

Estimation of total road traffic deaths for year 2016: WHO data and methodology

Background

During the process of preparing the fourth Global status report on road safety WHO updated the estimation of the total road traffic deaths for 2016 for all Member States. For each report the model has been improved and used updated data for the covariates.

For the first WHO *Global status report on road safety* (WHO 2009), WHO used a regression model based on reported road traffic deaths for countries classified as having good Vital Registration (VR) systems (a marker of good statistical systems) to predict road traffic deaths for 2007. For those countries without such good VR data, the estimates were based on covariates (some collected in the survey of Member States, others from available published sources). Separately, WHO has also estimated road traffic deaths using death registration data reported to WHO by Member States and from other sources of information on causes of death in regions with low coverage of death registration systems (WHO 2008).

For the second WHO *Global status report on road safety* published in March 2013, the WHO conducted a second survey in which 182 Member States participated and updated the estimates of road traffic deaths for 2010.

For the second report, estimation methods were improved by utilization of death registration data meeting a certain quality criteria and the total road traffic deaths from the second survey from national road traffic injury surveillance systems as well as from other information on population level injury deaths for some countries. In addition, an improved regression model to estimate road traffic deaths (all ages, both sexes) as a function of a set of covariates that include measures of economic development, road transport factors and legislation, road use and safety governance/enforcement and health system access was developed. The regression model used death registration data for the period 1950-2010 that were 80% or more complete for a given year or where the average completeness for last decade was greater or equal to 80%. Death registration information is submitted to WHO regularly by Ministries of Health from around the world, and most is coded using the International Classification of Diseases 9th or 10th revisions (WHO). The regression model produces estimates of total road traffic deaths according to the accepted International Classification of Disease definition, which counts all deaths that follow from a road traffic death, regardless of the time period in which they occur (unlike many official road traffic surveillance data sources, where road traffic death data are based on a 30-day definition following a road traffic crash). Where total deaths reported from the national surveillance system were greater than the deaths estimated from the regression or from the death registration data, these were used.

For this fourth WHO *Global status report on road safety*, the WHO Department of Management of Noncommunicable Diseases, Disability, Violence and Injury Prevention(NVI) conducted a fourth survey in which 175 Member States participated and updated the estimates of road traffic deaths for all WHO Member States for 2016.

For the fourth report, the road traffic deaths were estimated by building on the methods used in the second and third global report on road safety by improving and updating the database of vital registration, the data collection instrument (survey) and the database of the covariates for regressions.

The regression models used were the same as those of the second and third reports with updated VR data for the period 2000-2016. The regression models were fitted to data for the period 2000-2016, a time series for each covariate was used for this period for each Member States.

As in the second and third reports, there are four groups of countries and its estimation methodology is described in detail below.

1. Countries with death registration data

This group includes 86 countries with death registration data meeting the following completeness criteria: completeness for the year estimated at 80% or more, or average completeness for the decade including the country-year was 80% or more. Total road traffic deaths were calculated from the death registration data and population data reported to WHO as follows. Injury deaths classified as “undetermined intent” were redistributed pro-rata across all unintentional and intentional injury categories within age-sex groups. These data were then used to compute age-sex-specific death rates for road traffic deaths. Where completeness was assessed at less than 100%, death rates were adjusted for incompleteness by multiplying by (100/completeness %). These death rates were applied to the UN estimates of population by 5-year age group and sex (World Population Prospects 2016) to estimate total road traffic deaths for each country-year.

These countries fall into three categories:

1. Countries with death registration data for year 2016 where the estimated road traffic deaths for 2016 exceeded number reported from the surveillance system. The death-registration based estimate is used. This category contains 3 countries.
2. Countries where the latest death registration data submitted to WHO is earlier than 2015 but not earlier than 2007. Deaths in year 2016 were estimated based on a projection of the most recent death registration data using the trends in reported surveillance data: this category contains 58 countries.
3. Countries where the reported number of road traffic deaths adjusted to unlimited time for 2016 exceeded the estimate based on death registration data. For 25 countries, the reported road traffic deaths were used for year 2016.

2. Countries with other sources of information on causes of death

For India, Thailand and Viet Nam, data on total deaths by cause were available for a single year or very few earlier years. These data sources are documented in Annex B of the *Global Burden of Disease: 2004 update* report (WHO 2008) and as well as some more recent studies submitted to WHO. For these countries, the regression method described below was used to project forward from the most recent year for which an estimate of total road traffic deaths were available.

