Alcohol-attributable diseases and dose-response curves for the Sheffield Alcohol Policy Model version 4.0

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Introduction

This document presents the list of health conditions related to alcohol which are included in the most recent version (4.0) of the Sheffield Alcohol Policy Model (SAPM). It also presents the corresponding dose-response curves (the mathematical relationships between volume of alcohol consumed and risk of morbidity/mortality) for all included conditions which are not wholly-attributable to alcohol. This is based on recent reviews by Rehm et al. (J Rehm, A, Shield, & Gmel, 2017; Jürgen Rehm et al., 2017) and Sherk et al. (Sherk, Stockwell, Rehm, Dorocicz, & Shield, 2017), as well as previous versions of the Sheffield Model (Meier et al., 2016) supplemented with additional evidence as appropriate. Note that SAPM considers only conditions which affect the drinker and therefore several conditions related to alcohol, such as Foetal Alcohol Spectrum Disorders, are therefore not included.

Acknowledgements

The authors would like to thank Katrina Brown of Cancer Research UK, Kevin Shield of the Centre for Addiction and Mental Health in Toronto and Adam Sherk of the University of Victoria for their advice and input at various stages of the preparation of this document.

List of alcohol-attributable diseases included in SAPM 4.0

Category	Condition	ICD-10 code(s)	Condition type*
Cancer	Oropharyngeal cancer	C00-06, C09-10, C12-C14	Partial chronic
Cancer	Oesophageal cancer	C15	Partial chronic
Cancer	Colorectal cancer	C18-C20	Partial chronic
Cancer	Cancer of the liver and intrahepatic bile ducts	C22	Partial chronic
Cancer	Pancreatic cancer	C25	Partial chronic
Cancer	Laryngeal cancer	C32	Partial chronic
Cancer	Breast cancer	C50	Partial chronic
Cardiovascular	Hypertensive diseases	I10-I14	Partial chronic
Cardiovascular	Ischaemic heart disease	I20-I25	Partial chronic
Cardiovascular	Alcoholic cardiomyopathy	I42.6	100% chronic
Cardiovascular	Cardiac arrhythmias	I47-I49	Partial chronic
Cardiovascular	Haemorrhagic stroke	I60-I62	Partial chronic
Cardiovascular	Ischaemic stroke	I63-I67	Partial chronic
Digestive	Cirrhosis of the liver (excluding alcoholic liver disease)	K70 (excl. K70.0-K70.4, K70.9), K73-K74	Partial chronic
Digestive	Alcoholic Gastritis	K29.2	100% chronic
Digestive	Alcoholic liver disease	K70.0-K70.4, K70.9	100% chronic
Digestive	Acute pancreatitis (alcohol induced)	K85.2	100% chronic
Digestive	Acute pancreatitis	K85 (excl. K85.2, K85.3)	Partial chronic
Digestive	Chronic pancreatitis (alcohol induced)	K86.0	100% chronic
Digestive	Chronic pancreatitis	K86 (excl. K86.0)	Partial chronic
Poisoning	Excessive Blood Level of Alcohol	R78.0	100% acute
Poisoning	Toxic effect of alcohol	T51.0, T51.1, T51.8, T51.9	100% acute
Poisoning	Accidental poisoning by exposure to noxious substances	X40-X49 (excl. X45), Y10-Y14, Y16-Y19, T36-T50, T52-T65	Partial acute
Poisoning	Alcohol poisoning	X45, X65, Y15	100% acute
Poisoning	Evidence of alcohol involvement determined by blood alcohol level	Y90	100% acute
Injuries	Transport injuries (including road traffic accidents)	V01-V98, Y85.0	Partial acute
Injuries	Fall injuries	W00-W19	Partial acute

Injuries	Exposure to mechanical forces (including machinery accidents)	W20-W52	Partial acute
Injuries	Drowning	W65-W74, Y21	Partial acute
Injuries	Fire injuries	X00-X09, Y26	Partial acute
Injuries	Other Unintentional Injuries	W75-W99, X10-X33, Y20, Y22-Y25, Y27-Y29, Y31-Y34	Partial acute
Injuries	Intentional self-harm	X60-X84 (excl. X65), Y87.0	Partial acute
Injuries	Assault	X85-Y09, Y87.1	Partial acute
Injuries	Other intentional injuries	Y35	Partial acute
Endocrine	Diabetes (Type II)	E11	Partial chronic
Endocrine	Alcohol-induced pseudo-Cushing's syndrome	E24.4	100% chronic
Mental Health	Acute intoxication	F10.0	100% acute
Mental Health	Mental and behavioural disorders due to use of alcohol	F10.1-F10.9	100% chronic
Nervous System	Degeneration	G31.2	100% chronic
Nervous System	Epilepsy and status epilepticus	G40-G41	Partial chronic
Nervous System	Alcoholic polyneuropathy	G62.1	100% chronic
Nervous System	Alcoholic myopathy	G72.1	100% chronic
Other	Maternal care for (suspected) damage to foetus from alcohol	O35.4	100% chronic
Respiratory	Tuberculosis	A15-A19	Partial chronic
Respiratory	Lower respiratory tract infections	J09-J18	Partial chronic

* 100% conditions are those which are wholly-attributable to alcohol (i.e. which would not exist if nobody drank). Partial conditions are those which are partly attributable to alcohol but which would still exist, albeit with reduced prevalence, if nobody drank. Acute conditions are those which are related to intoxication. Chronic conditions are those which are related to chronic alcohol consumption in the longer term.

