Annex 2E Adjustments To Account For Burden Not Amenable To Surgical Care

In principle, the fatal burden for the hypothetical state of full access to high-quality surgical care was calculated by the following common equation:

$$Death'_{i,j,k} = Incidence_{i,j,k} \times CFR'_{i.j.k} \quad (1)$$

$$YLL'_{i,j,k} = Death'_{i,j,k} \times StdLifeExpect_i \quad (2)$$

where $Death'_{i.j.k}$ is the age-specific (i) and sex-specific (j) number of deaths for the hypothetical state in each super region (k), $Incidence_{i,j,k}$ is the age and sex-specific number of incident cases from GBD 2010 in each super region, $CFR'_{i,j,k}$ is the age and sex-specific case-fatality rates for the hypothetical state in each super region, $YLL'_{i,j,k}$ is the fatal burden in case of the hypothetical state, and $StdLifeExpect_i$ is the age-specific standard life expectancy used in GBD 2010. In order to estimate the $CFR'_{i,j,k}$, we assumed that the lowest age and sex-specific fatality rates among the 21 epidemiological regions from GBD 2010 reflect the hypothetical state (and hence the difference of those case-fatality rates reflecting the gap in surgical care).

The nonfatal burden for the hypothetical state was commonly estimated by the following equation:

$$YLD'_{i,j,k} = (Incidence_{i,j,k} - Death'_{i,j,k}) \times Duration \times DW \quad (3)$$

where $YLD'_{i,j,k}$ is the nonfatal burden in case of the hypothetical state, $Duration$ is the duration of disease, and DW is the disability weight attached to each condition.

However, not all cases are amenable to surgical care for some of the investigated conditions: maternal haemorrhage, neonatal encephalopathy, and injury. These conditions required adjustments to account for those cases that were not avertable by surgical care.

Maternal haemorrhage

Johns et al. estimated the resources needed to achieve universal coverage of maternal and neonatal health in 75 countries, including for maternal haemorrhage (see Table A).[1] Based on the findings of this study (although the authors did not provide detailed data sources for each procedure), we calculated that 36% of haemorrhage cases are amenable to surgical interventions:

$$\begin{aligned} SurgProp &= (Caesarean^{0.0011} + RemovePlacenta^{0.01} + RepairTear^{0.01} \\ &\quad + Hysterectomy^{0.0013}) \div HaemMgmtTotal^{0.0622} \\ &= 0.0224 \div 0.0622 \\ &= 0.3601 \end{aligned} \quad (4)$$

where $SurgProp$ is the proportion of haemorrhagic cases amenable to surgical interventions, $Caesarean^{0.0011}$, $RemovePlacenta^{0.01}$, $RepairTear^{0.01}$, $Hysterectomy^{0.0013}$ denote the numbers per completed pregnancy or delivery that require each surgical care (i.e., caesarean section, manual removal of placenta, repair of vaginal, perineal or cervical tears, and hysterectomy, respectively), and $HaemMgmtTotal^{0.0622}$ the total number per completed pregnancy or delivery that require medical or surgical care due to maternal haemorrhage. With this proportion, we calculated the case fatality rates for each super region as follows:

$$CFR'_{i,j,k} = CFR_{i,j,k} \times (1 - SurgProp) + CFR^{lowest}_{i,j,k} \times SurgProp \qquad (5)$$

For example, the $CFR'_{i,j,k}$ of maternal haemorrhage for women aged 35-39 in Sub-Saharan Africa was calculated as:

$$\begin{aligned} CFR'_{35,F,Sub-Saharan\ Africa} &= 0.01613 \times (1 - 0.3601) + 0.00015 \times 0.3601 \\ &= 0.010376 \end{aligned} \qquad (5')$$

Table A Interventions needed for maternal haemorrhage

Intervention	Per completed pregnancy or delivery
Caesarean*	0.0011
Blood transfusion (antepartum)	0.0073
Blood transfusion (postpartum)	0.0125
Additional supplies	0.0125
Treatment of bleeding lasting >24hrs	0.0075
Manual removal of placenta*	0.0100
Repair of vaginal or perineal tear*	0.0050
Repair of cervical tears*	0.0050
Hysterectomy*	0.0013
Total	0.0622