3. Countries with populations less than 150 000

For 9 small countries with populations less than 150 000 and which did not have eligible death registration data, regression estimates were not used. The reported deaths were used directly without adjustment.

4. Countries without eligible death registration data

For these countries without death registration data at least 80% complete and with populations greater than 150 000, a regression model was used to estimate total road traffic deaths. As for the first report, we used a negative binomial regression model, appropriate for modeling non-negative integer count data (number of road traffic deaths) (Law 2009, Hilbe 2007). A likelihood ratio test was used to assess that the negative binomial model provided a better fit to the data than a Poisson model (where the variance of the data is constrained to equal the mean).

$$\ln N = C + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \ln Pop + \varepsilon \quad (1)$$

where N is the total road traffic deaths (for a country-year), C is a constant term, X_i are a set of explanatory covariates, Pop is the population for the country-year, and ε is the negative binomial error term. Population was used as exposure, making it possible to interpret the coefficients (β_i) for the independent variables as effects on rates rather than a count. In a previous study, this type of model was used to represent "accident proneness" (Greenwood and Yule, 1920). Karlaftis and Tarko (1998) have also found a negative binomial regression model to be the appropriate for count data such as road traffic fatalities.

The parameters $\beta_1, \beta_2, \beta_3 \dots \beta_n$ (equation 1) were estimated by fitting the negative binomial regression model to estimated total road traffic deaths for all country-years in the range 2000-2016 meeting the completeness criteria. by using the number of road of traffic deaths from countries from group 1 described above. We chose three models (Models A, B and C) that had good in-sample- and out-of-sample fit, and for which all the covariates were statistically significant and overall estimation is the average of the prediction of these three best models. The table below describes the covariates used for our model:

Independent variables	Description	Source of information	Included in models
ln(GDP)	WHO estimates of Gross Domestic Product (GDP) per capita (international dollars or purchasing power parity dollars, 2011 base)	WHO database	Models A, B, C
ln(vehicles per capita)	Total vehicles per 1000 persons	GSRRS surveys and WHO database	Models A, B, C
Road density	Total roads (km) per 1000 hectares	International Futures database	Models A, B, C
National speed limits on rural roads	The maximum national speed limits on rural roads (km/h) from WHO questionnaire	GSRRS survey	Models A, B, C
National speed limits on urban roads	The maximum national speed limits on urban roads (km/h) from WHO questionnaire	GSRRS survey	Models A, B, C

Health system access	Health system access variable (principal component score based on a set of coverage indicators for each country)	Institute for Health Metrics and Evaluation dataset	Models A, B, C
Alcohol apparent consumption	Liters of alcohol (recorded plus unrecorded) per adult aged 15+	WHO database	Models A, B, C
Population working	Proportion of population aged 15-64 years	World Population Prospects 2016 revision (UNDESA)	Models A, B, C
Percentage motorbikes	Per cent of total vehicles that are motorbikes	GSRRS survey	Model B
Corruption index	Control of corruption index (units range from about -2.5 to +2.5 with higher values corresponding to better control of corruption)	World Bank (Kaufmann et al 2009), International Futures database	Model B
National policies <i>for walking /cycling</i>	Existence of national policies that encourage walking and / or cycling	GSRRS survey	Model C
Population	Total population (used as offset in negative binomial regression)	World Population Prospects 2016 revision (UNDESA)	Models A, B, C

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Annex 1

Country	Method	Latest death registration data	Classification of the countries
Afghanistan	Regression estimate		Group4
Albania	Regression estimate		Group4
Angola	Regression estimate		Group4
Antigua and Barbuda	Death reported (small population)	2015	Group3
Argentina	Projected death registration data	2014	Group1
Armenia	Regression estimate		Group4
Australia	Projected death registration data	2015	Group1
Austria	Projected death registration data	2015	Group1
Azerbaijan	Reported adjusted deaths (replacing death registration estimate)	2007	Group1
Bangladesh	Regression estimate		Group4
Barbados	Projected death registration data	2013	Group1
Belarus	Projected death registration data	2011	Group1
Belgium	Reported adjusted deaths (replacing death registration estimate)	2014	Group1
Belize	Reported adjusted deaths (replacing death registration estimate)	2015	Group1
Benin	Regression estimate		Group4
Bhutan	Regression estimate		Group4
Bolivia (Plurinational State of)	Regression estimate		Group4
Bosnia and Herzegovina	Regression estimate		Group4
Botswana	Regression estimate		Group4
Brazil	Projected death registration data	2015	Group1
Bulgaria	Reported adjusted deaths (replacing death registration estimate)	2014	Group1

