The Cost of Drowning

TECHNICAL STATEMENT SUPPORTING FRONTIER'S REPORT ON THE COST OF DROWNING FOR THE RNLI

October 2015

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Introduction and acknowledgements

This technical statement serves to provide additional insights into the analysis that is presented in the full report on the cost of drowning prepared by Frontier Economics for the RNLI.

- Annex 1 presents the best available evidence and literature on the components of the cost of drowning, the number of drowning fatalities and the VSL, adding insights into the methodological framework presented on pages six to ten.
- Annex 2 then relates to the rule of thumb approach, outlining the data collection and adjustment process in more depth and presenting the methodology and results. The former is the underlying base for pages eleven to thirteen of the full report, while the results refer to page fourteen of the full report.
- Annex 3 gives an overview of the final cost estimation. It shows the data collection and adjustments process for this step and presents a list of the results for all countries individually. This adds background to slides fifteen and sixteen.
- Annex 4 includes testing the results for sensitivities to the main assumptions drawn and an extension of the analyses using additional data and discusses area for future work. This section purely adds to the main analysis and is not referenced in the full report.

This work has drawn heavily upon previous work, and we must also acknowledge some significant contributions. In particular, we are indebted to

- previous work by McMahon and Dahdah (2009), looking at road traffic accidents, from which our methodology has been developed;
- two academic advisors who have provided critical review of the methodology and outputs and helped guiding sensibility checks: Professor John Appleby, Chief Economist at the King's Fund who is a specialist in health policy and Dr. Ulla Griffiths from the London School of Hygiene & tropical Medicine (LSHTM); and
- the RNLI for providing expert guidance on drowning data availability and interpretation.

1 Annex 1: Literature review

Annex 1 presents the best available evidence and literature on the components of the cost of drowning, the number of drowning fatalities and the VSL, adding insights into the methodological framework presented on pages six to ten. The focus of this review is on any estimates for these values, rather than on these issues more generally.

1.1 The cost of drowning

There is quite a wide literature on the incidence and impact of drowning. The WHO's 2014 Global Report on Drowning is a good recent summary. However, examples of empirical work on the costs associated with drowning are much more limited.

One source is work for the Accident Compensation Corporation in New Zealand undertaken in 2009.[1] This report estimated in New Zealand over 1,200 fatalities are avoided each year through rescue activities, with an estimated economic value of $4.28 billion per year.

A second example is taken from the Royal Life Saving Society Australia.[2] They report estimates for the cost of fatal drowning between $370,000 and $610,467.

These reports have focused on a particular country, whereas the focus for this study is the cost of drowning worldwide, across all countries for which this is possible.

1.2 The value of statistical life

There is a very wide academic literature on the Value of a Statistical Life (VSL). The work by McMahon and Dahdah (2009) for the International Road Assessment Programme (iRAP) serves as a good basis on which to understand this concept and contains a simple and replicable approach to estimate VSLs that is commonly used across the literature.[3] Another good summary of the general concept of VSL – albeit now slightly dated – is Viscusi and Aldy (2003)[4] who

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1 Available at http://www.acc.co.nz/publications/index.htm?ssBrowseSubCategory=Drowning%20Prevention%20Strategy

2 See their 2005 Annual Drowning Report at http://www.royallifesaving.com.au/facts-and-figures/research-and-reports/drowning-reports

3 McMahon and Dahdah (2009) "The true cost of road crashes: Valuing life and the cost of serious injury", International Road Assessment Programme. Available at www.irap.net

4 W. Kip Viscusi and Joseph E. Aldy (2003) "The Value of a Statistical Life: A Critical Review of Market Estimates throughout the World", *working paper from the* NBER.

have reviewed more than 60 studies which have attempted to estimate VSL. Moreover, Cropper and Sahin (2009)[5] summarise additional studies around the VSL and discuss certain aspects of the reliability of the underlying methodology.

We build on this existing literature and evidence with two main objectives:

1) to summarise the key methodological issues when estimating and applying VSL, as relevant to the RNLI's requirements; and
2) to identify the most recent estimates of VSL for as many countries as possible worldwide.

The results drawn from the second objective are outlined in the next section.

McMahon and Dahdah (2009)

McMahon and Dahdah (2009) point out that there are two main methods to estimate the benefits of fatality prevention:

1) the 'Human capital' or 'lost output' method, and
2) the 'willingness-to-pay' method.

The first method is an ex-post approach which values death in accordance with its economic impact. The main component of the value is the discounted present value of the victim's future output forgone due to death; medical costs are also included and sometimes a pain, grief and suffering component is added. The literature we reviewed doesn't provide much more detail on this method.

The willingness-to-pay is an ex-ante approach that estimates the value that individuals attach to prevention based on the amount of money that they would be prepared to spend to reduce the risk of loss of life. It involves some risk assessment and the willingness of individuals to use resources in order to reduce the risk of loss of life to an acceptable level; it represents a social cost-benefit analysis, showing preferences of those who will be affected by the policy decision. The method is based on contingent valuation, using either stated preferences, or more often, revealed preferences.

The authors appreciate that the willingness-to-pay approach is conceptually appealing and generally the preferred method, but that obtaining these values (particularly in undeveloped countries) through survey techniques is extremely costly and difficult. They therefore develop an alternative 'rule of thumb' approach that draws on the available data from both the human capital and the willingness-to-pay studies identifying the relationship of VSL and income (ratio) to be able to extrapolate values for the missing countries.

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5 Cropper, Maureen L. and Sahin, Sebnem (2009). "Valuing Mortality and Morbidity in the Context of Disaster Risk," *working paper from the World Bank*.

We have adopted and tested McMahon and Dahdah's methodological approach in the main analysis. Our analysis added to their work, with the addition of a few extra estimates of VSL incorporated in our estimate of a "rule of thumb". Our work supports the findings of McMahon and Dahdah. This is outlined in page eleven in the full report and empirically evidenced in Annex 3.

Viscusi and Aldy (2003)

Viscusi and Aldy (2003) discuss two types of willingness-to-pay estimations using revealed preferences in more detail:

- wage-risk trade-off, and
- rice-risk trade-off.

The wage-risk trade-off approach measures how much the risk of death on the job increases the wage; in this case, the term 'willingness-to-accept' might be more appropriate to use.

The value of the trade-off is obtained by estimating a hedonic wage equation, where wage rate is regressed on fatality risk and other covariates, such as characteristics of the job or the worker, injury risk and injury compensation benefits. The VSL is then obtained from the coefficient on the risk of fatality from the regression, β, using the following formula:

$$VSL = w * \beta * X \frac{hours}{year} * Y,$$

where w is the hour wage, X is the amount of hours worked annually on a full basis (e.g. 2,000) and Y is the denominator of the risk variable (e.g. 100,000).

This approach has a number of difficulties, such as:

- errors in risk measurement (incomplete reporting);
- potential omitted variable and endogeneity bias, for example the non-pecuniary characteristics of a job that make it unpleasant and are also correlated with risk; or
- heterogeneity in risk preferences of workers in different professions.

An alternative way to extract willingness-to-pay estimates is to use housing and product market decisions – the price-risk trade-off information can be obtained by estimating a hedonic price equation. Viscusi and Aldy (2003) mention examples of this method based on products like seatbelt use, cigarette smoking, home fire detectors, automobile safety, bicycle helmets and housing prices relative to hazardous waste site risks. These studies usually find VSLs of similar magnitude as wage equations, but they tend to be a little lower.

Some of the difficulties in using price equations involve:

- no continuum of price-risk opportunities (instead discrete choices which reveal only the lower bound on the WTP for the reduced risk);
- selection bias based on risk preferences, for example the smoking population is not a random sample; and
- values might be based on inferred, rather than observed price-risk trade-offs, for example in the case of seatbelt use, one needs to make assumptions about the length of time needed to secure the seatbelt and then monetize this time.

Cropper and Sahin (2009)

Cropper and Sahin (2009) dedicated a chapter to the VSL methodology in their World Bank working paper on valuing mortality and morbidity in disaster risks. An interesting point that they raise is the discussion around the use of a single rule of thumb for both developing and developed countries. Their key points are as summarised below:

- Estimating the VSL across countries by means of a single rule of thumb (VSL to income ratio) assumes that preferences, such as attitudes towards risk or discount rates, and survival probabilities are constant across countries. However, they argue that this might not always be the case as these factors are likely to be correlated with income and may therefore differ between developing and developed countries.
- However, if the income elasticity is found to be one, this would imply that the ratio of VSL to income per capita is constant across countries with different income levels.[6]

To validate their discussion, they provide results on the ratio of the VSL to income per capita which imply that there might be differences between developing and developed countries:

- Miller (2000)[7] found a ratio of 140:1 based on results from 13 high income countries and Kochi et al. (2006) found a ratio of 140:1 across a range of studies in the US;

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6 Income elasticity of VSL measures its responsiveness to changes in income; it is calculated as % change in VSL over % change in income. More precise, an income elasticity of one implies that 1% increase in income translates into 1% increase in the value of VSL. If income elasticity was bigger than 1%, each 1% of increase in income would mean more than 1% increase in the value of VSL. This means that VSL would increase more than proportionally for countries with higher income, in which case the ratio of VSL/GDP per capita among the countries with high income would be higher than that for poorer countries. Opposite case would take place if income elasticity was less than 1.

7 Miller, T.R. (2000). "Variations between Countries in Values of Statistical Life", *Journal of Transport Economics and Policy* 34(2), 169-188

- Robinson (2008)[8] found a ratio closer to 80:1 using VSLs from 11 middle-income countries; and
- Liu, Hammitt and Liu (1997)[9] found a ratio of 77:1 in Taiwan and Wang and Mullahy (2006)[10] found a ratio of 70:1 in China.

Given these results, Cropper and Sahin conclude that using a single ratio based on studies from developed countries (140:1) might overstate the value of VSLs in developing countries. One solution they propose is the use of Robinson's ratio of 80:1 that is based on data from middle income countries and to apply it to all the countries.

Moreover, the authors referred to other meta-analyses which helped us gather more VSL observations for additional countries (Miller (2000); Guo and Hammit (2009)[11]; Bowland and Beghin (2001)[12]; and Robinson and Hammit, (2009)[13]).

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8 Referenced by Cropper and Sahin (2009) as: Robinson, Lisa A (2008), Personal communication

9 Liu, J-T., J.K. Hammitt, and J-L Liu (1997) "Estimated Hedonic Wage Function and Value of Life in a Developing Country" *Economic Letters* 57(3):353-58

10 Wang, H., and J. Mullahy (2006) "Willingness to Pay for Reducing Fatal Risk by Improving Air Quality: A Contingent Valuation Study in Chongqing, China", *Science of the Total Environment* 367:50-57

11 Guo, X. and Hammitt, J. K. (2009) "Compensating Wage Differentials with Unemployment: Evidence from China", *Journal of Environmental and Resource Economics*, 42 (2), 187-209

12 Bowland, B. J. and Beghin, J.C. (2001) 'Robust Estimates of Value of a Statistical Life for Developing Economies", *Journal of Policy Modelling* 23, 385-396

13 Hammitt, James K. and Robinson, Lisa A. (2009) "The Income Elasticity of the Value per Statistical Life: Transferring Estimates between High and Low Income Populations," *Journal of Benefit-Cost Analysis*, 2(1), Article 1

2 Annex 2: The rule of thumb

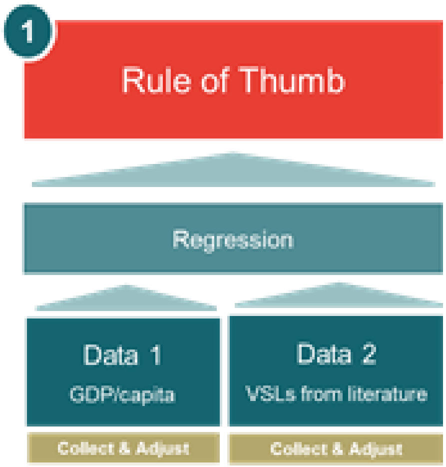
Generally, the 'rule of thumb' approach is a replication of the work by McMahon and Dahdah (2009) as explained previously, albeit extended using a slightly larger dataset on VSLs and an independently collected dataset on GDP per capita as outlined below. This adds robustness to the estimate and allows for comparison to check sensibility of the results.

