astana, % of GRP	Astana, KZT per capita
2015	143.87	0.757	85,798	42.17	0.420	48,522
2016	98.31	0.508	56,771	35.76	0.403	38,498
2017	90.42	0.448	50,763	38.69	0.394	38,388
2018	89.75	0.462	48,966	28.91	0.269	27,250
2019	93.18	0.453	49,293	28.58	0.240	25,666
2020	59.39	0.310	30,430	24.18	0.213	20,728
2021	65.61	0.332	32,710	29.78	0.253	24,443
2022	77.32	0.352	36,272	33.07	0.271	24,955
2023	91.90	0.364	41,861	42.73	0.330	30,692

Note: compiled by the author

In Astana, the burden declined from KZT 42.17 billion in 2015 to KZT 24.18 billion in 2020, but reached KZT 42.73 billion by 2023, 1.3% above its initial absolute level. At the same time, the per capita measure fell from KZT 48,522 to KZT 30,692, or by 36.7%, and the ratio to GRP decreased from 0.420% to 0.330%. The return of the absolute burden to its 2015 level occurred alongside rapid growth in population and the city economy, while the relative indicators continued to improve.

Figure 1 illustrates these contrasting trajectories of the annual monetized burden in Almaty and Astana.

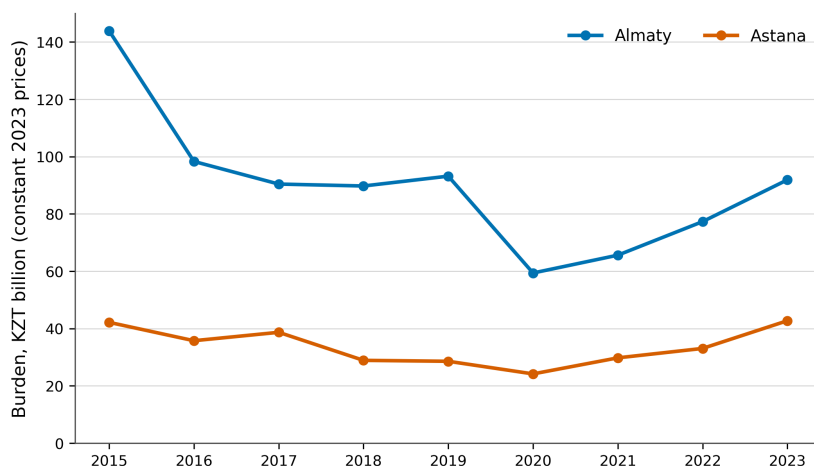


Figure 1. Annual monetized burden of registered fatalities and injuries in Almaty and Astana for 2015–2023

In Almaty, the indicator decreased from 143.87 billion tenge in 2015 to 59.39 billion tenge in 2020, after which it increased to 91.90 billion tenge in 2023. Despite the subsequent increase, the value of 2023 remained below the level of 2015. In Astana, the monetized burden decreased from 42.17 billion tenge in 2015 to 24.18 billion tenge in 2020, and then increased to 42.73 billion tenge in 2023, almost

returning to the initial level. Throughout the study period, the absolute monetized burden in Almaty remained higher than in Astana.

Table 4 reports the components of the cumulative baseline burden over the full period.

Table 4. Cumulative baseline burden for 2015–2023

City	Mortality, KZT billion	Hospitalized injuries, KZT billion	Other injuries, KZT billion	Total, KZT billion	Cumulative burden / cumulative GRP
Almaty	390.27	289.36	130.12	809.75	0.439%
Astana	119.62	176.79	7.47	303.88	0.305%
Two cities	509.89	466.15	137.59	1,113.63	–

Note: compiled by the author

From 2015 through 2023, the baseline monetized burden reached KZT 809.75 billion in Almaty and KZT 303.88 billion in Astana, a ratio of 2.66. Mortality was the largest component in Almaty, accounting for 48.2% of the total; hospitalized injuries contributed 35.7%, and other injuries 16.1%. Astana had a different composition: hospitalized injuries accounted for 58.2%, mortality for 39.4%, and other injuries for only 2.5%. This contrast follows directly from Astana's high administratively recorded hospitalization share; the data support administrative interpretation, while clinical severity remains unresolved.

Table 5 summarizes the scenario analysis and structural checks.