Source: Johns et al.[1]
*These procedures were assumed surgical

Neonatal encephalopathy

We limited the analysis to the burden of neonatal encephalopathy that can be averted by preventing obstructed labour cases; by caesarean section and instrumental delivery. The first step was to estimate the effect size in reducing the risk of fatal and nonfatal burden. We referred to the assumption of 40% risk reduction that was used in the World Health Organization Choosing Interventions that are Cost Effective (WHO CHOICE) project.[2-4] However, applying this assumption uniformly to all regions leads to an overestimation of avertable burden for those regions that already have relatively high coverage of surgical care. Therefore we scaled the effect size according to the access to healthcare covariate used in modelling the nonfatal burden in GBD 2010.[5] 0% risk reduction for the region with highest healthcare access; and 40% risk reduction for that with lowest access (see Table B). Based on these assumptions, the YLLs and YLDs in case of the hypothetical state were calculated as follows:

$$YLL'_{i,j,k} = Death_{i,j,k} \times (1 - RiskReduction_k) \times StdLifeExpect_i \quad (6)$$

$$YLD'_{i,j,k} = PrevMild_{i,j,k} \times DW_{mild} + PrevSevere_{i,j,k} \times DW_{severe} \times (1 - RiskReduction_k) \quad (7)$$

where $RiskReduction_k$ is the calculated reduction rate of mortality and morbidity risks for each super region, $PrevMild_{i,j,k}$ is the prevalent mild cases in 2010, and $PrevSevere_{i,j,k}$ the prevalent moderate to severe cases in 2010. For example, the $YLL'_{i,j,k}$ of neonatal encephalopathy for male infants in North Africa & Middle East was calculated as:

$$YLL'_{0,M,North\ Africa\ \&\ Middle\ East} = 8{,}844 \times (1 - 0.16) \times 86.4 = 641{,}862 \quad (6')$$

Table B Adjusted risk reduction

East Europe & Central Asia	Sub-Saharan Africa	North Africa & Middle East	Asia South	East Asia Pacific	Latin America & Caribbean	High-income
9%	39%	16%	40%	9%	10%	0%

Injury

In order to account for injury cases that result in deaths before reaching a hospital, we obtained information from survey literature [6-35] and country-level hospital data (Brazil, USA, South Africa) from a total of 18 countries on the proportion of deaths that never make it to hospital, and pooled and extrapolated those data to regions where there was no information available by means of DisMod-MR (see Table C). With this proportion of fatal pre-hospital cases, we adjusted the case fatality rates for each super region as follows:

$$CFR'_{i,j,k} = CFR_{i,j,k} \times NotReachProp_k + CFR^{lowest}_{i,j,k} \times (1 - NotReachProp_k) \quad (8)$$

where $NotReachProp_k$ is the proportion of fatal cases that take place before reaching hospitals in each region. For example, the $CFR'_{i,j,k}$ of road injury for men aged 75-79 in Asia South was calculated as:

$$CFR'_{75,M,Asia\ South} = 0.04612 \times 0.46 + 0.01772 \times (1 - 0.46) = 0.03078 \quad (8')$$

Table C Average cause-specific proportions of fatal cases prior to reaching hospitals

	East Europe & Central Asia	Sub-Saharan Africa	North Africa & Middle East	Asia South	East Asia Pacific	Latin America & Caribbean	Total
Male							
Road injury	54%	60%	49%	46%	55%	51%	54%
Other transport injury	75%	72%	71%	60%	72%	71%	72%
Falls	26%	55%	36%	65%	34%	30%	38%
Fire, heat and hot substances	47%	45%	33%	36%	43%	43%	43%
Unintentional injury others							
Exposure to mechanical forces	63%	72%	59%	59%	63%	57%	63%
Adverse effects of medical treatment	12%	16%	12%	12%	12%	9%	12%
Animal contact (non-venomous)	42%	73%	46%	75%	51%	43%	53%
Unintentional injuries not classified elsewhere	51%	68%	49%	58%	54%	49%	55%
Interpersonal violence	66%	70%	65%	64%	66%	65%	67%
Female							
Road injury	53%	60%	49%	45%	55%	51%	54%
Other transport injury	76%	73%	72%	61%	73%	72%	72%
Falls	25%	51%	34%	61%	32%	28%	36%
Fire, heat and hot substances	40%	39%	28%	31%	37%	37%	37%
Unintentional injury others							
Exposure to mechanical forces	57%	66%	54%	54%	58%	53%	58%
Adverse effects of medical treatment	11%	15%	11%	11%	11%	8%	11%
Animal contact (non-venomous)	41%	70%	45%	72%	49%	42%	52%
Unintentional injuries not classified elsewhere	44%	60%	43%	51%	48%	43%	49%
Interpersonal violence	73%	77%	71%	70%	73%	71%	73%