2.1 Data collection and adjustments

To run the regression to develop the rule of thumb, we collect VSLs evidenced in the literature and gather matching GDP per capita data on these countries as outlined in **Figure 1**.

This sub-section is the underlying base for pages nine to eleven of the full report

Figure 1. Underlying data for the rule of thumb



The estimation of the rule of thumb via the use of a simple regression[14] requires the construction of the variable *'VSLs as a ratio of GDP per capita'*.[15] Both dataset 1 (GDP per capita) and dataset 2 (VSLs from the literature) are therefore required to be expressed in the same unit of the same year, individually for each country. For both datasets, this requires some adjustments to the data collected.

The base year is the year of the study and the common unit is:

- International US$ (PPP adjusted) in constant 2005 prices

14 Details on the regression analysis and the results are presented in Annex 3.

15 The logic behind the rule of thumb approach and the underlying data is presented in page 11 in the main report.

Generally, when combining estimates from different countries, the data needs to be adjusted to a common base to be comparable, here international dollar.[16]

Details on each step and the appropriate adjustments are outlined in the subsequent section.

2.1.1 VSLs from literature [Data 2]

This dataset is a collection of VSLs evidenced throughout the literature. First, we gathered all available countries from McMahon and Dahdah (2009) on the 22 countries reported. We then extended this set of countries using other reliable studies from the literature that have already been introduced in the previous section. We always use the most recent study per country if there were several. The sample comprises 31 countries overall from six different sources as presented in **Table 1**.

Table 1. VSLs evidenced throughout the literature [Data 2]

	Study	Country	Method applied*	Year of Study	VSL	Currency & Unit
1	iRAP	Australia	HC	2003	1,304,135	2004 PPP $
2	iRAP	Austria	WTP	2006	3,094,074	2004 PPP $
3	iRAP	Bangladesh	HC	2002	71,066	2004 PPP $
4	iRAP	Canada	HC	2002	1,427,413	2004 PPP $
5	iRAP	France	HC	2005	1,252,083	2004 PPP $
6	iRAP	Germany	HC	2004	1,257,451	2004 PPP $
7	iRAP	Iceland	HC+PGS	2006	3,303,555	2004 PPP $
8	iRAP	India	WTP	2004	147,403	2004 PPP $
9	iRAP	Indonesia	HC	2002	92,433	2004 PPP $
10	iRAP	Latvia	HC	2006	1,042,743	2004 PPP $
11	iRAP	Lithuania	HC	2003	746,532	2004 PPP $

16 The base of international $ describes the conversion of different currencies to a common one that has the same purchasing power parity as the US$ at a given point in time. Purchasing power parity (PPP) conversion factor is the number of units of a country's currency required to buy the same amounts of goods and services in the domestic market as U.S. dollar would buy in the United States. This concept is commonly used by economists to determine the relative value of different currencies to allow for comparison (or aggregation of values) across countries.

12	iRAP	Malaysia	WTP	2003	722,022	2004 PPP $
13	iRAP	Netherlands	HC + PGS	2002	1,944,026	2004 PPP $
14	iRAP	New Zealand	WTP	2005	2,033,333	2004 PPP $
15	iRAP	Poland	HC	2006	573,806	2004 PPP $
16	iRAP	Singapore	HC	2005	924,240	2004 PPP $
17	iRAP	Sweden	WTP	2005	2,015,680	2004 PPP $
18	iRAP	Thailand	HC	2002	222,056	2004 PPP $
19	iRAP	UK	WTP	2004	2,292,157	2004 PPP $
20	iRAP	USA	WTP	2002	3,000,000	2004 PPP $
21	iRAP	Vietnam	HC	2003	53,063	2004 PPP $
22	iRAP	Myanmar	HC	2003	51,245	2004 PPP $
23	Viscusi & Aldy	Hong Kong	WTP	1991	1,700,000	2000 US$
24	Viscusi & Aldy	Japan	WTP	1986	9,700,000	2000 US$
25	Viscusi & Aldy	Switzerland	WTP	1995	7,450,000	2000 US$
26	Miller	Denmark	WTP (contingent value)	1995	3,764,000	1995 US$
27	Miller	South Korea	WTP	1987	872,000	1995 US$
28	Miller	Taiwan	WTP	1996	876,000	1995 US$
29	Guo & Hammitt	China	WTP	2009	45,000	2000 US$
30	Bowland & Beghin	Chile	WTP	2001	597,000	1992 PPP $
31	Robinson & Hammit	Mexico	WTP	2009	280,000	2002 PPP $

Note: WTP refers to willingness-to-pay approach, HC to the human capital approach and PGS to pain, grief and suffering component.

There are eight VSL entries that are not yet PPP adjusted (international $), but are stated in US$ only. To adjust these to the common unit, we used a PPP adjustment factor which we constructed using both PPP figures (national currency per US$) and the respective exchange rates (national currency/US$), extracted from the Penn World Tables[17].

17 Penn World Table, developed by the University of Groningen. Access to the data via: https://pwt.sas.upenn.edu/php_site/pwt71/pwt71_form.php

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$$Adjusted\ VSL * PPP\ adjustment\ factor\ ,$$ where

$$PPP\ adjustment\ factor = \frac{Exchange\ Rate}{PPP}$$

In addition, all values are inflated or deflated to 2005 prices using the US inflation rate (GDP deflator, annual %) provided by the World Bank.[18] The final adjusted VSL figures are presented in **Table 3** in Annex 3.

The *Year of the study* gives us the year for which the VSL was estimated, and therefore allows us to find the corresponding GDP value. For VSL values where tracing back the original study was possible and the study was available, *Year of the study* refers to the year of the data used in the estimation. Some of the studies weren't available to us, in which case we used the year in which the study was published as an approximation, following the approach of Miller (2000). McMahon and Dahdah (2009) didn't reference the sources from which the VSLs in their sample came from, and neither did they specify if the year they quoted for these estimates referred to the year of publication or data used. As the timeframe of the project didn't allow us to gather our own estimates from scratch, we relied on the estimates collected by McMahon and Dahdah for two reasons: their sample was large and their study is reasonably well-established in the policy evaluation area.

2.1.2 GDP per capita [Data 1]

GDP per capita for the 31 countries that have VSL estimates identified in the literature which is more closely explained in the previous step. We collected the GDP per capita figures for the year of the respective VSL in constant 2005 US$ from the World Bank[19]. We adjusted this data for purchasing power to bring it to the common base unit. To do this, we used a PPP adjustment factor which we constructed using both PPP figures (national currency per US$) and the respective exchange rates (national currency/US$), extracted from the Penn World Tables.

$$Adjusted\ \frac{GDP}{capita} = GDP\ capita * PPP\ adjustment\ factor\ ,$$ where

$$PPP\ adjustment\ factor = \frac{Exchange\ Rate}{PPP}$$

18 We have used US inflation rates to inflate price levels across countries throughout this analysis as opposed to using each country's individual inflation or the world's inflation rate for three main reasons: 1) The latter rates are often very volatile and not reported accurately and may overstate the true price increase, 2) the US inflation rate is a more conservative as tested across all countries on average and particularly across the 6 countries that are the main drivers of costs (India, Japan, Russia, China, Brazil and USA) covering roughly 62% of all costs and 3) world inflation rates are not as conservative. This implies that this method causes the final cost figure to be more conservative than in the alternative scenario. Applying individual inflation rates could be explored further in future work.

19 Development Indicators, World Bank. Access to the data via:: http://data.worldbank.org/indicator.

We were only able to collect data for 29 of the 31 countries with missing data for Taiwan and Myanmar.

For Taiwan, we employed the GDP per capita figure from the Penn World Tables which is already in the base unit international US$, PPP adjusted in constant 2005 prices.

For Myanmar, we used the GDP per capita figure from the IMF[20] which is PPP adjusted in current prices. This figure was then deflated to 2005 prices which we did using the US inflation rate (GDP deflator, annual %) provided by the World Bank.

The whole dataset and the adjustment figures are shown in **Table 2**.

Table 2. GDP per capita [Data 1]

	Study	Country	GDP per capita [at YoS]	Adjusted GDP per capita [at YoS]
			[2005, US$]	[2005, PPP$]
1	McMahon & Dahdah	Australia	32,416	38,154
2	McMahon & Dahdah	Austria	39,327	38,231
3	McMahon & Dahdah	Bangladesh	371	991
4	McMahon & Dahdah	Canada	34,228	44,763
5	McMahon & Dahdah	France	34,881	32,239
6	McMahon & Dahdah	Germany	34,387	31,833
7	McMahon & Dahdah	Iceland	57,639	45,847
8	McMahon & Dahdah	India	687	2,282
9	McMahon & Dahdah	Indonesia	1,143	3,338
10	McMahon & Dahdah	Latvia	8,116	12,995
11	McMahon & Dahdah	Lithuania	6,600	12,950
12	McMahon & Dahdah	Malaysia	5,127	10,042
13	McMahon & Dahdah	Netherlands	39,869	47,599
14	McMahon & Dahdah	New Zealand	27,526	26,777
15	McMahon & Dahdah	Poland	8,475	13,916
16	McMahon & Dahdah	Singapore	29,870	44,388
17	McMahon & Dahdah	Sweden	43,085	35,539
18	McMahon & Dahdah	Thailand	2,319	6,568
19	McMahon & Dahdah	UK	39,112	35,020
20	McMahon & Dahdah	USA	41,283	41,283

20 World Economic Outlook Database, International Monetary Fund, October 2014. Access to the data via: http://www.imf.org/external/pubs/ft/weo/2014/02/weodata/weoselser.aspx?c=518&t=1

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21	McMahon & Dahdah	Vietnam	619	2,136
22	McMahon & Dahdah	Myanmar	0	1,724
23	Viscusi & Aldy	Hong Kong	18,414	22,571
24	Viscusi & Aldy	Japan	25,545	22,744
25	Viscusi & Aldy	Switzerland	48,005	30,194
26	Miller	Denmark	40,759	27,347
27	Miller	South Korea	6,980	12,919
28	Miller	Taiwan		18,542
29	Guo & Hammitt	China	2,611	5,053
30	Bowland & Beghin	Chile	6,691	11,296
31	Robinson & Hammit	Mexico	7,788	12,514

Source: World Bank and Frontier adjustments

Note: GDP per capita figures at year of the study of the according VSL estimate, as explained in the previous section.

2.2 Methodology and results

As outlined previously, we use dataset 1 & dataset 2 for this stage of the analysis. There are two parts to estimating the rule of thumb as well as the lower and upper bounds for the sensitivity analysis.

1) The relationship between income and VSL
2) Derivation of the rule of thumb

The rule of thumb is important to apply to the GDP per capita figures for the countries where we were not able to collect VSLs from the literature.

2.2.1 Final dataset

There are 29 countries that form the core sample for use in the regression analysis and 2 countries, Japan and Switzerland, which are considered outliers are excluded as shown in **Table 3**.

The evidence that they are outliers is presented at a later stage in this section when discussing the sensitivity analysis.