Table 5. Parameter sensitivity and structural checks

Scenario / check	Almaty, KZT billion	Astana, KZT billion	Total, KZT billion	Almaty / Astana	Change from baseline model
Low scenario	571.45	205.14	776.58	2.79	–30.3%
Baseline scenario	809.75	303.88	1,113.63	2.66	0.0%
High scenario	1,160.10	429.98	1,590.08	2.70	+42.8%
International VSL transfer function	833.84	312.92	1,146.76	2.66	+3.0%
Baseline model, 2016–2023	665.89	261.71	927.60	2.54	–16.7%
Common national hospitalization share	1,463.12	267.55	1,730.67	5.47	+55.4%
Mortality only	390.27	119.62	509.89	3.26	–54.2%

Note: compiled by the author

The integrated scenarios produce a combined burden ranging from KZT 776.58 billion in the low scenario to KZT 1,590.08 billion in the high scenario. Across all three scenarios, the estimated burden in Almaty remains approximately 2.7 times that in Astana. The international VSL transfer function yields a combined estimate of KZT 1,146.76 billion, which is 3.0% above the baseline estimate.

One-at-a-time sensitivity checks indicate that the 2012 VSL input has the largest effect among the individual valuation parameters. Replacing the baseline VSL with

its low or high value changes the combined estimate by -18.8% and $+18.8\%$, respectively. Changing the hospitalized-injury weight from 13% to 10% or 16% changes the estimate by approximately -9.7% and $+9.7\%$. Varying the income elasticity from 1.0 to 1.4 changes the combined estimate by -3.6% to $+3.7\%$. Changes in the weight assigned to other injuries have a smaller effect: reducing the weight to 0.9% decreases the estimate by 1.2% , whereas increasing it to 1.5% raises the estimate by 6.2% .

Excluding 2015 reduces the cumulative burden by 16.7% , while the Almaty-to-Astana ratio changes only from 2.66 to 2.54 . Standardizing hospitalization shares produces the largest change among the structural checks. Applying the common annual national hospitalization share increases the estimated burden in Almaty to KZT 1,463.12 billion and reduces the estimate for Astana to KZT 267.55 billion. Consequently, the Almaty-to-Astana ratio increases from 2.66 to 5.47 , while the ranking of the two cities remains unchanged.

Table 6 presents the results of the Shapley decomposition using 2015 and 2016 as alternative base years.

Table 6. Endpoint sensitivity of the Shapley decomposition

City	Base period	Change in VSL	Change in Q	VSL effect, KZT billion	Registered-outcomes effect, KZT billion	Total change, KZT billion
Almaty	2015–2023	+23.9%	−48.5%	+26.08	−78.05	−51.97
Almaty	2016–2023	+31.4%	−28.9%	+26.41	−32.82	−6.41
Astana	2015–2023	+23.9%	−18.2%	+9.17	−8.60	+0.57
Astana	2016–2023	+31.4%	−9.1%	+10.72	−3.75	+6.97

Q denotes equivalent registered casualties, with weights of 1.00 for a fatality, 0.13 for a hospitalized casualty, and 0.01 for another injured person. The two Shapley components sum to the total change, apart from numerical rounding

Note: compiled by the author

With 2015 as the base year, Almaty's Q decreased from 449.71 to 231.80 , corresponding to a 48.5% decline. The registered-outcomes effect was KZT -78.05 billion, while the VSL effect was KZT $+26.08$ billion, resulting in a total decline of KZT 51.97 billion. In Astana, the registered-outcomes effect of KZT -8.60 billion was almost fully offset by the VSL effect of KZT $+9.17$ billion, resulting in a small net increase of KZT 0.57 billion.

Using 2016 as the base year produces smaller registered-outcomes effects in both cities. In Almaty, Q decreased from 325.83 to 231.80 , and the registered-outcomes effect fell in magnitude to KZT -32.82 billion. Combined with a VSL effect of KZT $+26.41$ billion, this resulted in a total decline of KZT 6.41 billion. In Astana, Q decreased from 118.53 to 107.79 . The registered-outcomes effect was KZT -3.75 billion, while the VSL effect was KZT $+10.72$ billion, resulting in a net increase of KZT 6.97 billion.

The registered-outcomes effect is negative for both cities under both base-year specifications, while the VSL effect is positive. However, the magnitude of the registered-outcomes effect differs considerably depending on whether 2015 or

2016 is used as the base year.