Dose-response curves for partially alcohol attributable chronic conditions

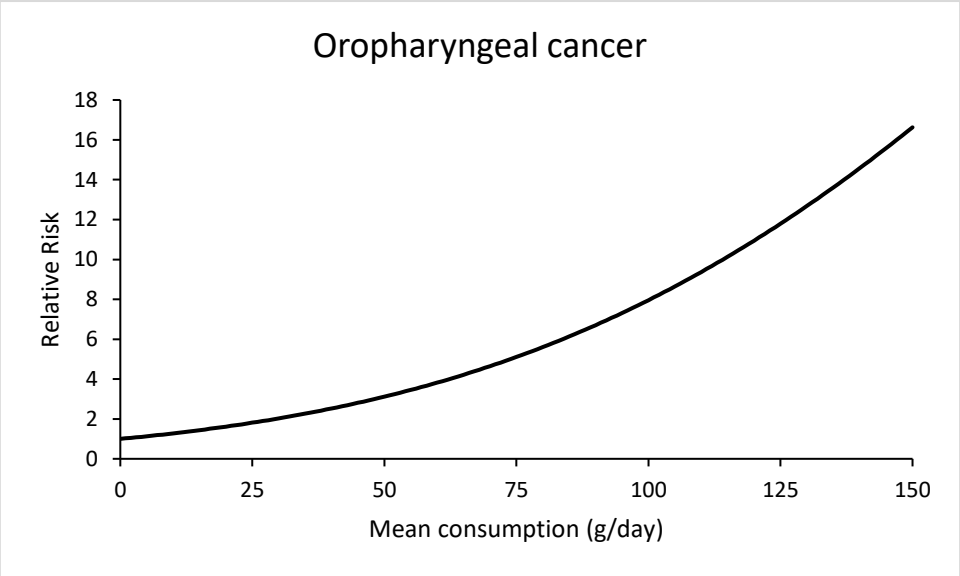
Relative risk of harm for drinkers at consumption level x, measured in grams of ethanol per day, versus lifetime abstainers. Due to small sample sizes, published risk functions are not stable above 150g/day, so we assume $RR(x) = RR(150)\ \forall\ x > 150$ for all conditions. All risk functions are applied to both genders and for both mortality and morbidity except where stated otherwise.

Cancers

Oropharyngeal

C00-06, C09-10, C12-14

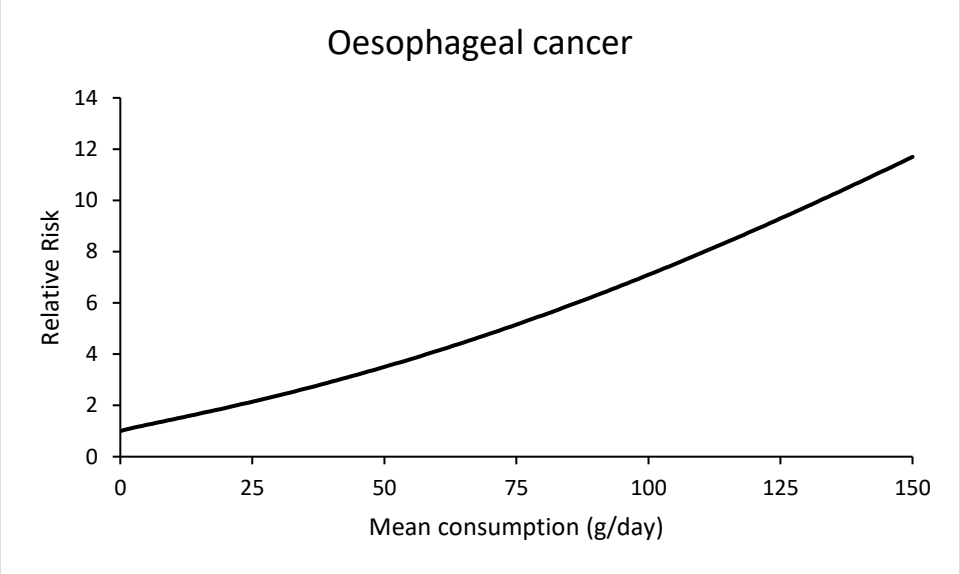
$$\ln\big(RR(x)\big) = 0.02474 \cdot x - 0.00004 \cdot x^2$$



Source (Bagnardi et al., 2015)

Oesophageal
C15

$$\ln\big(RR(x)\big) = 0.05593 \cdot x - 0.00789 \cdot x \cdot \ln(x)$$



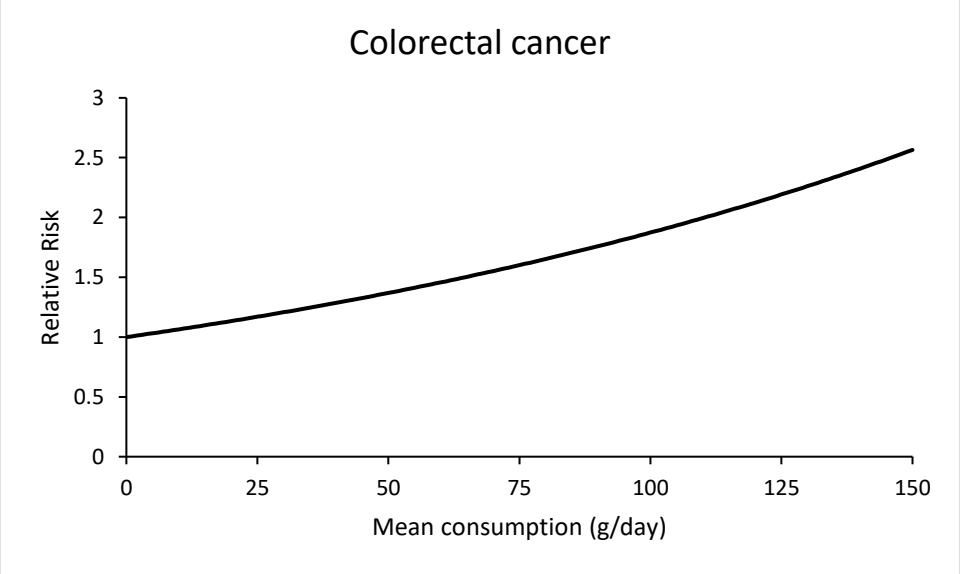
Source (Bagnardi et al., 2015)

Notes: Oesophageal cancer has two main histological types: Squamous Cell Carcinoma (SCC) and Adenocarcinoma (AC). Alcohol is only associated with SCC, not AC (Bagnardi et al., 2015). The relative prevalence of SCC and AC varies widely between countries and within population subgroups (Arnold, Soerjomataram, Ferlay, & Forman, 2015) and it may therefore be necessary to apportion overall oesophageal cancer prevalence between SCC and AC using external data such as that from cancer registries.