Table 3. Core sample for the analysis and outliers

	Study	Country	Year of Study	Adjusted VSL [Data 1]	Adjusted GDP/capita [Data 2]
				[2005, PPP, I$]	
1	iRAP	Australia	2003	1,339,965	38,154
2	iRAP	Austria	2006	3,179,082	38,231
3	iRAP	Bangladesh	2002	73,019	991
4	iRAP	Canada	2002	1,466,630	44,763

5	iRAP	France	2005	1,286,483	32,239
6	iRAP	Germany	2004	1,291,999	31,833
7	iRAP	Iceland	2006	3,394,318	45,847
8	iRAP	India	2004	151,453	2,282
9	iRAP	Indonesia	2002	94,973	3,338
10	iRAP	Latvia	2006	1,071,392	12,995
11	iRAP	Lithuania	2003	767,042	12,950
12	iRAP	Malaysia	2003	741,859	10,042
13	iRAP	Netherlands	2002	1,997,437	47,599
14	iRAP	New Zealand	2005	2,089,198	26,777
15	iRAP	Poland	2006	589,571	13,916
16	iRAP	Singapore	2005	949,633	44,388
17	iRAP	Sweden	2005	2,071,060	35,539
18	iRAP	Thailand	2002	228,157	6,568
19	iRAP	UK	2004	2,355,133	35,020
20	iRAP	USA	2002	3,082,423	41,283
21	iRAP	Vietnam	2003	54,521	2,136
22	iRAP	Myanmar	2003	2,340,096	1,724
23	Viscusi & Aldy	Hong Kong	1991	3,043,857	22,571
24	Miller	Denmark	1995	124,148	27,347
25	Miller	South Korea	1987	743,238	12,919
26	Miller	Taiwan	1996	385,112	18,542
27	Guo & Hammitt	China	2009	52,653	5,053
28	Bowland & Beghin	Chile	2001	8,911,048	11,296
29	Robinson & Hammit	Mexico	2009	8,142,149	12,514
30	Viscusi & Aldy	Japan	1986	1,004,722	22,744
31	Viscusi & Aldy	Switzerland	1995	1,122,747	30,194

Source: Frontier calculations.

Note: Fields marked in grey are data excluded from the analysis around the rule of thumb

2.2.2 Evidenced income elasticity

Extrapolating VSL values to different countries requires both the understanding of how VSL vary with income and how the relationship between income and VSL varies in different contexts. Specifically, Cropper and Sahin (2009) point out that if risk preferences, discount rates and survival probabilities are correlated with income, the relationship between income and VSL will not be constant and the use of a single ratio of VSL to GDP per capita (rule of thumb) for developing and developed countries might not be appropriate. However, as Cropper and

Sahin (2009) also point out, this relationship is constant if income elasticity is one, in which case one rule of thumb for all countries is appropriate.[21]

Following the approach of McMahon and Dahdah (2009), we estimated the income elasticity of VSL to check if using a single rule of thumb is appropriate. This involved estimating the following regression:[22]

$$\log(VSL) = a + b * \log\left(GDP_{capita}\right) + c * method$$

where *method* is a dummy variable equal to 1 if the estimate is based on willingness-to-pay approach and equal to 0 if it is based on the human capital approach. Coefficient b can be interpreted as the income elasticity of VSL.

The regression results are presented in **Table 4**. The coefficient on the logarithmic transformation of GDP per capita is 1.06 and it is statistically significant at 1% level.[23] Since this result is very close to one, we conclude that the relationship is linear, which supports the use of a single VSL to GDP per capita ratio as the rule of thumb for all countries equally.

Table 4. Regression results: Elasticity

Regression Statistics	
Multiple R	0.95
R Square	0.91
Adjusted R Square	0.90
Standard Error	0.41
Observations	29

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	3.15	0.67	4.73	0.00	1.78	4.53
Log (GDP/capita)	1.06	0.07	15.18	0.00	0.92	1.20
Method	0.45	0.15	2.95	0.01	0.14	0.77

Source: Frontier regression

McMahon and Dahdah (2009) estimated the income elasticity to be 1.25, which led them to conclude that the relationship between income and VSL is approximately linear and they used a single rule of thumb for all the countries.

21 The concept of income elasticity is explored in Footnote 6.

22 We employ the variables in their logarithmic transformation. This concept is commonly applied in econometric analysis for various reasons. It helps to obtain residuals that are approximately symmetrically distributed and removes the systematic change in the spread of the variables, i.e. the systematic change of the residuals with the values of the dependent variables (heteroscedasticity). Moreover, expressing the variables in logs directly demonstrates the elasticity.

23 This implies a p-value<0.01. For reference on p-values: p-value<0.01 (99% confidence) - extremely significant, p-value<0.05 (95% confidence) - highly significant, p-value 0.1 (90% confidence) - significant. Although not indicated in the regression table, even a level of p-value<0.2 can be argued to be sufficiently significant. Confidence suggests that the effect is statistically strong.

Our result is based on a larger sample and it is even closer to one which strongly supports the use of single ratio for countries with different income levels throughout this analysis.

In addition, the subsequent section on the ratio demonstrates that our rule of thumb is at the lower end of ranges of estimates from Cropper and Sahin (2009). As such, the rule of thumb we use is very conservative, and if anything might underestimate the true cost of drowning.

2.2.3 The ratio of VSL to income

In order to obtain the rule of thumb, the following equation, based on McMahon and Dahdah (2009), was estimated:

$$\frac{\text{VSL}}{GDP_{capita}} = a + b * method.$$

The results are presented in **Table 5**. The coefficients of the intercept and the method are both statistically significant at the 1% level, which implies a very strong confidence in the figures.

The rule of thumb is derived as the sum of these two coefficients, which is roughly 70 times the GDP per capita to estimate the VSL (which is equivalent to calculating a mean ratio conditional on the method being equal to willingness-to-pay).[24] This gives higher weight to the results based on willingness-to-pay, which is the more widely preferred method.

The lower and upper bounds can be obtained by adding the lower and upper bounds on both coefficients, respectively. The lower bound is 42 and the upper bound is 97 times the GDP per capita figures. We use the rule of thumb for the main part of the analysis, and test the lower and upper bounds as sensitivity checks at a later stage.

24 The exact number for the rule of thumb is 69.718327 to be precise.

Table 5. Regression results: The rule of thumb

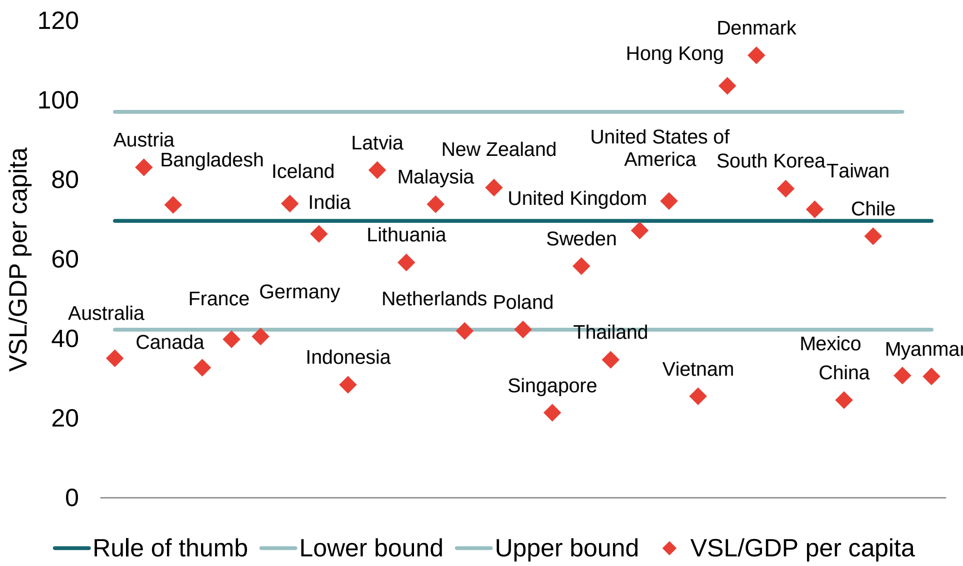
Regression Statistics	
Multiple R	0.53
R Square	0.28
Adjusted R Square	0.25
Standard Error	21.20
Observations	29

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	44.18	5.47	8.07	0.00	32.95	55.42
Method	25.53	7.88	3.24	0.00	9.37	41.70

Source: Frontier regression

Figure 2 graphically presents the observations on the VSL to GDP per capita ratios and the derived rule of thumb with its lower and upper bounds.

Figure 2. The rule of thumb with upper and lower bounds



Source: Frontier calculations

Our result are comparable to that of McMahon and Dahdah (2009), whose estimate from the regression was 71, with a 95% confidence interval of [55, 89]. In the light of this result, they recommended using a rule of thumb of 70, with a lower and upper bounds of 60 and 80, respectively.

3 Annex 3: The cost of fatal drowning

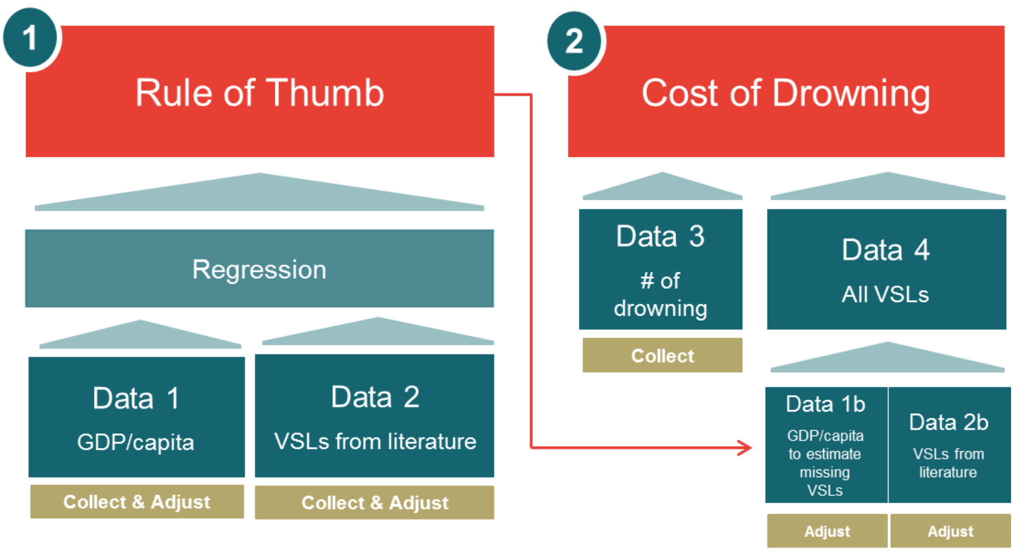
To calculate the cost of fatal drowning for each individual country, we need to multiply the respective VSL with the number of drowning fatalities. This always gives us the cost of drowning at the year where the most recent drowning data was collected which differs for the individual countries.

This section adds background to the calculations which support all the results in the main report.

3.1 Data collection and adjustments

The underlying data comprises the number of drownings and all VSLs, a combination of the VSLs collected from the literature and VSLs estimated using the rule of thumb derived in the first step. The data building block is shown in **Figure 3**.

Figure 3. Underlying data to calculate the cost of drowning



The cost estimate needs to be expressed in a unit comparable across countries using most recent prices, therefore the common unit for all data in this section is:

- International US$ (PPP adjusted) in current 2014 prices

3.1.1 The number of drownings [Data 3]

Overall, combining the dataset of the WHO and the Global Burden of Diseases Study (GBD) leaves us with a dataset of 188 countries, as outlined below.