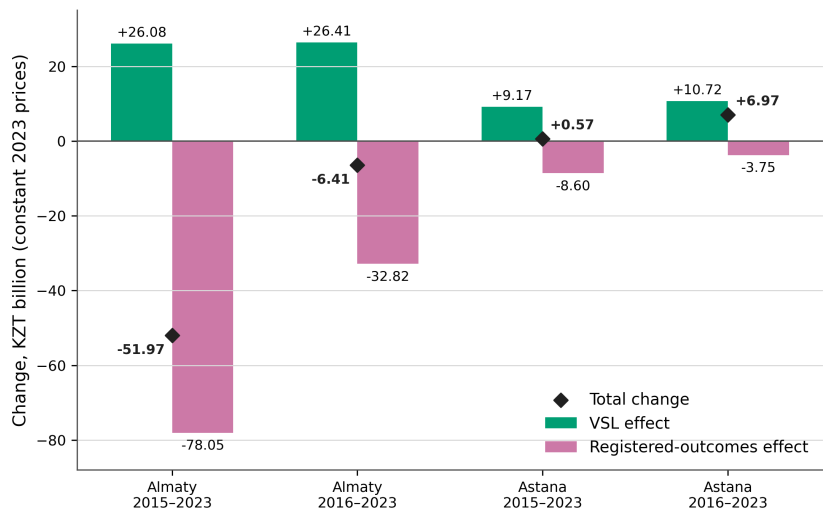


Figure 2. Sensitivity of the Shapley decomposition to the choice of base year

The mortality-only estimate is KZT 509.89 billion, 54.2% below the full baseline model. Omitting injuries would materially understate the burden, particularly in Astana, where hospitalized casualties contribute more than half of the estimate. Overall, the checks confirm substantial losses, Almaty’s higher absolute and relative burden, and declining per capita indicators in both cities. Exact cross-city ratios still require caution because hospitalization practices differ, injuries may be underreported, and GRP is deflated using the national CPI.

5 | DISCUSSION

The principal finding extends beyond the higher monetized burden estimated for Almaty: the difference between the two cities persists after normalization by population and GRP and across the parameter and structural robustness checks. Because the same national VSL is applied to both cities in each year, the cross-city difference reflects the number and administratively recorded composition of casualties, summarized by the weighted casualty indicator *Q*, rather than differences in the monetary value assigned to risk reduction. This accounting relationship does not imply causality. The available data cannot determine whether the observed differences are associated with traffic exposure, speed, road design, enforcement, modal composition, emergency care, or other urban characteristics.

The Shapley decomposition further demonstrates the importance of the choice of base year. With 2015 as the base year, the registered-outcomes effect dominates the valuation effect in Almaty and is almost offset by the valuation effect in Astana. When 2016 is used as the base year, Almaty’s total decline decreases to KZT 6.41 billion, while in Astana the positive VSL effect exceeds the negative registered-outcomes effect, resulting in a KZT 6.97 billion increase. Although

the registered-outcomes effect remains negative in both cities under both specifications, its magnitude is sensitive to the choice of base year. The anomalous hospitalization share observed in Almaty in 2015 therefore cautions against interpreting the full 2015-based decline as a pure improvement in road safety. Similarly, the minimum burden observed in 2020 cannot be causally attributed to pandemic-related mobility restrictions.

The cross-city ranking is more robust than the estimated magnitude of the difference. Almaty retains the higher burden under the low, baseline, and high valuation scenarios, after exclusion of 2015, in the mortality-only calculation, and after normalization by population and GRP. However, applying a common national hospitalization share increases the Almaty-to-Astana ratio from 2.66 to 5.47, indicating that administrative classification substantially affects the estimated size of the difference. The evidence therefore supports the conclusion that Almaty has the larger registered welfare burden, while a precise clinical or causal interpretation of the cross-city gap is not supported by the available data. Until police and medical records are more closely harmonized, the mortality component provides a more directly comparable indicator than the composition of nonfatal injuries.