References

1. Johns B, Sigurbjörnsdóttir K, Fogstad H, Zupan J, Mathai M, Tan-Torres Edejer T. Estimated global resources needed to attain universal coverage of maternal and newborn health services. Bulletin of the World Health Organization. 2007;85(4):256-63.
2. Adam T, Lim SS, Mehta S, Bhutta ZA, Fogstad H, Mathai M, et al. Cost effectiveness analysis of strategies for maternal and neonatal health in developing countries. BMJ. 2005;331(7525):1107.
3. Darmstadt GL, Bhutta ZA, Cousens S, Adam T, Walker N, de Bernis L. Evidence-based, cost-effective interventions: how many newborn babies can we save? The Lancet. 2005;365(9463):977-88.
4. World Health Organization maternal health and safe motherhood programme. World Health Organization partograph in management of labour. The Lancet. 1994;343(8910):1399-404.
5. Vos T, Flaxman AD, Naghavi M, Lozano R, Michaud C, Ezzati M, et al. Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. The Lancet. 2012;380(9859):2163-96.
6. Pali Lehohla. Road traffic accident deaths in South Africa, 2001–2006: evidence from death notification. Pretoria: Statistics South Africa, 2009.
7. Singh Y, Das KC. An Epidemiological study of road traffic accident victims in medicolegal autopsies. Journal of Indian Academy of Forensic Medicine. 2005;27(3):166-9.
8. Gedeborg R, Chen LH, Thiblin I, Byberg L, Melhus H, Michaelsson K, et al. Prehospital injury deaths—Strengthening the case for prevention: Nationwide cohort study. The Journal of Trauma and Acute Care Surgery. 2012;72(3):765.
9. Wisborg T, Høylo T, Siem G. Death after injury in rural Norway: high rate of mortality and prehospital death. Acta Anaesthesiologica Scandinavica. 2003;47(2):153-6.
10. Tsegaye F, Abdella K, Ahmed E, Tadesse T, Bartolomeos K. Pattern of Fatal Injuries in Addis Ababa, Ethiopia. A One-year Audit. East and Central African Journal of Surgery. 2010;15(2):10-7.
11. Søreide K, Krüger AJ, Vårdal AL, Ellingsen CL, Søreide E, Lossius HM. Epidemiology and contemporary patterns of trauma deaths: changing place, similar pace, older face. World Journal of Surgery. 2007;31(11):2092-103.
12. Roudsari B, Shadman M, Ghodsi M. Childhood trauma fatality and resource allocation in injury control programs in a developing country. BMC Public Health. 2006;6(1):117. PubMed PMID: doi:10.1186/1471-2458-6-117.
13. Masella CA, Pinho VF, Passos ADC, Netto FACS, Rizoli S, Scarpelini S. Temporal distribution of trauma deaths: quality of trauma care in a developing country. The Journal of Trauma and Acute Care Surgery. 2008;65(3):653-8.
14. Arreola-Risa C, Mock C, Padilla D, Cavazos L, Maier R, Jurkovich G. Trauma care systems in urban Latin America: the priorities should be prehospital and emergency room management. The Journal of Trauma and Acute Care Surgery. 1995;39(3):457-62.