Burkina Faso	Regression estimate		Group4
Burundi	Regression estimate		Group4
Cabo Verde	Regression estimate		Group4
Cambodia	Regression estimate		Group4
Cameroon	Regression estimate		Group4
Canada	Projected death registration data	2013	Group1
Central African Republic	Regression estimate		Group4
Chad	Regression estimate		Group4
Chile	Reported adjusted deaths (replacing death registration estimate)	2015	Group1
China	Projected death registration data	2012	Group1
Colombia	Projected death registration data	2013	Group1
Comoros	Regression estimate		Group4
Congo	Regression estimate		Group4
Cook Islands	Death reported (small population)		Group3
Costa Rica	Projected death registration data	2014	Group1
Côte d'Ivoire	Regression estimate		Group4
Croatia	Projected death registration data	2015	Group1
Cuba	Projected death registration data	2015	Group1
Cyprus	Projected death registration data	2015	Group1
Czech Republic	Reported adjusted deaths (replacing death registration estimate)	2015	Group1
Democratic Republic of the Congo	Regression estimate		Group4
Denmark	Projected death registration data	2015	Group1
Dominica	Death reported (small population)	2015	Group3
Dominican Republic	Projected death registration data	2013	Group1
Ecuador	Projected death registration data	2015	Group1

Egypt	Projected death registration data	2015	Group1
El Salvador	Projected death registration data	2014	Group1
Equatorial Guinea	Regression estimate		Group4
Eritrea	Regression estimate		Group4
Estonia	Projected death registration data	2015	Group1
Ethiopia	Regression estimate		Group4
Fiji	Projected death registration data	2012	Group1
Finland	Reported adjusted deaths (replacing death registration estimate)	2015	Group1
France	Reported adjusted deaths (replacing death registration estimate)	2014	Group1
Gabon	Regression estimate		Group4
Gambia	Regression estimate		Group4
Georgia	Reported adjusted deaths (replacing death registration estimate)	2014	Group1
Germany	Projected death registration data	2015	Group1
Ghana	Regression estimate		Group4
Greece	Projected death registration data	2014	Group1
Grenada	Death reported (small population)	2016	Group3
Guatemala	Reported adjusted deaths (replacing death registration estimate)	2015	Group1
Guinea	Regression estimate		Group4
Guinea-Bissau	Regression estimate		Group4
Guyana	Projected death registration data	2013	Group1
Honduras	Regression estimate		Group4
Hungary	Projected death registration data	2015	Group1
Iceland	Death registration data	2016	Group1
India	Regression estimate projected from 2001-2003 & 2010-2013 data	2002 & 2005	Group2

Indonesia	Regression estimate		Group4
Iran (Islamic Republic of)	Reported adjusted deaths (replacing death registration estimate)	2016	Group1
Iraq	Regression estimate		Group4
Ireland	Reported adjusted deaths (replacing death registration estimate)	2014	Group1
Israel	Reported adjusted deaths (replacing death registration estimate)	2015	Group1
Italy	Projected death registration data	2014	Group1
Jamaica	Reported adjusted deaths (replacing death registration estimate)	2011	Group1
Japan	Projected death registration data	2015	Group1
Jordan	Regression estimate		Group4
Kazakhstan	Projected death registration data	2015	Group1
Kenya	Regression estimate		Group4
Kiribati	Death reported (small population)		Group3
Kuwait	Projected death registration data	2014	Group1
Kyrgyzstan	Projected death registration data	2015	Group1
Lao People's Democratic Republic	Regression estimate		Group4
Latvia	Projected death registration data	2015	Group1
Lebanon	Regression estimate		Group4
Lesotho	Regression estimate		Group4
Liberia	Regression estimate		Group4
Libya	Regression estimate		Group4
Lithuania	Projected death registration data	2015	Group1
Luxembourg	Reported adjusted deaths (replacing death registration estimate)	2015	Group1
Madagascar	Regression estimate		Group4
Malawi	Regression estimate		Group4