Colorectal

C18-C20

$$\ln\big(RR(x)\big) = 0.006279 \cdot x$$



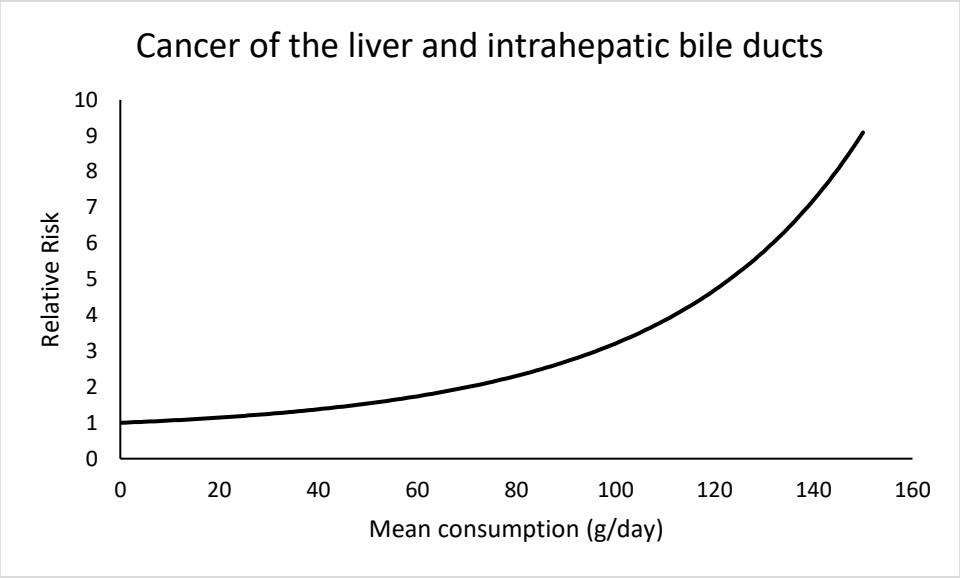
Source (Bagnardi et al., 2015)

Liver and intrahepatic bile ducts

C22

$$\ln\big(RR(x)\big) = 0.4100701 * (y - 0.6728571429) + 0.6101417 * (y^2 - 0.4527367347) + 0.4939596$$

$$where\ y = \frac{x + 12}{100}$$



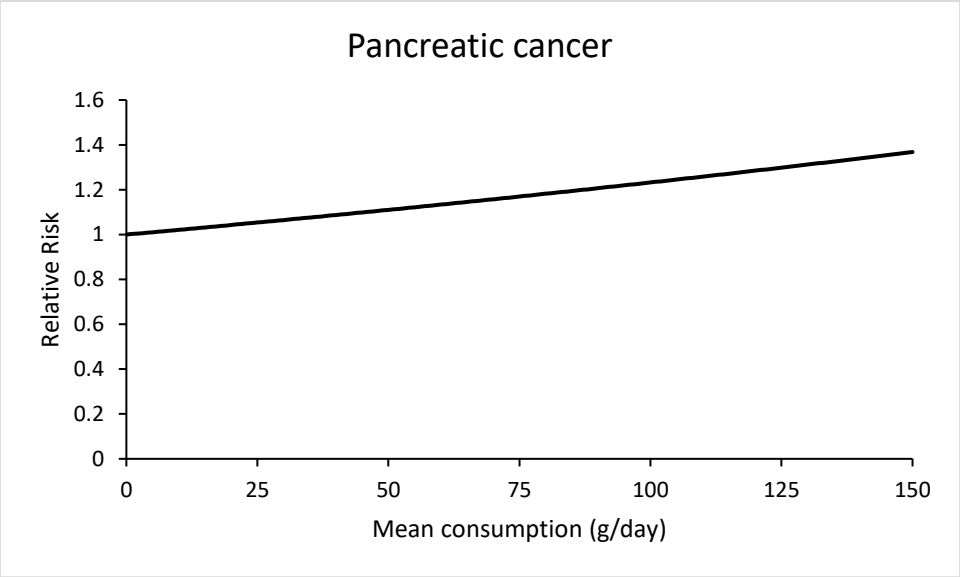
Source (Chuang, Lee, Wu, Straif, & Hashibe, 2015)

Notes: Bagnardi et al., which we use as the source for all other cancer risk curves do provide a curve for liver cancer, however this has extremely high Relative Risks at high levels of consumption (RR=45 at 150g/day), driven by high risks from a small number of case-control studies. Alternative meta-analyses from Chuang et al and Turati et al have found lower risks at high levels of consumption (Chuang et al., 2015; Turati et al., 2014), however these risk curves are still quite divergent. It may therefore be advisable to present modelled estimates using several alternative sources to illustrate the impact of this uncertainty.