World Health Organization

We extracted the number of unintentional drowning fatalities (codes W65-W74) at the most recent year available from the WHO Mortality Database[25] for 113 countries using the ICD10 revision.[26] The most recent year of data availability ranges from 2000 until 2012. We excluded 5 of them as they are either double-counted or not part of the WHO region: (1) Double counted 3 separate entries for the UK (England & Wales, Scotland, Northern Ireland), (2) Occupied Palestinian Territory and (3) Serbia and Montenegro. There is one country in addition to this list in the ICD9 revision which is Albania. This leaves us with a dataset of 109 countries extracted from the WHO database.

Comparing this set of countries to the set in the WHO Global Report on Drowning[27] (116 countries), we have a discrepancy of 7 countries: there are 15 countries in the report that are not in the data extract, but likewise there are 8 countries that are in the data extract but do not form part of the report.

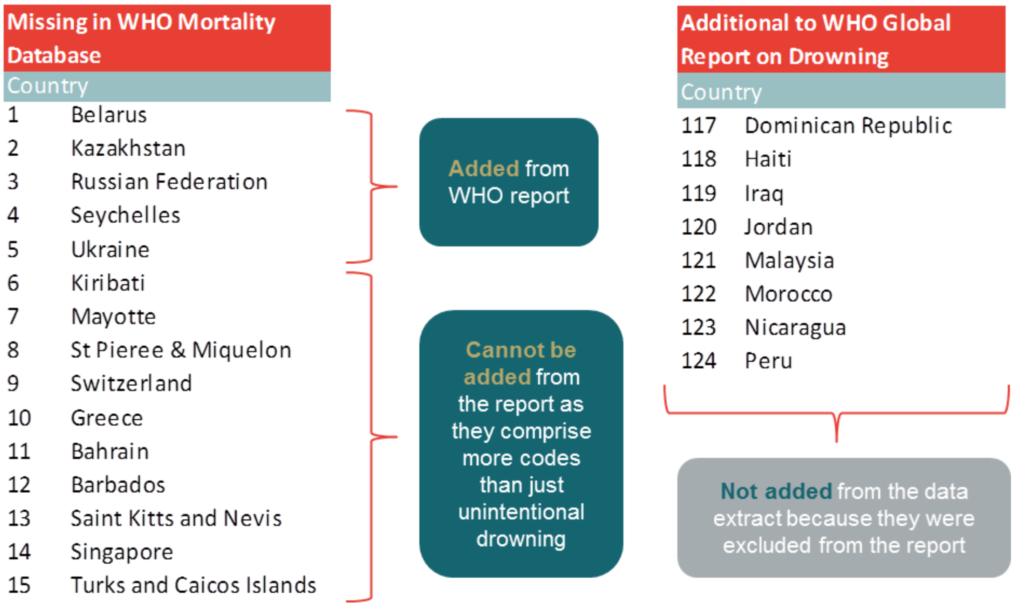
Accordingly, we have added 5 of the 15 countries hardcoded from the WHO report as outlined in **Figure 4**, but cannot add the other 10 countries as the detailed country list in Annex 2 reports the number of drowning fatalities for codes W65-74, V90, V92, X71, X92 and Y21 for those countries which is inconsistent with our applied definition of unintentional drowning fatalities only. We do not include the 8 countries that are additionally in the data extract because they might have been excluded from the WHO for reasons of lack in data reliability.

25 Data of the WHO Mortality Database can be accessed here: http://apps.who.int/healthinfo/statistics/mortality/causeofdeath_query/start.php

26 At a later stage, we also extract additional codes that are not part of the official WHO definition of drowning fatalities for a sensitivity analysis.

27 WHO (2014). "Global Report on Drowning – Preventing a leading killer". Available at http://www.who.int/violence_injury_prevention/global_report_drowning/en/

Figure 4. Comparison of datasets of the WHO



Note: Comparison between the availability of the countries in the WHO Mortality Database and the WHO Global Report on Drowning.

It is noteworthy here that Malaysia is part of the group of countries that are not part of the WHO report and we have little confidence in the number of drowning fatalities. Although we use this country in the precious section as data for the regression (the collected VSL), we do not include the country in the final cost estimation.

- The final dataset of the WHO comprises 106 countries.

We note that the number of deaths recorded by the WHO in this dataset is 60,500. The WHO have estimated that the total number of deaths globally is 372,000, but the breakdown by individual country is not available. In this study we have used the 60,500 deaths reported by WHO, and supplemented this with additional data for those countries which are excluded in the WHO dataset.

Global Burden of Diseases Report

In addition, we extracted data on the number of drowning fatalities for 82 countries that were not in the WHO data extract from the Global Burden of Diseases (GBD) database[28]. These estimates are simulations from the data available.

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28 Institute for Health Metrics and Evaluation (IHME), GBD database. Seattle, WA: IHME, University of Washington, 2014. Available from http://www.healthdata.org/search-gbd-data?s=Drowning

3.1.2 All VSLs [Data 4]

VSLs collected from the literature [Data 2b]

The VSLs collected from the literature have already been adjusted previously in dataset 2 and are thus expressed in international $ in constant 2005 prices. As described previously, we need the VSLs at the year of drowning (which differs between countries) in current 2014 international $. The adjustment comprises two steps:

1) Using GDP per capita growth rates from the World Bank to convert the VSLs in the year of the study [YoS] to the year of the drowning data [YoD]. This implicitly assumes that there is a linear relationship between the VSL and GDP per capita which is evidenced in Section 3.

   The growth rate from World Bank was not available for Taiwan and Myanmar. For Taiwan, we imputed the growth using the GDP per capita data from Penn, while we used the same approach with IMF data for Myanmar.

2) Inflating the values to current prices using the US inflation rate (GDP deflator, annual %) provided by the World Bank as done previously.

The final adjusted VSL figures are presented in **Table 6** including the GDP per capita growth from the year of the study to the year of drowning as well as inflation from 2005 to 2014.

There are 31 countries where VSLs have been collected from the literature, but two countries (Japan and Switzerland) are extreme outliers, as explained in more detail at a later stage, and we decided not to use their VSLs from the literature but instead apply the rule of thumb in dataset 2a.

Table 6. Adjusted VSLs for cost calculation [Data 2b]

	Study	Country	GDP per capita growth [YoS to YoD]	VSL I$ [at YoD, 2014 prices]
1	iRAP	Australia	1.136	1,823,540
2	iRAP	Austria	1.075	4,094,347
3	iRAP	Bangladesh	1.418	123,990
4	iRAP	Canada	1.085	1,906,749
5	iRAP	France	1.018	1,568,804
6	iRAP	Germany	1.132	1,752,003
7	iRAP	Iceland	1.081	4,396,567
8	iRAP	India	1.466	265,861

9	iRAP	Indonesia	1.350	153,580
10	iRAP	Latvia	1.106	1,419,369
11	iRAP	Lithuania	1.620	1,488,059
12	iRAP	Malaysia	1.211	1,076,274
13	iRAP	Netherlands	1.101	2,634,211
14	iRAP	New Zealand	1.034	2,588,217
15	iRAP	Poland	1.306	922,538
16	iRAP	Singapore	1.079	1,227,397
17	iRAP	Sweden	1.087	2,696,046
18	iRAP	Thailand	1.208	329,981
19	iRAP	UK	1.017	2,868,046
20	iRAP	USA	1.056	3,899,162
21	iRAP	Vietnam	1.459	95,270
22	iRAP	Myanmar	1.776	111,982
23	Viscusi & Aldy	Hong Kong	1.783	4,998,677
24	Viscusi & Aldy	Japan	1.459	15,574,781
25	Viscusi & Aldy	Switzerland	1.186	11,570,259
26	Miller	Denmark	1.211	4,415,141
27	Miller	South Korea	3.645	4,385,738
28	Miller	Taiwan	1.557	2,094,254
29	Guo & Hammitt	China	1.087	161,591
30	Bowland & Beghin	Chile	1.314	1,169,888
31	Robinson & Hammit	Mexico	1.004	463,036

Source: Frontier calculations

GDP per capita to estimate missing VSLs [Data 1b]

We collected the GDP per capita figures for the year of drowning in current international US$[29] from the World Bank. In addition to the 29 countries (31 minus Japan & Switzerland) that are already covered by a VSL collected from the literature, we collected data for 143 countries. In addition, Penn data covers two more countries, Somalia and Syria, in the same unit. This implies that for 15 countries we were not able to estimate a VSL and can then not calculate the final cost of drowning.

This leaves us with a dataset of 145 countries for which we have estimated VSLs by applying the rule of thumb to their GDP per capita data.

29 'Current prices' refers to the price level applicable at the year of the data, e.g. if the drowning data is from 2008 then the GDP per capita in current prices at the year of drowning is expressed at a 2008 price level.

The only adjustment to this data is to bring it to a 2014 price level using the US inflation rate (GDP deflator, annual %) provided by the World Bank as done previously.

The GDP per capita figures for the 145 countries are presented in **Table 18** at the end of the report.

3.2 Results

To calculate the cost of drowning, we multiplied the VSLs [dataset 4] with the number of drowning [dataset 3] on a country by country basis for the 181 countries that we have VSLs for:

- VSLs from the literature: 28 countries [originally 29 countries but since Malaysia is not part of the WHO report we do not trust the number of drowning fatalities data and cannot include this country for the final cost estimation]
- VSLs estimated via the rule of thumb: 145 countries [rule of thumb is 70 times the GDP per capita of the respective country]

Likewise, out of these 173 countries, the figures for the number of drowning fatalities stem from:

- WHO # of drowning fatalities: 93
- GBD simulated # of drowning fatalities: 80

Finally, the individual country's cost estimates are summed up to get to an aggregated total figure for the world.

See **Table 18** at the bottom of the report with a list of all countries included in the main analysis with their respective datasets and the final cost of drowning fatalities figure.

It is noteworthy that all final figures are calculated in the year of the most recent drowning data, e.g. if the drowning data is from 2008 then the cost of drowning figure for this country is also from 2008, expressed in today's prices. This implies that all calculated figures are likely relatively conservative given that it would be a reasonable estimate to assume that both the GDP and the VSL have since grown and would lead to a larger cost figure. Only if the number of drowning fatalities would have dramatically declined, then a more recent cost estimate might be slightly lower, but this force outweighing the increase in VSL is highly unlikely as a scenario.

4 Annex 4: Further insights

4.1 Sensitivity & quality reassurance

In addition to the main analysis, whenever suitable we have conducted sensitivity analysis around the results to understand the possible variations and the ranges when adapting underlying assumptions.

We have also reassured confidence in our methodology and the results more generally by means of:

- Comparing the results throughout to the cost estimates of individual countries that were presented in the literature review and to the results on the rule of thumb by McMahon and Dahdah (2009); and
- Involving two academic advisors who have provided critical review of the methodology and outputs and helped guiding sensibility checks: Professor John Appleby, Chief Economist at the King's Fund who is a specialist in health policy and Dr. Ulla Griffiths from the London School of Hygiene & tropical Medicine (LSHTM).