Comparisons with previous studies require careful consideration of differences in scope. Wijnen (2021) estimated the total national social cost of road crashes at 3.3% of GDP, including property damage, production losses, medical costs, and administrative costs, whereas the World Bank (2022) examined health-system and household costs associated with road traffic injuries in Central Asia. In contrast, the present study estimates registered human welfare losses, with cumulative burden-to-GRP ratios of 0.439% in Almaty and 0.305% in Astana. The lower ratios are consistent with the narrower scope of the present analysis, although the estimates are not directly comparable across studies. The substantial contribution of fatalities and hospitalized casualties is also consistent with previous evidence showing that human losses account for a major share of welfare-based road crash costs (Bouagna et al., 2022; Wijnen & Stipdonk, 2016; Wijnen et al., 2019).

Applying a common national VSL to both cities provides a consistent basis for comparison by assigning the same monetary value to an equivalent reduction in mortality risk. However, local preferences and willingness to pay may differ and can only be assessed through city-specific WTP studies. Accordingly, the results indicate the relative scale of registered welfare losses rather than a direct priority ranking for public expenditure. Decisions on specific road-safety interventions additionally require evidence on expected reductions in fatalities and injuries, implementation costs, feasibility, and the distribution of benefits.

6 | LIMITATIONS

The study has several limitations. First, hospitalization is an administrative proxy for injury severity and is not clinically harmonized with the MAIS3+ classification. Differences in hospitalization practices between Almaty and Astana may therefore affect the estimated composition and magnitude of the nonfatal injury burden. Second, the analysis is based on registered casualties. Nonfatal injuries may be

underreported, while city-, year-, and severity-specific correction factors are unavailable. Third, the valuation results depend on the initial WTP estimate and assumptions regarding income elasticity and injury weights. Finally, the dataset contains only 18 city-year observations and does not include measures of traffic exposure, speed, infrastructure, or enforcement. Consequently, the analysis is descriptive and does not support causal estimates of the effects of specific road-safety policies.

7 | CONCLUSION

The study estimated the monetized welfare burden associated with registered road crash fatalities and injuries in Almaty and Astana during 2015–2023. Under the baseline specification, the cumulative burden amounted to KZT 809.75 billion in Almaty and KZT 303.88 billion in Astana, or approximately KZT 1.114 trillion across the two cities. Almaty had a higher estimated burden not only in absolute terms but also per capita and relative to gross regional product. These estimates represent welfare losses associated with registered casualties and should not be interpreted as direct reductions in economic output or public budgets.

The results are robust to alternative valuation assumptions. Across the low, baseline, and high scenarios, the combined burden ranges from KZT 776.58 billion to KZT 1,590.08 billion, while Almaty consistently remains above Astana. Excluding 2015 changes the Almaty-to-Astana ratio only moderately, from 2.66 to 2.54. However, standardizing hospitalization shares increases the ratio to 5.47, indicating that the magnitude of the cross-city difference is sensitive to administrative classification of nonfatal injuries. Thus, the cross-city ordering is more robust than the estimated size of the gap.

The Shapley decomposition further shows that changes in the monetized burden reflect both changes in registered casualties and changes in the real VSL. The registered-outcomes effect is negative in both cities under both base-year specifications, while the VSL effect is positive. However, the magnitude of these effects is sensitive to whether 2015 or 2016 is used as the base year. In particular, the anomalous hospitalization share observed in Almaty in 2015 substantially affects the estimated temporal change and therefore does not support interpreting the full 2015-based decline as a direct improvement in underlying road safety.

The estimates can serve as monetary benchmarks for the cost-benefit analysis of road-safety interventions when expected reductions in fatalities and injuries and full implementation costs are available. The most robust comparative findings are Almaty's higher registered welfare burden and the mortality component, which is less sensitive to differences in hospitalization practices. Future research should prioritize linkage of police and medical records, clinically harmonized measures of injury severity, city-specific estimates of underreporting, transport-exposure indicators, and local willingness-to-pay studies.

AUTHOR CONTRIBUTIONS

Writing – Original Draft: Kanat Zh. Daubayev.

Conceptualization: Kanat Zh. Daubayev.

Formal Analysis and Investigation: Kanat Zh. Daubayev.

Funding Acquisition and Research Administration: Kanat Zh. Daubayev.

Development of Research Methodology: Kanat Zh. Daubayev.

Software and Supervision: Kanat Zh. Daubayev.

Data Collection, Analysis, and Interpretation: Kanat Zh. Daubayev.

Visualization: Kanat Zh. Daubayev.