Pancreatic

C25

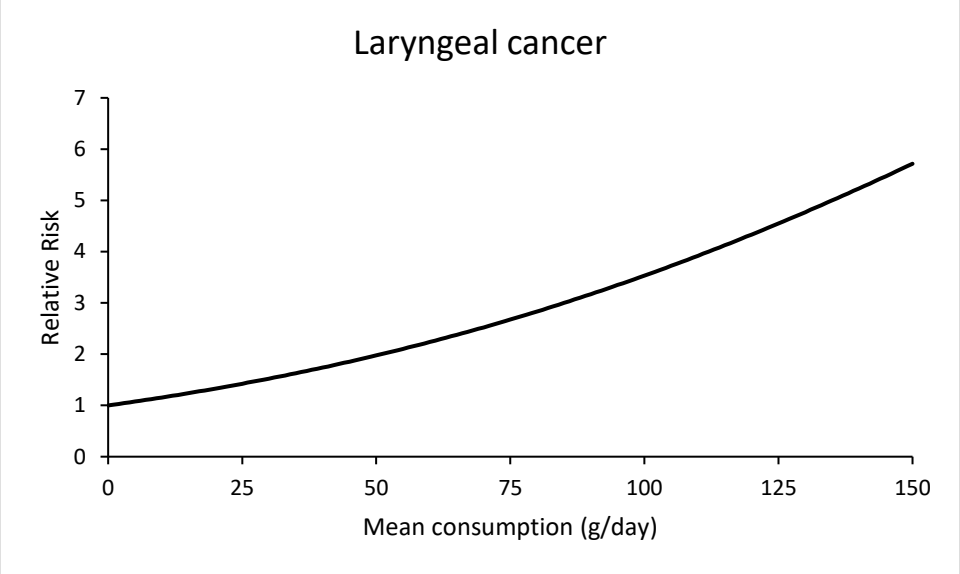
$$\ln\big(RR(x)\big) = 0.002089x$$



Source (Bagnardi et al., 2015)

Laryngeal
C32

$$\ln\big(RR(x)\big) = 0.01462 \cdot x - 0.00002 \cdot x^2$$

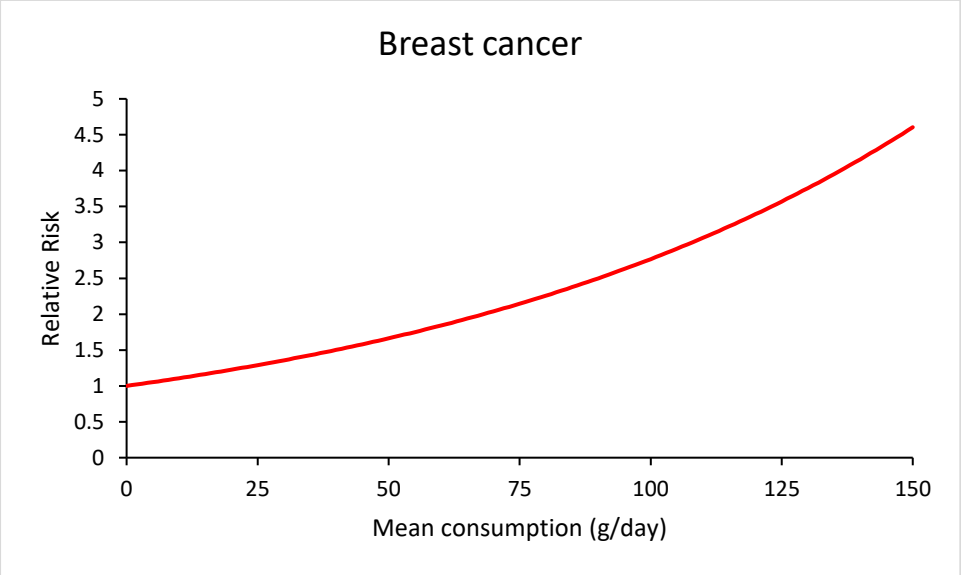


Source (Bagnardi et al., 2015)

Breast
C50

Female

$$\ln\big(RR(x)\big) = 0.01018 \cdot x$$



Source (Bagnardi et al., 2015)

Cardiovascular diseases

Hypertensive diseases

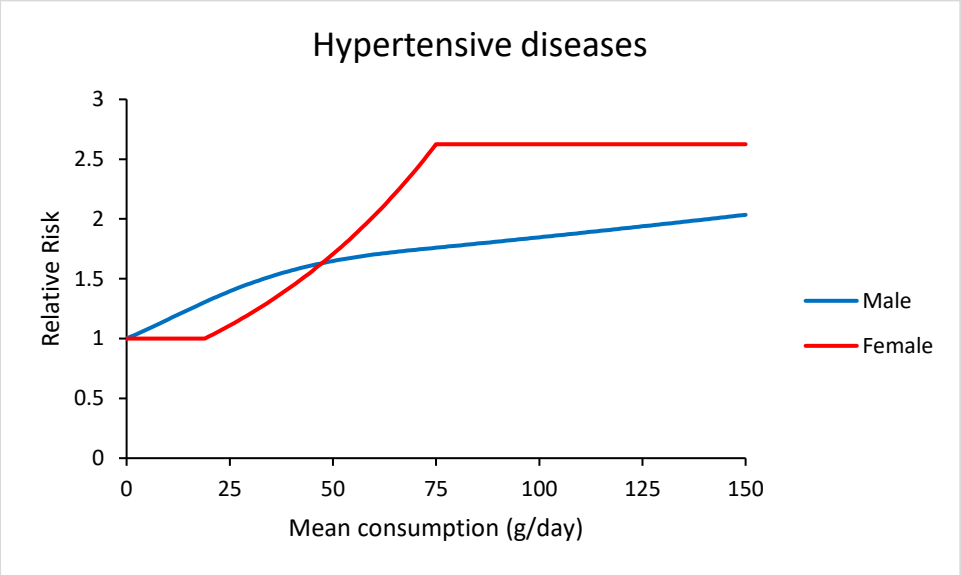
I10-I14

Male

$$\ln\left(RR(x)\right) = \begin{cases} 0.0150537 \cdot x - 0.0156155 \cdot \dfrac{x^3}{75^2} & ,0 \leq x < 21 \\ 0.0150537 \cdot x - 0.0156155 \cdot \dfrac{x^3 - \dfrac{(x-21)^3 \cdot 75}{(75-21)}}{75^2} & ,21 \leq x < 75 \\ 0.0150537 \cdot x - 0.0156155 \cdot \dfrac{x^3 - \dfrac{(x-21)^3 \cdot 75 - (x-75)^3 \cdot 21}{(75-21)}}{75^2} & ,75 \leq x \end{cases}$$