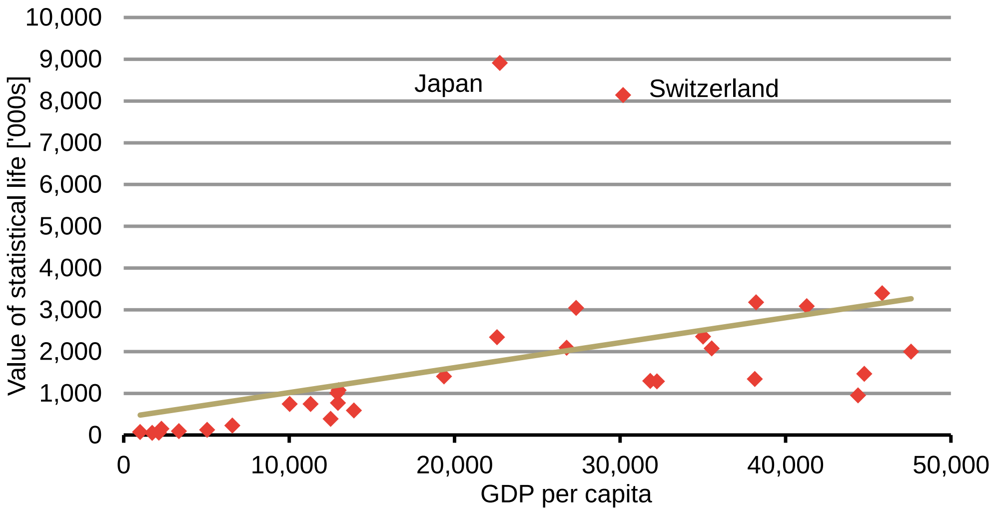
4.1.1 Estimating the rule of thumb

Outliers

The results that we presented in the main part of this analysis were not based on the whole sample of VSL estimates we collected as outlined previously in **Table 3**.

This is due to the fact that we identified two outliers in the sample, Japan and Switzerland, as demonstrated in **Figure 5**.

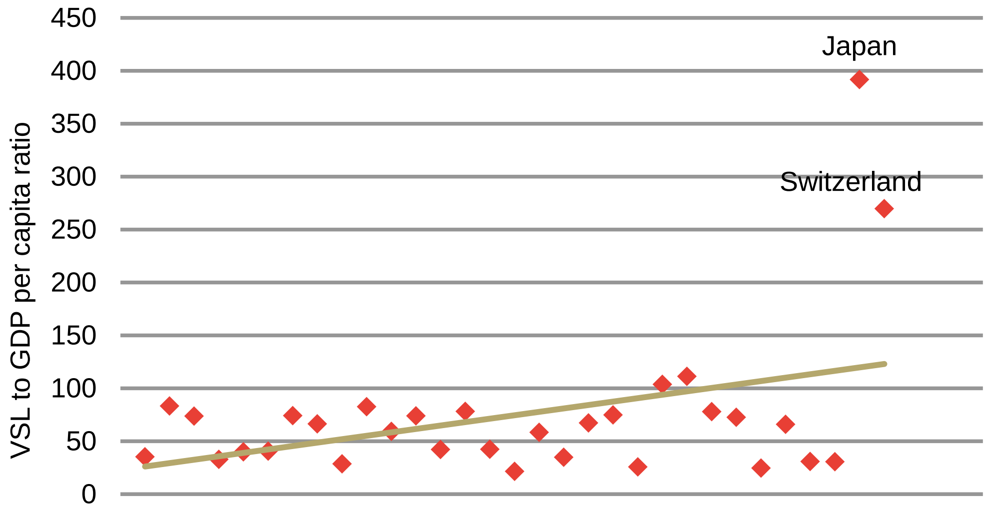
Figure 5. Outliers in relationship of VSLs to GDP per capita



Note: Figures are converted to international $ at constant 2005 prices. Note that base year is the year of study, which is 1986 for Japan and 1995 for Switzerland.

The VSLs for these countries were very high, even relative to their respective GDP per capita, and this meant that their VSL to GDP per capita ratios were a lot higher than for the other countries; this can be seen in **Figure 6**.

Figure 6. Sensitivity: Outliers in the main regression variable



Source: Frontier calculations

As a sensitivity test, we also estimated the rule of thumb on the whole sample of 31 countries, including the outliers. The results in **Table 14** show that based on this sample the rule of thumb is equal to 102 which is considerably larger than when excluding the outliers [102 vs 70].

Table 7. The rule of thumb regression results, including outliers

Regression Statistics	
Multiple R	0.40
R Square	0.16
Adjusted R Square	0.13
Standard Error	69.19
Observations	31

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	44.18	17.86	2.47	0.02	7.65	80.72
Method	58.16	24.87	2.34	0.03	7.30	109.02

Source: Frontier Economics calculations

Concerning the outliers, a quick look at the summary of the results in the literature provides some background as to why Japan might be so far off:

- The underlying sample is "Two-digit manufacturing data, 1986" which suggests that the survey might have been limited to a very specific industry and not across the whole labour market.
- The average income level for Japan in 1986 (2000,US$) used from the sample is $44,863. The World Bank data states that the GDP per capita for Japan in 1986 (2005, US$) is $25,545 which is a much lower value, even expressed at a higher price level. The sample underlying the study is therefore likely to be a non-representative collection of the true income in the economy.

It is therefore likely that the VSL for Japan is an overstated value and does not represent the true economic value of life foregone in the country.

For Switzerland, this logic does not apply and it is beyond the scope of this analysis to investigate the exact causes of the high VSLs.

However, taking into account the strength of the influence they had on the result and the fact that a rule of thumb should provide a broadly accurate principle based on the average trend, we decided it was more appropriate to use the result based on a sample without the outliers. In doing so the rule of thumb represents the general trend in already large set of comparable results, rather than reflecting a result that gives so much weight to two observations that were exceptionally high.

A further support for this approach is implicit in the resulting lower rule of thumb which leads to a lower final cost estimate, which is a far more conservative overall estimate.

Annex 4: Further insights

Alternative GDP source

In the main analysis we used the World Bank as the primary source for our data collection as outlined in Dataset 1. Here, we also tested the sensitivity of results to the use of an alternative source of data for the GDP information, which is using the Penn Data where available. This datasets varies slightly from the World Bank dataset. **Table 8** and **Table 9** show the regression results for the income elasticity and the rule of thumb, respectively.

The income elasticity estimate is 1.06 and the rule of thumb is 73, relative to 1.05 and 70, respectively, based on the World Bank data. The change in results is very minor across the two datasets, implying a low sensitivity to the source of data for GDP.

Table 8. Sensitivity: Income elasticity regression results, Penn Data

Regression Statistics	
Multiple R	0.95
R Square	0.90
Adjusted R Square	0.89
Standard Error	0.43
Observations	29

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	3.18	0.70	4.54	0.00	1.74	4.62
Log (GDP/capita)	1.07	0.07	14.41	0.00	0.91	1.22
Method	0.40	0.16	2.45	0.02	0.06	0.73

Source: Frontier regressions

Table 9. Sensitivity: Rule of thumb regression results, Penn Data

Regression Statistics	
Multiple R	0.51
R Square	0.26
Adjusted R Square	0.23
Standard Error	22.39
Observations	29

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	47.57	5.78	8.23	0.00	35.71	59.44
Method	25.59	8.32	3.07	0.00	8.51	42.66

Source: Frontier regressions

4.1.2 Assumptions on VSLs and cost calculations

In the main part of the analysis we have calculated the cost of drowning using the VSLs from the literature, except for Japan and Switzerland, and applied the rule of thumb wherever we did not find a VSL in the literature.

In the process of making the decision, we have also considered two alternative scenarios in terms of the cost assessment and the underlying VSLs:

1) Estimating all VSLs using the rule of thumb approach, and
2) Calculating the cost by using all VSLs from the literature that are available, including the outlier Japan and Switzerland

The following gives an insight into the sensitivities around these carrying assumptions and points out why the choice for the main analysis is the most sensible and conservative approach.

Assumptions applied in analysis

Table 10 presents the number of drowning fatalities and the cost of drowning of the five countries with the highest cost shares which represent roughly 60% of all costs worldwide. We choose this sample to demonstrate the sensitivities in the results when we vary underlying assumptions on the VSLs, as these countries are the major cost drivers.

Table 10. Base case

All VSLs from literature used, except for CHE & JPN				
	Costs		# of drowning fatalities	
India	22,798	**15.6%**	85,752	**26.6%**
Japan	18,557	**12.7%**	7,356	**2.3%**
Russia	18,314	**12.5%**	11,981	**3.7%**
USA	14,871	**10.1%**	3,814	**1.2%**
China	10,892	**7.4%**	67,402	**20.9%**
Total	85,433	**58.2%**	176,305	**54.8%**

Source: Frontier calculations

Note: Costs are expressed at YoD (year of drowning), international $, current 2014 prices.

The fact that these countries have a relatively high cost of drowning may be caused by different factors, i.e. either by a very large proportion of the number of fatal drownings or by a relatively high VSL, or a combination of both. This suggests that the presentation of these countries throughout this section shall not be regarded as a direct comparison between the countries, but rather as a sensitivity and sensibility check for each country individually when flexing underlying assumptions.

Alternative assumptions

Table 11 demonstrates the results for the first alternative scenario and **Table 10** for the second. This shows that using the rule of thumb for all countries instead of employing the VSLs where collected strongly overestimates the cost share for China, having risen from 7.4% of all costs to 23%. This can be explained by the fact that, although China follows the trend line and thus forms part of the regression analysis, the VSL to GDP per capita ratio is to be found at the lower end of the scale rather than at the average.

Table 11. Alternative scenario (1)

(1) All VSL estimated via the 'rule of thumb'				
	Costs		Number of Drowning fatalities	
China	45,362	**23.0%**	67,402	**20.9%**
India	28,999	**14.7%**	85,752	**26.6%**
Japan	18,557	**9.4%**	7,356	**2.3%**
Russia	18,314	**9.3%**	11,981	**3.7%**
USA	13,731	**7.0%**	3,814	**1.2%**
Total	124,963	**63.4%**	176,305	**54.8%**

Source: Frontier calculations

Note: Costs are expressed at YoD (year of drowning), international $, current 2014 prices.

Since China has such a large number of drowning fatalities, with 21% of all drowning fatalities, China's cost figure increases strongly. Overall, the worldwide aggregated cost figure is I$ 197bn which is much higher than in the base case.

Table 12 presents the results for the second alternative scenario. This shows that using all VSLs from the literature (including Japan and Switzerland) massively increases the cost share of the five countries of overall costs (from 58% to 75%). In addition, Japan's cost share rises from 12.7% to 47.2% due to the fact that it was such a strong outlier and has a non-neglect able share of drowning fatalities worldwide. Switzerland doesn't very much influence the results because it only has 51 drowning fatalities. The results do not seem sensible, given that Japan has already been identified as an outlier.

Table 12. Alternative scenario (2)

(2) All VSLs from literature for the 31 countries				
	Costs		Number of Drowning fatalities	
Japan	114,568	**47.2%**	7,356	**2.3%**
India	22,798	**9.4%**	85,752	**26.6%**
Russia	18,314	**7.5%**	11,981	**3.7%**
USA	14,871	**6.1%**	3,814	**1.2%**
China	10,892	**4.5%**	67,402	**20.9%**
Total	181,443	**74.6%**	176,305	**54.8%**

Source: Frontier calculations

Note: Costs are expressed at YoD (year of drowning), international $, current 2014 prices.

Overall, the worldwide aggregate cost figure is I$ 243bn which is much higher than both the base case and the first alternative scenario.

Annex 4: Further insights

Both alternative scenarios result in higher worldwide cost figures and, following the argumentation outlined previously, the base case assumptions and the respective results are the most conservative cost figure and most robust.

4.1.3 Applying the upper and lower bounds

Throughout the main analysis, we apply the rule of thumb as a ratio to the GDP per capita figures for the countries where we weren't able to collect VSL estimates. We have also evidenced using the sample that the applying the rule of thumb is justified and robust.

In addition, we have estimated two extreme alternative scenarios using the lower and the upper bounds of the regression results as the 'rule of thumb' to see a "maximum case scenario" and "minimum case scenario" which are presented in **Table 13.**

Table 13. Cost figure for the lower and upper bounds

	Estimate	Costs
Lower bound	42	115bn
Rule of thumb	70	147bn
Upper bound	97	178bn

Source: Frontier regression

This demonstrates that range of the worldwide cost figures is from 115bn in the minimum cost scenario to 178bn in the maximum cost scenario. As outlined previously, however, using the rule of thumb approach is a robust assumption.