Malaysia	Regression estimate		Group4
Maldives	Reported adjusted deaths (replacing death registration estimate)	2011	Group1
Mali	Regression estimate		Group4
Malta	Projected death registration data	2014	Group1
Mauritania	Regression estimate		Group4
Mauritius	Death registration data	2016	Group1
Mexico	Reported adjusted deaths (replacing death registration estimate)	2015	Group1
Micronesia (Federated States of)	Death reported (small population)		Group3
Mongolia	Regression estimate		Group4
Montenegro	Reported adjusted deaths (replacing death registration estimate)	2009	Group1
Morocco	Regression estimate		Group4
Mozambique	Regression estimate		Group4
Myanmar	Regression estimate		Group4
Namibia	Regression estimate		Group4
Nepal	Regression estimate		Group4
Netherlands	Reported adjusted deaths (replacing death registration estimate)	2015	Group1
New Zealand	Projected death registration data	2013	Group1
Niger	Regression estimate		Group4
Nigeria	Regression estimate		Group4
Norway	Projected death registration data	2015	Group1
Oman	Reported adjusted deaths (replacing death registration estimate)	2014	Group1
Pakistan	Regression estimate		Group4
Panama	Projected death registration data	2015	Group1
Papua New Guinea	Regression estimate		Group4
Paraguay	Projected death registration data	2014	Group1
Peru	Regression estimate		Group4

Philippines	Projected death registration data	2011	Group1
Poland	Projected death registration data	2015	Group1
Portugal	Projected death registration data	2014	Group1
Qatar	Projected death registration data	2015	Group1
Republic of Korea	Projected death registration data	2015	Group1
Republic of Moldova	Death registration data	2016	Group1
Romania	Projected death registration data	2015	Group1
Russian Federation	Projected death registration data	2011	Group1
Rwanda	Regression estimate		Group4
Saint Lucia	Projected death registration data	2014	Group1
Samoa	Regression estimate		Group4
San Marino	Death reported (small population)	2015	Group3
Sao Tome and Principe	Regression estimate		Group4
Saudi Arabia	Regression estimate		Group4
Senegal	Regression estimate		Group4
Serbia	Projected death registration data	2015	Group1
Seychelles	Death reported (small population)	2012	Group3
Singapore	Projected death registration data	2015	Group1
Slovakia	Projected death registration data	2014	Group1
Slovenia	Reported adjusted deaths (replacing death registration estimate)	2015	Group1
Solomon Islands	Regression estimate		Group4
Somalia	Regression estimate		Group4
South Africa	Reported adjusted deaths (replacing death registration estimate)	2015	Group1
South Sudan	Regression estimate		Group4
Spain	Projected death registration data	2015	Group1

Sri Lanka	Regression estimate		Group4
Sudan	Regression estimate		Group4
Suriname	Projected death registration data	2014	Group1
Swaziland	Regression estimate		Group4
Sweden	Projected death registration data	2015	Group1
Switzerland	Reported adjusted deaths (replacing death registration estimate)	2015	Group1
Syrian Arab Republic	Regression estimate		Group4
Tajikistan	Regression estimate		Group4
Thailand	Projected death registration data	2005	Group2
The former Yugoslav Republic of Macedonia	Reported adjusted deaths (replacing death registration estimate)	2013	Group1
Timor-Leste	Regression estimate		Group4
Togo	Regression estimate		Group4
Tonga	Death reported (small population)		Group3
Trinidad and Tobago	Projected death registration data	2011	Group1
Tunisia	Regression estimate		Group4
Turkey	Projected death registration data	2015	Group1
Turkmenistan	Regression estimate		Group4
Uganda	Regression estimate		Group4
Ukraine	Projected death registration data	2012	Group1
United Arab Emirates	Regression estimate		Group4
United Kingdom	Projected death registration data	2015	Group1
United Republic of Tanzania	Regression estimate		Group4
United States of America	Projected death registration data	2015	Group1
Uruguay	Reported adjusted deaths (replacing death registration estimate)	2015	Group1
Uzbekistan	Projected death registration data	2014	Group1
Vanuatu	Regression estimate		Group4

Venezuela (Bolivarian Republic of)	Projected death registration data	2013	Group1
Viet Nam	Projected national verbal autopsy survey data	2006	Group2
West Bank and Gaza Strip	Projected death registration data		Group1
Zimbabwe	Regression estimate		Group4