Female

$$\ln\left(RR(x)\right) = \begin{cases} 0 & ,x < 18.9517 \\ -0.0154196 \cdot x + 0.0217586 \cdot \dfrac{x^3 - \dfrac{(x-10)^3 \cdot 20 - (x-20)^3 \cdot 10}{(20-10)}}{20^2} & ,18.9517 \leq x < 75 \\ 0.9649937 & ,x \geq 75 \end{cases}$$



Source (J Rehm et al., 2017)

Ischaemic heart disease

I20-I25

Mortality

Male **16-34** $$\ln(RR(x)) = \begin{cases} 1.111874 \cdot (-0.4870068 \cdot \sqrt{y} + 1.550984 \cdot y^3), x \leq 60 \\ 0 \quad , 60 < x < 100 \\ 0.012 \cdot (x - 100) \quad , x \geq 100 \end{cases}$$

35-64 $$\ln(RR(x)) = \begin{cases} 1.035623 \cdot (-0.4870068 \cdot \sqrt{y} + 1.550984 \cdot y^3), x \leq 60 \\ 0 \quad , 60 < x < 100 \\ 0.012 \cdot (x - 100) \quad , x \geq 100 \end{cases}$$

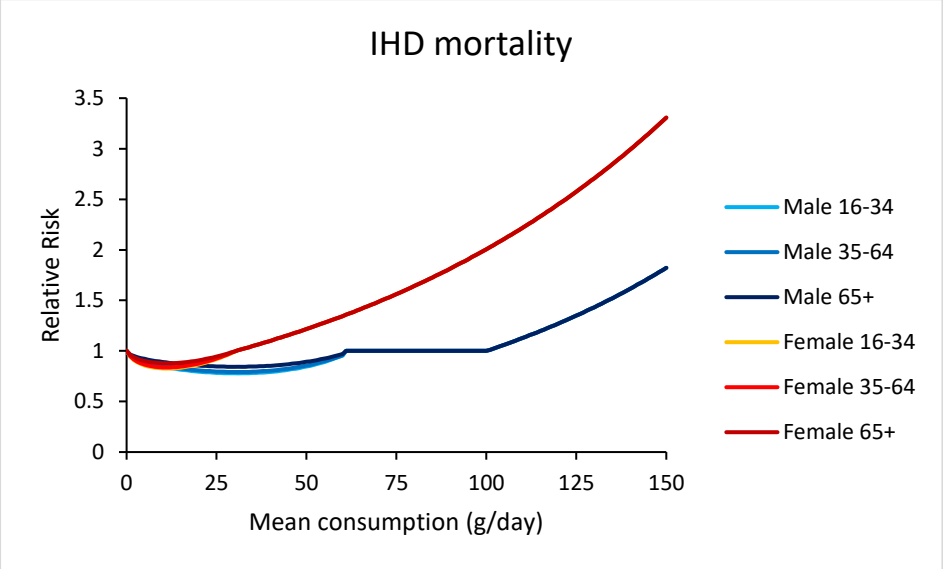
65+ $$\ln(RR(x)) = \begin{cases} 0.757104 \cdot (-0.4870068 \cdot \sqrt{y} + 1.550984 \cdot y^3), x \leq 60 \\ 0 \quad , 60 < x < 100 \\ 0.012 \cdot (x - 100) \quad , x \geq 100 \end{cases}$$

Female 16-34 $$\ln(RR(x)) = \begin{cases} 1.111874 \cdot (1.832441 \cdot y + 1.538557 \cdot y \cdot ln(y)), x < 30.3814 \\ 0.01 \cdot (x - 30.3814) \quad , x \geq 30.3814 \end{cases}$$

35-64 $$\ln(RR(x)) = \begin{cases} 1.035623 \cdot (1.832441 \cdot y + 1.538557 \cdot y \cdot ln(y)), x < 30.3814 \\ 0.0093 \cdot (x - 30.3814) \quad , x \geq 30.3814 \end{cases}$$

65+ $$\ln(RR(x)) = \begin{cases} 0.757104 \cdot (1.832441 \cdot y + 1.538557 \cdot y \cdot ln(y)), x < 30.3814 \\ 0.0068 \cdot (x - 30.3814) \quad , x \geq 30.3814 \end{cases}$$

$$where\ y = \frac{x + 0.0099999997764826}{100}$$



Source (Jürgen Rehm, Shield, Roerecke, & Gmel, 2016)

Notes: All protective effects are removed for drinkers who consume more than 60g in a single drinking occasion at least once per month, as per (Roerecke & Rehm, 2010)