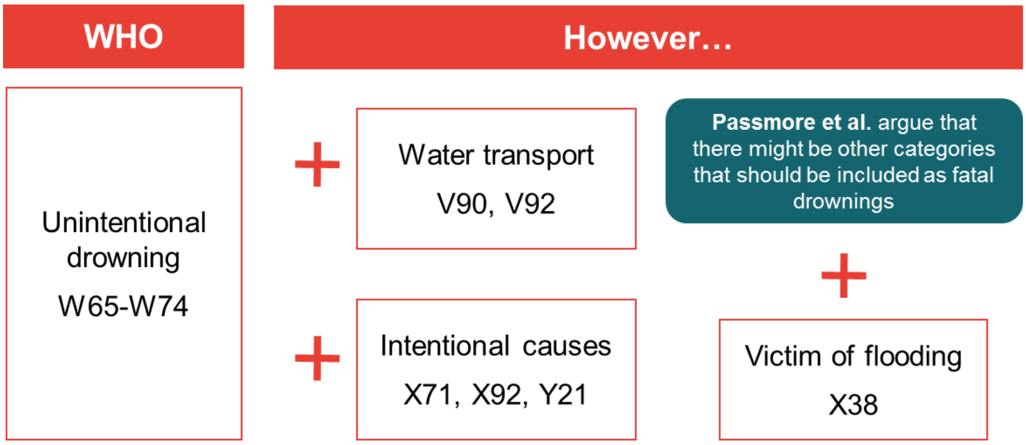
4.2 Potential extension

4.2.1 Codes WHO

In the WHO report, the numbers of drowning fatalities reported refer to unintentional drowning fatalities, which are codes W65-W74 in the ICD-10. Likewise, all results stated throughout this report relate to this definition of drowning.

However, there are other codes that relate to death by drowning if we were to extend the definition. **Figure 7** outlines the additional codes and the respective approximate number of drowning fatalities which we will use for the sensitivity analysis of the results.

Figure 7. Additional codes of drowning



Source: WHO database

There is no data on these codes in the Global Burden of Diseases database, so the number of countries is much lower. Moreover, we did not consider results on countries that are not part of dataset selected in the precious analysis.

Table 14 shows the number of countries available, the number of drowning fatalities and the results on the aggregated cost figure for the additional codes separately and a total figure.

Table 14. Additional # of drowning fatalities and costs

	V90, V92	X71,X92,Y21	X38	Total
Countries	47	74	19	
Drowning fatalities	1,341	8,425	170	**9,936**
Cost	2,690	18,693	288	**21,671**

Source: WHO database

Overall, extending the definition of the WHO on drowning fatalities, the additional codes would add up to I$ 22bn which raises the worldwide cost figure to I$ 168bn.

It is noteworthy here, that this is likely to be a much underestimated number of the true cost of drowning for the additional codes, as the number of countries for which these codes have been reported is so much lower than for the codes included in the WHO definition.

4.2.2 Extended set of countries

As a set of countries for the main analysis we have used the 106 countries from the WHO data as outlined in dataset 3 previously. As shown there in **Table 15**, we had excluded countries that were in the WHO data extract but did not form part of the WHO report.

Table 15 presents these countries in more detail and also the cost of drowning for the individual countries and as a total for the 8 countries.

Table 15. Additional countries to the WHO report

Country	Tier	Data source of drowning fatalities	Year of drowning [YoD]	Number of fatal drowning fatalities [at YoD]	GDP/capita (I$, current prices) [at YoD]	Cost of Drowning [in I$m] [at YoD]
Dominican Republic	Tier 2	WHO	2010	24	11,594	19,400
Haiti	Tier 2	WHO	2004	3	1,653	346
Iraq	Tier 2	WHO	2008	430	12,233	366,725
Jordan	Tier 2	WHO	2009	61	11,707	49,787
Malaysia	Tier 1	WHO	2008	342	21,027	369,501
Morocco	Tier 2	WHO	2011	193	7,062	95,029
Nicaragua	Tier 2	WHO	2011	129	4,444	39,970
Peru	Tier 2	WHO	2010	431	10,369	311,583
Total				1,613		1,252,340

Source: Who data extract and Frontier calculations

Overall, adding these countries to the sample would add another I$ 1.3bn to the aggregated worldwide figure of the cost of drowning.

4.3 Areas for future work

Beyond a potential extension of the dataset as explained above by means of additional codes to the definition of drowning or additional countries, there are other areas of this analysis that may further be improved which is beyond the scope of this piece of work.

4.3.1 Data limitations

We have encountered some limitations to the data during the data collection and cleaning process.

Number of fatal drownings

For instance, the WHO Mortality database only provides figures on the numbers of fatal drownings for 113 countries, some of which we decided to exclude because they were not in the WHO Global Report on Drowning which could imply that the data was not reliable enough. Moreover, the countries reporting data tend to be those which are more economically developed. The 106 countries that we included in the analysis, as outlined previously, reported just over 60,500 deaths by drowning. Overall, this represents only roughly 20% of all drownings worldwide.

The Global Burden of Disease Study extrapolates cause-specific mortality using CodMod, a probabilistic cause of death simulation model to provide mortality estimates where vital registration reporting is either partial or non-existent. In regions such as Sub-Saharan Africa, vital registration data upon which such modelling is based is extremely limited therefore the subsequent estimates have low confidence levels.

In addition, the most recent figure on the number of drowning fatalities within the WHO mortality database varies from 2000 until 2012 with at least 38 countries estimated at 2010 and older. The cost estimate is always at the year of the drowning data, and is therefore often not the most recent cost figure that would be incurred, which are (due to income growth) are often likely to be higher even. More recent estimates on the number of drownings would strongly improve the result.

To account for this issue, one could potentially estimate the number of drowning fatalities for 2013 (or 2014) using an estimated rate of drowning. This rate could be derived by extracting the number of drownings as a time series and population data, which gives us a time series on the rate of drowning. This can be used to estimate a ratio from a trend rends and averages for individual countries to estimate a more recent drowning figure.

Income data

In terms of the income data, there are 15 countries out of the 188 countries that did not report any GDP per capita data in the World Bank indicator, or the Penn World Tables. A further investigation into these numbers could add value.

Value of statistical life

We have heavily relied on the VSL estimates collected in the McMahon and Dahdah (2009) article, which are not sourced to the original studies. In addition, we have explored various other papers, as outlined previously, and have only been able to collect estimates for 31 countries. The confidence in the collected VSLs might improve with a more in-depth analysis of the studies underlying the McMahon and Dahdah work, and with access to additional studies more estimates might be uncovered. An even larger dataset on the collected VSLs from the literature would improve the confidence in the regression analysis. However, having extended the McMahon and Dahdah work with 10 additional countries has not drastically changed the result of the rule of thumb, which is reassuring of our results.

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In addition, in the literature identified, there were occasionally different data entries for one individual country. If this was the case, we always chose to use the most recent estimate available. One could consider sensitivities around this regression by including all data points available or taking an average across the set which would require further resources.

4.3.2 Income elasticity

As discussed previously, one could investigate the issue of differing ratios for undeveloped and developed countries further by extending the sample, testing different econometric specifications or checking the sensitivity of results to the ratios quoted by Cropper and Sahin (2009). However, given the scope of this analysis, we are very confident using this simplified approach.

4.3.3 Age adjustments

One interesting issue from the policy literature examined is whether estimating the value of prevention for different types of risks requires different values for lives saved. For example, if drowning *disproportionately* affects children, this would suggest a higher VSL value might be appropriate.

In the course of this analysis, we have investigated possible ways to adjust for the age factor in the VSL, but have come to the conclusion that this is a very complex topic and beyond the scope of this analysis.

In ideal world, we would adjust the collected VSLs for the age difference at the stage of their construction. However, the breakdown of how these estimates were constructed is not described in enough detail. Furthermore, it appears that most of the VSL estimates don't explicitly take into account the age factor.

An alternative approach would be to use the value of VSL to extract the Value of Statistical Life-Year (VSLY). The estimates of the VSLY could then be used to adjust the VSL to take into account the age differences of the victims of drowning, and thus provide a more accurate figure for the overall cost. For example, Aldy and Viscusi (2008)[30] annuitized age-specific VSLs based on age-specific years of life expectancy L and discount rate r using the following equation:

$$\text{VSLY} = \frac{rVSL}{1 - 1(1 + r)^{-L}}$$

Unfortunately, this approach entails a number of limitations:

30 Aldy, Joseph E., and Viscusi, W. Kip (2008). "Adjusting the Value of Statistical Life For Age and Cohort Effects," *The Review of Economics and Statistics*, August 2008, 90(3): 573-581.

- Once again there is uncertainty around the average age underlying the VSL estimates we collected and this would require us to make strong assumptions on what the average age of death for these values is.
- We would have to make assumptions about the discount rate *r*.
- There is uncertainty about how the VSLY evolves throughout the lifetime: many studies assume it is constant, however there is evidence in the literature that this might not be the case, but no clear conclusions are reached on how the value evolves exactly[31]. Therefore we would have to make assumptions about this as well.

So as this brief overview presents, incorporating the age adjustment is a complex task, subject to many limitations and strong assumptions. Further investigations may develop a more thorough methodological foundation to account for an age effect - if at all evidenced that it is indeed younger (with better data).

4.3.4 Non-fatal drownings

The WHO has clearly stated that "non-fatal drowning statistics in many countries are not readily available or are unreliable".[32] If data would improve in the future, estimating the cost of non-fatal drownings in the same way as fatal drownings could be a valuable additional analysis.

At the moment, there is the potential for a simple scenario analysis, which would provide a broad range for the possible cost of non-fatal drownings.

The scenario analysis would depend on a small number of key assumptions, which are summarised in the table below.

[31] For example, Aldy and Smyth (2007) show a steadily declining value of life if there are perfect annuity and insurance markets, and an inverted- U age-VSL relationship in an economy with no borrowing or insurance. As reference see Aldy, Joseph E., and Seamus J. Smyth, (2007). "A Numerical Model of the Value of Life," *Resources for the Future discussion paper* 07-09.

[32] WHO website, http://www.who.int/violence_injury_prevention/other_injury/drowning/en/

Table 16. Estimated cost of non-fatal drownings – key assumptions

Key assumption	Possible values
Number of fatal drownings worldwide	372,000
Ratio of non-fatal drownings to fatal drownings	2:1 – 50:1
Cost of non-fatal drowning as a proportion of cost of fatal drowning	8-22%

Source: Frontier Economics

Based on these assumptions, plus our analysis of the cost of fatal drowning, it would be straightforward to estimate the worldwide cost of non-fatal drowning (albeit potentially with a large range!).

To support this simple analysis, one would need some evidence to estimate:

- the ratio of non-fatal drownings to fatal drownings; and
- the cost of non-fatal drownings.

The ratio of non-fatal to fatal drownings has been investigated in a small number of academic papers. These report a wide range of estimates. Clemens (2013) summarises these papers, suggesting a ratio of between 2 and 50 times as many non-fatal drownings:

Table 17. Estimated ratio of non-fatal to fatal drownings

Article	Estimated incidence
Suominen, P. K. & Vahatalo, R. (2012)	It has been estimated that the number of non-fatal drownings are **two to four** times higher than the numbers of fatal drownings.
Layon, J. A. & Modell, J. H. (2009)	**1 death per 13 survivors** of a drowning episode in the United States
Onyekwelu, E. (2009)	The estimated range [of near drowning] is thought to be at least **20-50 times** the rate of drowning.
Brenner, R. A. (2003)	It is estimated that for each drowning death, there are **1 to 4** nonfatal submersions serious enough to result in hospitalization

Moon, R. E. & Long, R. J. (2002)	It is estimated that for every child who drowns, **four are hospitalized and 16 receive emergency department care** for near-drowning
Weinstein, M.D. & Krieger, B. P. (1996)	Near-drowning has been estimated to be from **two-to twentyfold** more common than reported drownings.
Orlowski, J. P. (1988)	Hospitalization for near drowning occurs **five times** more frequently than for drownings, and near-drowning accidents are estimated to be **500 to 600 times** more common than their fatal counterpart.