Writing – Review and Editing: Kanat Zh. Daubayev.

REFERENCES

- ADB. (2025). *Kazakhstan road crash data review and reporting: Status and recommendations*. Central Asia Regional Economic Cooperation Program. Retrieved May 30, 2026, from https://www.carecp.org/uploads/KAZ-Road-Crash-Data-Review_MAR2025_web.pdf
- Bougna, T., Hundal, G., & Taniform, P. (2022). Quantitative analysis of the social costs of road traffic crashes literature. *Accident Analysis & Prevention*, 165, 106282. <https://doi.org/10.1016/j.aap.2021.106282>
- Bureau of National Statistics. (2025). *Official statistical data*. Retrieved March 15, 2026 from <https://stat.gov.kz/en/>
- Chantith, C., Permpoonwiwat, C. K., & Hamaide, B. (2021). Measure of productivity loss due to road traffic accidents in Thailand. *IATSS Research*, 45(1), 131–136. <https://doi.org/10.1016/j.iatssr.2020.07.001>
- Connelly, L. B., & Supangan, R. (2006). The economic costs of road traffic crashes: Australia, states and territories. *Accident Analysis & Prevention*, 38(6), 1087–1093. <https://doi.org/10.1016/j.aap.2006.04.015>
- Elvik, R. (2000). How much do road accidents cost the national economy? *Accident Analysis & Prevention*, 32(6), 849–851. [https://doi.org/10.1016/S0001-4575\(00\)00015-4](https://doi.org/10.1016/S0001-4575(00)00015-4)
- Hammitt, J. K., & Robinson, L. A. (2011). The income elasticity of the value per statistical life: Transferring estimates between high and low income populations. *Journal of Benefit-Cost Analysis*, 2(1), 1–29. <https://doi.org/10.2202/2152-2812.1009>
- Milligan, C., Kopp, A., Dahdah, S., & Montufar, J. (2014). Value of a statistical life in road safety: A benefit-transfer function with risk-analysis guidance based on developing country data. *Accident Analysis & Prevention*, 71, 236–247. <https://doi.org/10.1016/j.aap.2014.05.026>
- OECD. (2012). *Mortality risk valuation in environment, health and transport policies*. OECD Publishing. <https://doi.org/10.1787/9789264130807-en>
- OECD. (2025). *Mortality risk valuation in policy assessment: A global meta-analysis of value of statistical life studies*. OECD Publishing. <https://doi.org/10.1787/76ca89a2-en>
- Prosecutor General of the Republic of Kazakhstan. (2024). *On amendments to Order No. 131 concerning the reporting of road traffic crashes resulting in death or injury* (Order No. 75, June 12, 2024). Adilet. <https://adilet.zan.kz/rus/docs/V2400034491> (In Russ.)
- Robinson, L. A., Hammitt, J. K., & O’Keeffe, L. (2019). Valuing mortality risk reductions in global benefit-cost analysis. *Journal of Benefit-Cost Analysis*, 10(S1), 15–50. <https://doi.org/10.1017/bca.2018.26>
- Schoeters, A., Large, M., Koning, M., Carnis, L., Daniels, S., Mignot, D., Urmeew, R., Wijnen, W., Bijleveld, F., & van der Horst, M. (2022). Economic valuation of preventing fatal and serious road injuries: Results of a willingness-to-pay study in four European countries. *Accident Analysis & Prevention*, 173, 106705. <https://doi.org/10.1016/j.aap.2022.106705>
- Shorrocks, A. F. (2013). Decomposition procedures for distributional analysis: A unified framework based on the Shapley value. *The Journal of Economic Inequality*, 11, 99–126. <https://doi.org/10.1007/s10888-011-9214-z>
- Taniform, P., Persia, L., Usami, D. S., Kunsoan, N. B., Karumba, M. M., & Wijnen, W. (2023). An assessment of the social costs of road traffic crashes in Cameroon. *Sustainability*, 15(2), 1316. <https://doi.org/10.3390/su15021316>