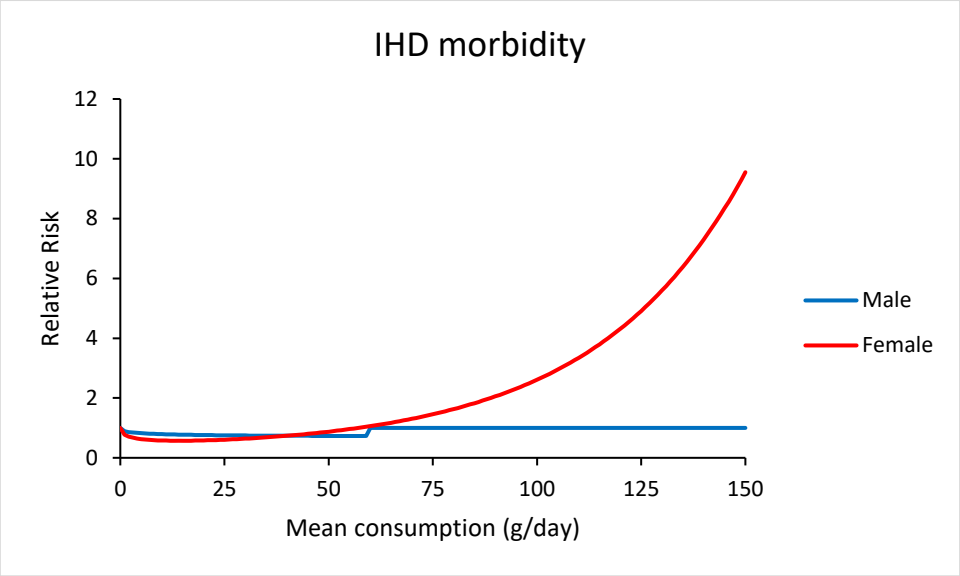
Morbidity

Male

$$ln\big(RR(x)\big) = \begin{cases} -0.1178113\sqrt{x} + 0.0189\sqrt{x} \cdot ln(x) & , x < 60 \\ 0 & , x \geq 60 \end{cases}$$

Female

$$ln\big(RR(x)\big) = -0.296842\sqrt{x} + 0.0392805x$$



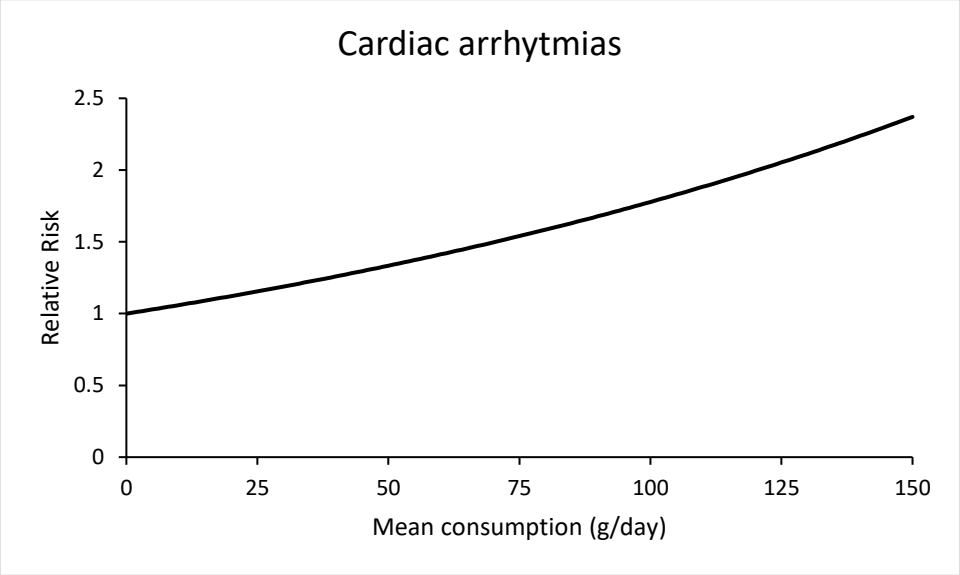
Source (Roerecke & Rehm, 2012)

Notes: All protective effects are removed for drinkers who consume more than 60g in a single drinking occasion at least once per month, as per (Roerecke & Rehm, 2010)

Cardiac arrhythmias

I47-I49

$$\ln(RR) = 0.0575183 * \frac{(x + 0.0499992370605469)}{10}$$



Source (Andriy V. Samokhvalov, Irving, & Rehm, 2010)

Haemorrhagic and other non-ischaemic stroke
I60-I62

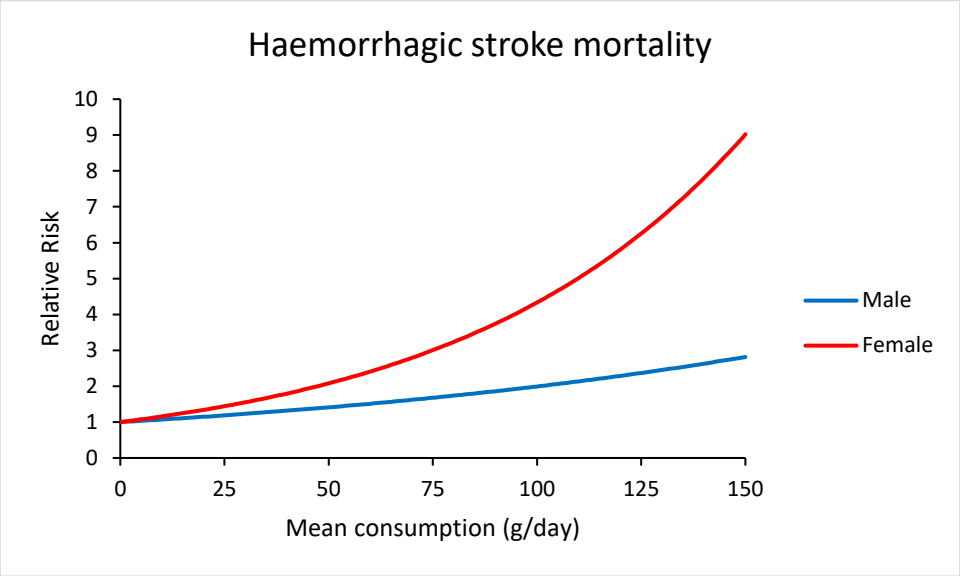
Mortality

Male

$$\ln\big(RR(x)\big) = \begin{cases} ln\big(1 - x \cdot (1 - 1.006943)\big) & , x \leq 1 \\ 0.6898937 \cdot \dfrac{x + 0.0028572082519531}{100} & , x > 1 \end{cases}$$