Source: Clemens (2013), "Non-fatal Drowning: A review of epidemiology, pathophysiology, treatment and prevention"

The costs of non-fatal injury are summarised – in the context of road incidents – in the McMahon and Dahdah (2009) work. They report cross-country estimates of the costs of serious injury at 8-22% of the cost of fatality.

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Table 18. Results of all countries by region [at YoD, international $, current 2014 prices]

Country	Income Group	Tier	Source	YoD	# of D	GDP per capita	VSL estimates		Cost of Drowning	Share of GNI
							(1) Literature	(2) Estimated		
East Asia & Pacific										
Australia	High income	Tier 1	WHO	2011	169	43,977	1,823,540		308,178,257	0.03%
Hong Kong	High income	Tier 1	WHO	2011	30	52,814	4,998,677		149,960,296	0.04%
Japan	High income	Tier 1	WHO	2011	7,356	36,185		2,522,738	18,557,259,507	0.39%
New Zealand	High income	Tier 1	WHO	2010	57	32,381	2,588,217		147,528,346	0.11%
Republic of Korea	High income	Tier 1	WHO	2012	712	32,876	4,385,738		3,122,645,283	0.19%
Brunei Darussalam	High income	Tier 2	WHO	2011	13	75,912		5,292,450	68,801,845	
Taiwan	High income	Tier 3	GBD	2010	645	34,470	2,620,809		1,691,611,639	
Singapore	High income	Tier 3	GBD	2010	18	75,106	1,227,397		21,592,614	0.01%
Thailand	Low & middle	Tier 1	WHO	2006	4,666	12,140	329,981		1,539,691,625	0.20%
Fiji	Low & middle	Tier 2	WHO	2012	67	7,680		535,463	35,876,017	0.55%
Philippines	Low & middle	Tier 2	WHO	2008	3,451	5,615		391,453	1,350,904,894	0.21%
China	Low & middle	Tier 3	GBD	2010	67,402	9,653	161,591		10,891,604,001	0.08%
Indonesia	Low & middle	Tier 3	GBD	2010	5,396	8,394	153,580		828,737,679	0.04%

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Country	Income Group	Tier	Source	YoD	# of D	GDP per capita	VSL estimates		Cost of Drowning	Share of GNI
							(1) Literature	(2) Estimated		
Myanmar	Low & middle	Tier 3	GBD	2010	3,711	3,666	111,982		415,543,005	
Vietnam	Low & middle	Tier 3	GBD	2010	6,422	4,692	95,270		611,826,053	0.16%
Cambodia	Low & middle	Tier 4	GBD	2010	957	2,628		183,232	175,436,930	0.49%
Laos	Low & middle	Tier 4	GBD	2010	424	4,079		284,411	120,456,957	0.49%
Marshall Islands	Low & middle	Tier 4	GBD	2010	4	3,675		256,208	978,941	0.42%
Mongolia	Low & middle	Tier 4	GBD	2010	189	6,772		472,137	89,108,360	0.53%
Papua New Guinea	Low & middle	Tier 4	GBD	2010	456	2,211		154,153	70,358,729	0.47%
Samoa	Low & middle	Tier 4	GBD	2010	8	5,665		394,981	3,313,555	0.32%
Solomon Islands	Low & middle	Tier 4	GBD	2010	35	1,868		130,251	4,618,822	0.63%
Timor-Leste	Low & middle	Tier 4	GBD	2010	70	1,859		129,574	9,023,739	0.13%
Tonga	Low & middle	Tier 4	GBD	2010	4	5,210		363,219	1,422,015	0.26%
Vanuatu	Low & middle	Tier 4	GBD	2010	15	3,084		214,977	3,267,452	0.46%
Europe & Central Asia										
Austria	High income	Tier 1	WHO	2012	46	46,173	4,094,347		188,339,957	0.05%
Denmark	High income	Tier 1	WHO	2012	34	44,301	4,415,141		150,114,793	0.06%

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Country	Income Group	Tier	Source	YoD	# of D	GDP per capita	VSL estimates		Cost of Drowning	Share of GNI
							(1) Literature	(2) Estimated		
France	High income	Tier 1	WHO	2011	918	39,344	1,568,804		1,440,162,077	0.05%
Germany	High income	Tier 1	WHO	2012	417	44,601	1,752,003		730,585,051	0.02%
Iceland	High income	Tier 1	WHO	2009	4	43,008	4,396,567		17,586,267	0.16%
Latvia	High income	Tier 1	WHO	2012	135	21,746	1,419,369		191,614,756	0.43%
Lithuania	High income	Tier 1	WHO	2012	232	24,603	1,488,059		345,229,666	0.49%
Netherlands	High income	Tier 1	WHO	2012	81	46,919	2,634,211		213,371,090	0.03%
Poland	High income	Tier 1	WHO	2012	862	23,373	922,538		795,227,446	0.09%
Sweden	High income	Tier 1	WHO	2012	81	45,067	2,696,046		218,379,702	0.05%
United Kingdom	High income	Tier 1	WHO	2010	264	38,345	2,868,046		757,164,089	0.03%
Belgium	High income	Tier 2	WHO	2010	71	41,858		2,918,302	207,199,430	0.04%
Croatia	High income	Tier 2	WHO	2012	100	21,813		1,520,797	152,079,671	0.17%
Cyprus	High income	Tier 2	WHO	2011	18	31,908		2,224,590	40,042,611	0.14%
Czech Republic	High income	Tier 2	WHO	2012	151	29,338		2,045,391	308,854,076	0.11%
Estonia	High income	Tier 2	WHO	2012	48	25,159		1,754,049	84,194,374	0.27%
Finland	High income	Tier 2	WHO	2012	86	41,047		2,861,734	246,109,092	0.11%

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Country	Income Group	Tier	Source	YoD	# of D	GDP per capita	VSL estimates		Cost of Drowning	Share of GNI
							(1) Literature	(2) Estimated		
Ireland	High income	Tier 2	WHO	2010	31	45,796		3,192,835	98,977,882	0.06%
Italy	High income	Tier 2	WHO	2010	374	37,060		2,583,743	966,319,945	0.04%
Luxembourg	High income	Tier 2	WHO	2012	1	92,546		6,452,152	6,452,152	0.02%
Norway	High income	Tier 2	WHO	2012	45	66,988		4,670,297	210,163,372	0.06%
Portugal	High income	Tier 2	WHO	2012	50	27,017		1,883,598	94,179,882	0.03%
Slovakia	High income	Tier 2	WHO	2010	156	26,082		1,818,366	283,665,133	0.21%
Slovenia	High income	Tier 2	WHO	2010	28	29,425		2,051,429	57,440,010	0.10%
Spain	High income	Tier 2	WHO	2012	438	33,373		2,326,733	1,019,109,067	0.07%
Russian Federation	High income	Tier 2	WHO	2010	11,981	21,926		1,528,617	18,314,362,177	0.61%
Switzerland	High income	Tier 3	GBD	2010	51	54,786		3,819,602	193,435,347	0.04%
Albania	Low & middle	Tier 2	WHO	2004	81	7,187		501,039	40,584,129	0.18%
Armenia	Low & middle	Tier 2	WHO	2012	26	7,668		534,586	13,899,228	0.06%
Azerbaijan	Low & middle	Tier 2	WHO	2007	62	14,047		979,328	60,718,326	0.06%
Bosnia and Herzegovina	Low & middle	Tier 2	WHO	2011	3	9,752		679,877	2,039,631	0.01%
Bulgaria	Low & middle	Tier 2	WHO	2012	135	16,191		1,128,828	152,391,769	0.13%

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Country	Income Group	Tier	Source	YoD	# of D	GDP per capita	VSL estimates		Cost of Drowning	Share of GNI
							(1) Literature	(2) Estimated		
Georgia	Low & middle	Tier 2	WHO	2012	65	7,049		491,451	31,944,335	0.10%
Hungary	Low & middle	Tier 2	WHO	2012	131	23,334		1,626,839	213,115,925	0.10%
Kyrgyzstan	Low & middle	Tier 2	WHO	2010	325	2,918		203,437	66,116,966	0.44%
Montenegro	Low & middle	Tier 2	WHO	2009	7	14,102		983,165	6,882,156	0.08%
Republic of Moldova	Low & middle	Tier 2	WHO	2012	214	4,365		304,337	65,128,152	0.38%
Romania	Low & middle	Tier 2	WHO	2012	657	18,720		1,305,156	857,487,626	0.23%
Serbia	Low & middle	Tier 2	WHO	2012	84	13,230		922,384	77,480,264	0.08%
TFYR Macedonia	Low & middle	Tier 2	WHO	2010	24	12,132		845,829	20,299,894	0.08%
Turkey	Low & middle	Tier 2	WHO	2011	183	18,978		1,323,116	242,130,283	0.02%
Uzbekistan	Low & middle	Tier 2	WHO	2005	1,042	3,243		226,107	235,603,238	0.28%
Belarus	Low & middle	Tier 2	WHO	2009	837	15,149		1,056,196	884,036,135	0.63%
Kazakhstan	Low & middle	Tier 2	WHO	2012	872	22,618		1,576,901	1,375,057,325	0.42%
Ukraine	Low & middle	Tier 2	WHO	2012	2,713	8,763		610,967	1,657,553,756	0.41%
Tajikistan	Low & middle	Tier 4	GBD	2010	505	2,207		153,865	77,751,215	0.47%
Turkmenistan	Low & middle	Tier 4	GBD	2010	251	10,491		731,427	183,377,498	0.38%

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Country	Income Group	Tier	Source	YoD	# of D	GDP per capita	VSL estimates		Cost of Drowning	Share of GNI
							(1) Literature	(2) Estimated		
Latin America & Caribbean										
Chile	High income	Tier 1	WHO	2011	386	21,252	1,169,888		451,576,762	0.13%
Antigua and Barbuda	High income	Tier 2	WHO	2009	5	23,313		1,625,362	8,126,810	0.42%
Bahamas	High income	Tier 2	WHO	2010	20	23,983		1,672,034	33,440,671	0.40%
Puerto Rico	High income	Tier 2	WHO	2010	28	36,035		2,512,306	70,344,564	0.08%
Trinidad and Tobago	High income	Tier 2	WHO	2008	50	32,514		2,266,791	113,339,554	0.28%
Uruguay	High income	Tier 2	WHO	2010	107	17,250		1,202,632	128,681,586	0.23%
Mexico	Low & middle	Tier 1	WHO	2012	2,095	16,714	463,036		970,060,775	0.05%
Belize	Low & middle	Tier 2	WHO	2010	28	8,585		598,532	16,758,885	0.70%
Bolivia	Low & middle	Tier 2	WHO	2003	83	4,601		320,791	26,625,642	0.07%
Brazil	Low & middle	Tier 2	WHO	2011	5,450	15,080		1,051,324	5,729,715,350	0.20%
Colombia	Low & middle	Tier 2	WHO	2011	906	11,950		833,101	754,789,558	0.14%
Costa Rica	Low & middle	Tier 2	WHO	2012	116	13,838		964,772	111,913,586	0.17%
Cuba	Low & middle	Tier 2	WHO	2011	220	19,820		1,381,809	303,997,897	0.14%
Dominica	Low & middle	Tier 2	WHO	2011	6	10,895		759,599	4,557,595	0.60%