- Trawén, A., Maraste, P., & Persson, U. (2002). International comparison of costs of a fatal casualty of road accidents in 1990 and 1999. *Accident Analysis & Prevention*, 34(3), 323–332. [https://doi.org/10.1016/S0001-4575\(01\)00029-X](https://doi.org/10.1016/S0001-4575(01)00029-X)
- Viscusi, W. K., & Aldy, J. E. (2003). The value of a statistical life: A critical review of market estimates throughout the world. *Journal of Risk and Uncertainty*, 27(1), 5–76. <https://doi.org/10.1023/A:1025598106257>
- Viscusi, W. K., & Masterman, C. J. (2017). Income elasticities and global values of a statistical life. *Journal of Benefit-Cost Analysis*, 8(2), 226–250. <https://doi.org/10.1017/bca.2017.12>
- Wijnjen, W. (2021). Socio-economic costs of road crashes in middle-income countries: Applying a hybrid approach to Kazakhstan. *IATSS Research*, 45(3), 293–302. <https://doi.org/10.1016/j.iatssr.2020.12.006>
- Wijnjen, W., Dahdah, S., & Pkhikidze, N. (2026). The value of a statistical life in the context of road safety: A new value transfer approach. *Traffic Injury Prevention*, 27(1), 42–49. <https://doi.org/10.1080/15389588.2025.2476607>
- Wijnjen, W., & Stipdonk, H. (2016). Social costs of road crashes: An international analysis. *Accident Analysis & Prevention*, 94, 97–106. <https://doi.org/10.1016/j.aap.2016.05.005>
- Wijnjen, W., Weijermars, W., Schoeters, A., van den Berghe, W., Bauer, R., Carnis, L., Elvik, R., & Martensen, H. (2019). An analysis of official road crash cost estimates in European countries. *Safety Science*, 113, 318–327. <https://doi.org/10.1016/j.ssci.2018.12.004>
- Wisutwattanasak, P., Jomnonkwao, S., Khampirat, B., Raungratanaamporn, I.-S., & Ratanavaraha, V. (2024). Multilevel structural equation modeling of willingness-to-pay for fatality risk reduction: Perspectives of driver and district levels. *International Journal of Injury Control and Safety Promotion*, 31(1), 96–110. <https://doi.org/10.1080/17457300.2023.2266841>
- World Bank. (2022). *Socioeconomic impacts of road traffic injuries in Central Asia*. Retrieved May 30, 2026, from <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099655004252264808>
- World Bank. (2025). *World Development Indicators*. Retrieved May 30, 2026, from <https://databank.worldbank.org/source/world-development-indicators>
- WHO. (2023). *Global status report on road safety 2023*. Retrieved May 30, 2026, from <https://www.who.int/publications/i/item/9789240086517>

AUTHOR BIOGRAPHIES

Kanat Zh. Daubayev – Doc. Sc. (Econ.), Institute of Logistics and Business, ALT University named after Mukhamedzhan Tynyshpayev, Almaty, Kazakhstan, email: k.daubaev@alt.edu.kz, ORCID ID: <https://orcid.org/0009-0004-2033-2181>

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APPENDIX A. INPUT DATA USED IN THE CALCULATIONS

Panel A. Registered casualty inputs

Year	Almaty fatalities	Almaty injured	Almaty hospitalized	Astana fatalities	Astana injured	Astana hospitalized
2015	159	6,559	1,876	57	761	560
2016	156	6,231	896	42	777	573
2017	136	6,059	722	60	624	458
2018	133	5,352	684	34	559	391
2019	144	4,387	628	28	546	394
2020	84	3,807	419	31	521	283
2021	84	3,759	492	35	595	342
2022	96	4,364	475	28	750	405
2023	142	4,012	414	35	907	531

Note: compiled by the author

Panel B. Valuation and normalization inputs

Year	Baseline VSL, KZT million	Almaty population	Almaty GRP, KZT billion	Astana population	Astana GRP, KZT billion
2015	319.907	1,676,792	18,992.46	869,021	10,038.11
2016	301.723	1,731,687	19,347.39	928,965	8,879.17
2017	319.257	1,781,272	20,201.53	1,007,961	9,810.32
2018	334.146	1,832,948	19,411.73	1,060,809	10,729.31
2019	353.996	1,890,394	20,577.08	1,113,591	11,900.67
2020	344.601	1,951,746	19,157.65	1,166,590	11,351.41
2021	363.228	2,005,788	19,760.87	1,218,389	11,755.97
2022	393.212	2,131,693	21,937.22	1,325,135	12,222.93
2023	396.445	2,195,288	25,229.71	1,392,332	12,960.84

Note: compiled by the author