15. Bakke HK, Wisborg T. Rural high north: a high rate of fatal injury and prehospital death. World Journal of Surgery. 2011;35(7):1615-20.
16. Chiara O, Scott JD, Cimbanassi S, Marini A, Zoia R, Rodriguez A, et al. Trauma deaths in an Italian urban area: an audit of pre-hospital and in-hospital trauma care. Injury. 2002;33(7):553-62.
17. Di Bartolomeo S, Sanson G, Michelutto V, Nardi G, Burba I, Francescutti C, et al. Epidemiology of major injury in the population of Friuli Venezia Giulia—Italy. Injury. 2004;35(4):391-400.
18. Hansen K, Morild I, Engesaeter L, Viste A. Epidemiology of severely and fatally injured patients in western part of Norway. Scandinavian Journal of Surgery. 2004;93(3):198-203.
19. Jayaraman S, Ozgediz D, Miyamoto J, Caldwell N, Lipnick MS, Mijumbi C, et al. Disparities in injury mortality between Uganda and the United States: comparative analysis of a neglected disease. World Journal of Surgery. 2011;35(3):505-11.
20. London J, Mock C, Abantanga FA, Quansah RE, Boateng K. Using mortuary statistics in the development of an injury surveillance system in Ghana. Bulletin of the World Health Organization. 2002;80(5):357-64.
21. Leong M, Mujumdar S, Raman L, Lim Y, Chao T, Anantharaman V. Injury related deaths in Singapore. j. emerg. med. 2003;10:88-96.
22. Mock CN, Jurkovich GJ, Arreola-Risa C, Maier RV. Trauma mortality patterns in three nations at different economic levels: implications for global trauma system development. The Journal of Trauma and Acute Care Surgery. 1998;44(5):804-14.
23. Sauaia A, Moore FA, Moore EE, Moser KS, Brennan R, Read RA, et al. Epidemiology of trauma deaths: a reassessment. The Journal of Trauma and Acute Care Surgery. 1995;38(2):185-93.
24. Demetriades D, Murray J, Sinz B, Myles D, Chan L, Sathyaragiswaran L, et al. Epidemiology of major trauma and trauma deaths in Los Angeles County. Journal of the American College of Surgeons. 1998;187(4):373.
25. Potenza BM, Hoyt DB, Coimbra R, Fortlage D, Holbrook T, Hollingsworth-Fridlund P. The epidemiology of serious and fatal injury in San Diego County over an 11-year period. The Journal of Trauma and Acute Care Surgery. 2004;56(1):68-75.
26. Baker CC, Oppenheimer L, Stephens B, Lewis FR, Trunkey DD. Epidemiology of trauma deaths. The American Journal of Surgery. 1980;140(1):144-50.
27. Sills Mr LAMOHD. Prehospital and in-hospital mortality: A comparison of intentional and unintentional traumatic brain injuries in colorado children. Archives of Pediatrics & Adolescent Medicine. 2005;159(7):665-70.
28. Hussain L, Redmond A. Are pre-hospital deaths from accidental injury preventable? BMJ. 1994;308(6936):1077-80.

29. Murad M, Larsen S, Husum H. Prehospital trauma care reduces mortality. Ten-year results from a time-cohort and trauma audit study in Iraq. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine. 2012;20(1):13. PubMed PMID: doi:10.1186/1757-7241-20-13.

30. Meel BL. Pre-hospital and hospital traumatic deaths in the former homeland of Transkei, South Africa. Journal of Clinical Forensic Medicine. 2004 2//;11(1):6-11.

31. Ryan M, Stella J, Chiu H, Ragg M. Injury patterns and preventability in prehospital motor vehicle crash fatalities in Victoria. Emergency Medicine. 2004;16(4):274-9.

32. Montazeri A. Road-traffic-related mortality in Iran: a descriptive study. Public Health. 2004 3//;118(2):110-3.

33. Ngo AD, Rao C, Hoa NTP, Hoy D, Trang KTQ, Hill PS. Road traffic related mortality in Vietnam: Evidence for policy from a national sample mortality surveillance system. BMC Public Health. 2012;12(1):561.

34. VanRooyen M, Sloan E, Barrett J, Smith R, Reyes H. Outcome in an urban pediatric trauma system with unified prehospital emergency medical services care. Prehospital and Disaster Medicine. 1995;10(1):19.

35. Papadopoulos IN, Bonovas S, Kanakaris NK, Nikolopoulos G, Kotsilianou O, Konstantoudakis G, et al. Alcohol and psychoactive drugs increased the pre-hospital mortality in 655 fall-related fatalities in Greece: A call for management protocols. Injury. 2012 9//;43(9):1522-6.