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Country	Income Group	Tier	Source	YoD	# of D	GDP per capita	VSL estimates		Cost of Drowning	Share of GNI
							(1) Literature	(2) Estimated		
Ecuador	Low & middle	Tier 2	WHO	2012	485	10,762		750,320	363,905,136	0.22%
El Salvador	Low & middle	Tier 2	WHO	2011	259	7,753		540,515	139,993,338	0.30%
Grenada	Low & middle	Tier 2	WHO	2012	3	11,620		810,116	2,430,347	0.21%
Guatemala	Low & middle	Tier 2	WHO	2012	346	7,347		512,190	177,217,667	0.16%
Guyana	Low & middle	Tier 2	WHO	2010	75	5,796		404,083	30,306,197	0.66%
Jamaica	Low & middle	Tier 2	WHO	2006	18	9,535		664,792	11,966,260	0.04%
Panama	Low & middle	Tier 2	WHO	2011	138	17,139		1,194,895	164,895,528	0.27%
Paraguay	Low & middle	Tier 2	WHO	2011	136	7,577		528,263	71,843,801	0.15%
Saint Lucia	Low & middle	Tier 2	WHO	2012	10	10,806		753,389	7,533,888	0.40%
Saint Vincent and Grenadines	Low & middle	Tier 2	WHO	2012	4	10,505		732,361	2,929,444	0.26%
Suriname	Low & middle	Tier 2	WHO	2009	32	14,315		998,014	31,936,453	0.43%
Venezuela	Low & middle	Tier 2	WHO	2009	462	17,761		1,238,250	572,071,576	0.11%
Honduras	Low & middle	Tier 4	GBD	2010	329	4,466		311,339	102,310,564	0.32%
Middle East & North Africa										
Israel	High income	Tier 2	WHO	2011	44	31,802		2,217,153	97,554,732	0.04%

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Country	Income Group	Tier	Source	YoD	# of D	GDP per capita	VSL estimates		Cost of Drowning	Share of GNI
							(1) Literature	(2) Estimated		
Kuwait	High income	Tier 2	WHO	2011	17	86,967		6,063,164	103,073,793	0.04%
Malta	High income	Tier 2	WHO	2011	8	29,712		2,071,484	16,571,875	0.14%
Oman	High income	Tier 2	WHO	2010	29	51,765		3,608,988	104,660,641	0.08%
Qatar	High income	Tier 2	WHO	2011	22	141,017		9,831,492	216,292,818	0.09%
Saudi Arabia	High income	Tier 4	GBD	2010	715	48,297		3,367,159	2,406,888,740	0.18%
United Arab Emirates	High income	Tier 4	GBD	2010	138	59,523		4,149,835	571,116,865	0.11%
Egypt	Low & middle	Tier 2	WHO	2011	1,305	11,208		781,376	1,019,695,747	0.12%
Algeria	Low & middle	Tier 4	GBD	2010	666	13,066		910,967	606,868,868	0.13%
Djibouti	Low & middle	Tier 4	GBD	2010	71	2,787		194,336	13,783,963	
Iran	Low & middle	Tier 4	GBD	2010	2,129	16,424		1,145,073	2,437,573,423	
Lebanon	Low & middle	Tier 4	GBD	2010	56	17,008		1,185,765	66,907,751	0.09%
Libya	Low & middle	Tier 4	GBD	2010	141	31,647		2,206,399	310,841,947	
Syria	Low & middle	Tier 4	GBD	2010	206	4,332		302,030	62,173,859	
Tunisia	Low & middle	Tier 4	GBD	2010	151	10,886		758,935	114,446,713	0.10%
Yemen	Low & middle	Tier 4	GBD	2010	682	4,742		330,599	225,362,501	0.22%

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Country	Income Group	Tier	Source	YoD	# of D	GDP per capita	VSL estimates		Cost of Drowning	Share of GNI
							(1) Literature	(2) Estimated		
North America										
Canada	High income	Tier 1	WHO	2011	253	43,584	1,906,749		482,407,426	0.03%
USA	High income	Tier 1	WHO	2010	3,814	51,638	3,899,162		14,871,402,163	0.09%
Bermuda	High income	Tier 2	WHO	2010	3	58,978		4,111,871	12,335,612	0.26%
South Asia										
Maldives	Low & middle	Tier 2	WHO	2011	14	11,766		820,291	11,484,078	0.35%
Sri Lanka	Low & middle	Tier 2	WHO	2006	865	6,627		462,020	399,647,066	0.31%
Bangladesh	Low & middle	Tier 3	GBD	2010	21,930	2,572	123,990		2,719,128,521	0.65%
India	Low & middle	Tier 3	GBD	2010	85,752	4,851	265,861		22,798,039,595	0.39%
Afghanistan	Low & middle	Tier 4	GBD	2010	3,240	1,712		119,379	386,775,748	0.79%
Bhutan	Low & middle	Tier 4	GBD	2010	34	6,814		475,058	16,318,962	0.35%
Nepal	Low & middle	Tier 4	GBD	2010	651	2,091		145,757	94,862,641	0.17%
Pakistan	Low & middle	Tier 4	GBD	2010	11,350	4,413		307,656	3,491,833,228	0.44%
Sub-Saharan Africa										
Equatorial Guinea	High income	Tier 4	GBD	2010	65	36,041		2,512,714	163,660,584	0.78%

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Country	Income Group	Tier	Source	YoD	# of D	GDP per capita	VSL estimates		Cost of Drowning	Share of GNI
							(1) Literature	(2) Estimated		
Mauritius	Low & middle	Tier 2	WHO	2012	41	17,034		1,187,553	48,689,667	0.22%
South Africa	Low & middle	Tier 2	WHO	2010	1,428	12,185		849,486	1,213,066,111	0.20%
Seychelles	Low & middle	Tier 2	WHO	2012	6	24,010		1,673,922	10,043,531	0.50%
Angola	Low & middle	Tier 4	GBD	2010	1,411	7,370		513,814	724,997,240	0.56%
Benin	Low & middle	Tier 4	GBD	2010	283	1,712		119,324	33,749,694	0.21%
Botswana	Low & middle	Tier 4	GBD	2010	30	13,961		973,317	29,504,736	0.11%
Burkina Faso	Low & middle	Tier 4	GBD	2010	842	1,535		107,035	90,145,603	0.38%
Burundi	Low & middle	Tier 4	GBD	2010	757	759		52,883	40,055,037	0.58%
Cameroon	Low & middle	Tier 4	GBD	2010	742	2,689		187,440	139,042,278	0.25%
Cape Verde	Low & middle	Tier 4	GBD	2010	10	6,280		437,832	4,328,753	0.15%
Central African Republic	Low & middle	Tier 4	GBD	2010	426	942		65,703	28,007,127	0.68%
Chad	Low & middle	Tier 4	GBD	2010	429	2,042		142,363	61,017,992	0.26%
Comoros	Low & middle	Tier 4	GBD	2010	81	1,440		100,392	8,144,066	0.81%
Congo	Low & middle	Tier 4	GBD	2010	270	5,787		403,436	108,872,032	0.61%
Cote d'Ivoire	Low & middle	Tier 4	GBD	2010	815	3,025		210,879	171,938,426	0.31%

Annex 4: Further insights

Country	Income Group	Tier	Source	YoD	# of D	GDP per capita	VSL estimates		Cost of Drowning	Share of GNI
							(1) Literature	(2) Estimated		
Democratic Republic of the Congo	Low & middle	Tier 4	GBD	2010	7,196	716		49,934	359,316,578	0.84%
Eritrea	Low & middle	Tier 4	GBD	2010	423	1,133		78,981	33,445,660	0.52%
Ethiopia	Low & middle	Tier 4	GBD	2010	3,861	1,131		78,841	304,431,915	0.31%
Gabon	Low & middle	Tier 4	GBD	2010	113	17,492		1,219,514	137,862,369	0.57%
Ghana	Low & middle	Tier 4	GBD	2010	660	3,205		223,471	147,552,994	0.19%
Guinea	Low & middle	Tier 4	GBD	2010	363	1,240		86,433	31,416,361	0.26%
Guinea-Bissau	Low & middle	Tier 4	GBD	2010	70	1,431		99,734	6,971,300	0.31%
Kenya	Low & middle	Tier 4	GBD	2010	2,237	2,617		182,453	408,225,875	0.38%
Lesotho	Low & middle	Tier 4	GBD	2010	131	2,331		162,486	21,258,258	0.38%
Liberia	Low & middle	Tier 4	GBD	2010	154	720		50,202	7,736,669	0.32%
Madagascar	Low & middle	Tier 4	GBD	2010	1,157	1,454		101,379	117,261,616	0.39%
Malawi	Low & middle	Tier 4	GBD	2010	1,679	771		53,758	90,258,069	0.80%
Mali	Low & middle	Tier 4	GBD	2010	691	1,740		121,299	83,852,209	0.36%
Mauritania	Low & middle	Tier 4	GBD	2010	92	2,796		194,962	17,995,639	0.18%
Mozambique	Low & middle	Tier 4	GBD	2010	2,509	975		68,009	170,625,922	0.75%

Country	Income Group	Tier	Source	YoD	# of D	GDP per capita	VSL estimates		Cost of Drowning	Share of GNI
							(1) Literature	(2) Estimated		
Namibia	Low & middle	Tier 4	GBD	2010	81	8,824		615,228	50,117,674	0.27%
Niger	Low & middle	Tier 4	GBD	2010	642	880		61,335	39,370,249	0.28%
Nigeria	Low & middle	Tier 4	GBD	2010	6,187	5,348		372,852	2,306,845,481	0.29%
Rwanda	Low & middle	Tier 4	GBD	2010	569	1,320		92,014	52,335,030	0.37%
Sao Tome and Principe	Low & middle	Tier 4	GBD	2010	3	2,869		200,030	576,980	0.11%
Senegal	Low & middle	Tier 4	GBD	2010	352	2,282		159,072	55,987,302	0.19%
Sierra Leone	Low & middle	Tier 4	GBD	2010	188	1,408		98,175	18,474,214	0.23%
Somalia	Low & middle	Tier 4	GBD	2010	789	558		38,872	30,659,612	
Sudan	Low & middle	Tier 4	GBD	2010	2,339	3,479		242,554	567,436,047	0.39%
Swaziland	Low & middle	Tier 4	GBD	2010	66	6,810		474,777	31,378,984	0.40%
Tanzania	Low & middle	Tier 4	GBD	2010	3,367	1,616		112,664	379,322,195	0.54%
The Gambia	Low & middle	Tier 4	GBD	2010	68	1,743		121,550	8,226,247	0.29%
Togo	Low & middle	Tier 4	GBD	2010	217	1,303		90,849	19,718,697	0.28%
Uganda	Low & middle	Tier 4	GBD	2010	2,141	1,353		94,348	201,954,558	0.45%
Zambia	Low & middle	Tier 4	GBD	2010	1,240	3,609		251,607	311,985,280	0.70%

Annex 4: Further insights

Country	Income Group	Tier	Source	YoD	# of D	GDP per capita	VSL estimates		Cost of Drowning	Share of GNI
							(1) Literature	(2) Estimated		
Zimbabwe	Low & middle	Tier 4	GBD	2010	1,313	1,552		108,219	142,123,761	0.71%

Source: Frontier calculations.

Notes:
The exact rule of thumb applied to estimate the VSL is 69.718327.
All figures are at the year of the most recent drowning estimate [YoD] in international $ [PPP adjusted], expressed in 2014 prices.
The results are sorted by region and income groups as defined by the World Bank.
GNI (formerly GNP) is the gross national income within a country.

Annex 4: Further insights

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