Female

$$ln\big(RR(x)\big) = \begin{cases} ln\big(1 - x \cdot (1 - 1.014815)\big) & , x \leq 1 \\ 1.466406 \cdot \dfrac{x + 0.0028572082519531}{100} & , x > 1 \end{cases}$$



Source (Patra et al., 2010)

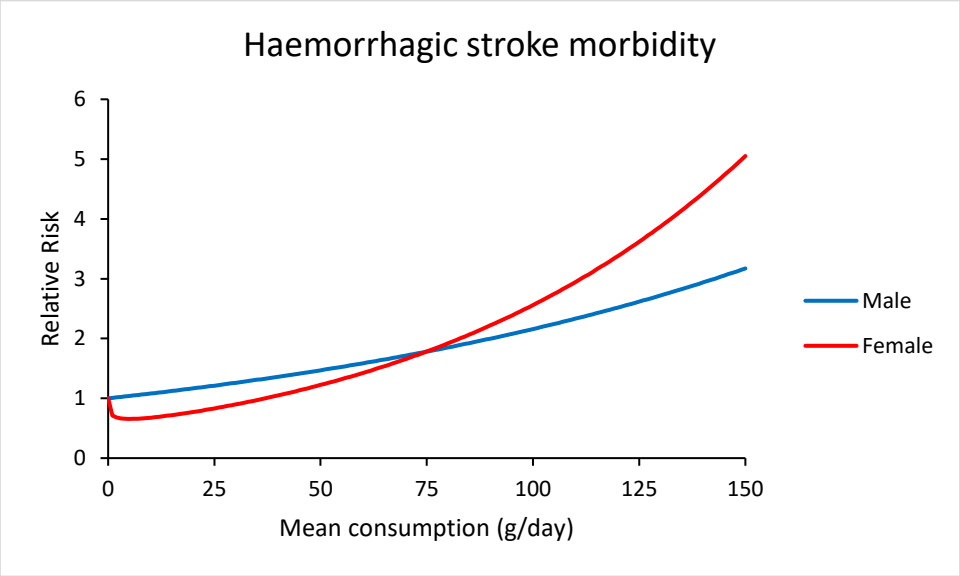
Morbidity

Male

$$ln\big(RR(x)\big) = 0.007695021x$$

Female

$$ln\big(RR(x)\big) = -0.340861\sqrt{x} + 0.0944208\sqrt{x} \cdot ln(x)$$



Source (Patra et al., 2010)

Ischaemic stroke

I63-I67

Mortality

Male 16-34

$$\ln\big(RR(x)\big) = \begin{cases} \ln\left(1 - x \cdot (1 - e^{-0.03521})\right) & , x \leq 1 \\ 1.111874 \cdot \left(0.4030081\sqrt{y} + 0.3877538\sqrt{y} \cdot \ln(y)\right) & , x > 1 \end{cases}$$

35-64

$$\ln\big(RR(x)\big) = \begin{cases} \ln\left(1 - x \cdot (1 - e^{-0.03279})\right) & , x \leq 1 \\ 1.035623 \cdot \left(0.4030081\sqrt{y} + 0.3877538\sqrt{y} \cdot \ln(y)\right) & , x > 1 \end{cases}$$

65+

$$\ln\big(RR(x)\big) = \begin{cases} \ln\left(1 - x \cdot (1 - e^{-0.02397})\right) & , x \leq 1 \\ 0.757104 \cdot \left(0.4030081\sqrt{y} + 0.3877538\sqrt{y} \cdot \ln(y)\right) & , x > 1 \end{cases}$$

Female 16-34

$$\ln\big(RR(x)\big) = \begin{cases} \ln\left(1 - x \cdot (1 - e^{-0.37987})\right) & , \leq 1 \\ 1.111874 \cdot \left(-2.48768\sqrt{y} + 3.708724y\right) & , x > 1 \end{cases}$$

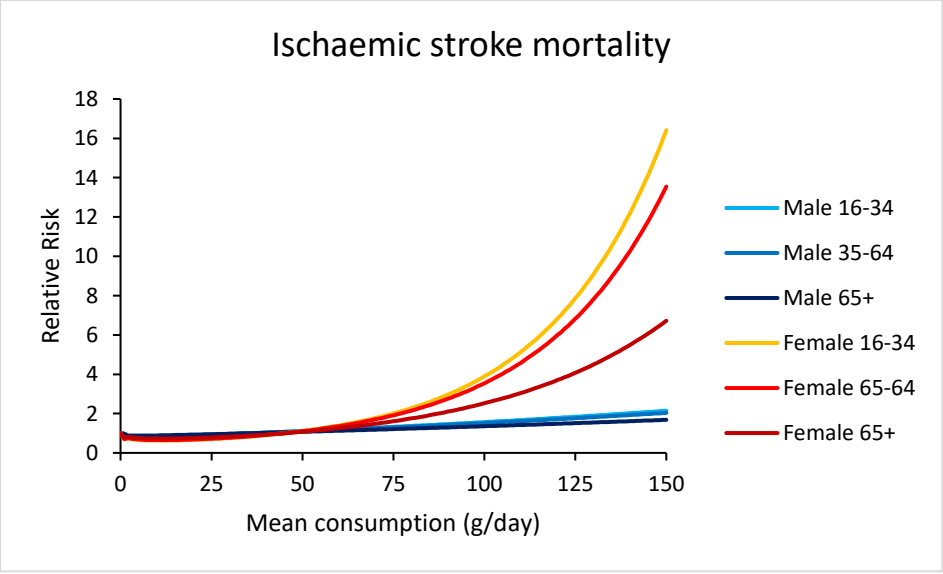
35-64

$$\ln\big(RR(x)\big) = \begin{cases} \ln\left(1 - x \cdot (1 - e^{-0.35382})\right) & , x \leq 1 \\ 1.035623 \cdot \left(-2.48768\sqrt{y} + 3.708724y\right) & , x > 1 \end{cases}$$

65+

$$\ln\big(RR(x)\big) = \begin{cases} \ln\left(1 - x \cdot (1 - e^{-0.25866})\right) & , x \leq 1 \\ 0.757104 \cdot \left(-2.48768\sqrt{y} + 3.708724y\right) & , x > 1 \end{cases}$$

$$where\ y = \frac{x\ +\ 0.0028572082519531}{100}$$



Source (Jürgen Rehm et al., 2016)

Notes: All protective effects are removed for drinkers who consume more than 60g in a single drinking occasion at least once per month, as per (Jürgen Rehm et al., 2016)

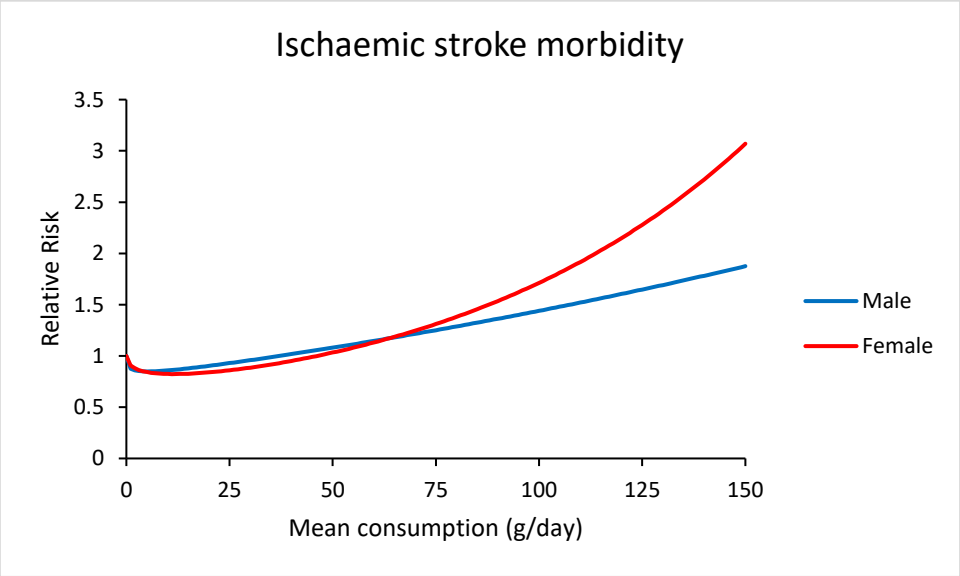
Morbidity

Male

$$\ln\big(RR(x)\big) = -0.132894\sqrt{x} + 0.03677422\sqrt{x} \cdot \ln(x)$$

Female

$$ln\big(RR(x)\big) = -0.114287\sqrt{x} + 0.01680936x$$



Source (Patra et al., 2010)

Notes: All protective effects are removed for drinkers who consume more than 60g in a single drinking occasion at least once per month, as per (Jürgen Rehm et al., 2016)

Digestive diseases

Cirrhosis of the liver

K70 (excl. K70.0-K70.4, K70.9), K73-K74

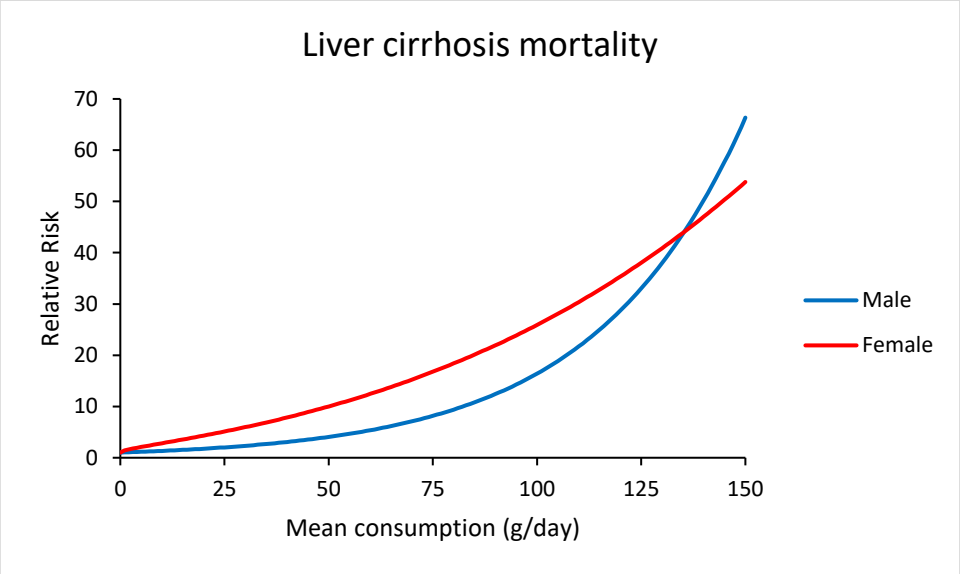
Mortality

Male

$$\ln\big(RR(x)\big) = \begin{cases} \ln\big(1 + x \cdot (1.033224 - 1)\big) & , x \leq 1 \\ 2.793524 \cdot \dfrac{x + 0.1699981689453125}{100} & , x > 1 \end{cases}$$

Female

$$\ln\big(RR(x)\big) = \begin{cases} \ln\big(1 + x \cdot (1.421569 - 1)\big) & , x \leq 1 \\ 3.252035 \cdot \sqrt{\dfrac{x + 0.1699981689453125}{100}} & , x > 1 \end{cases}$$



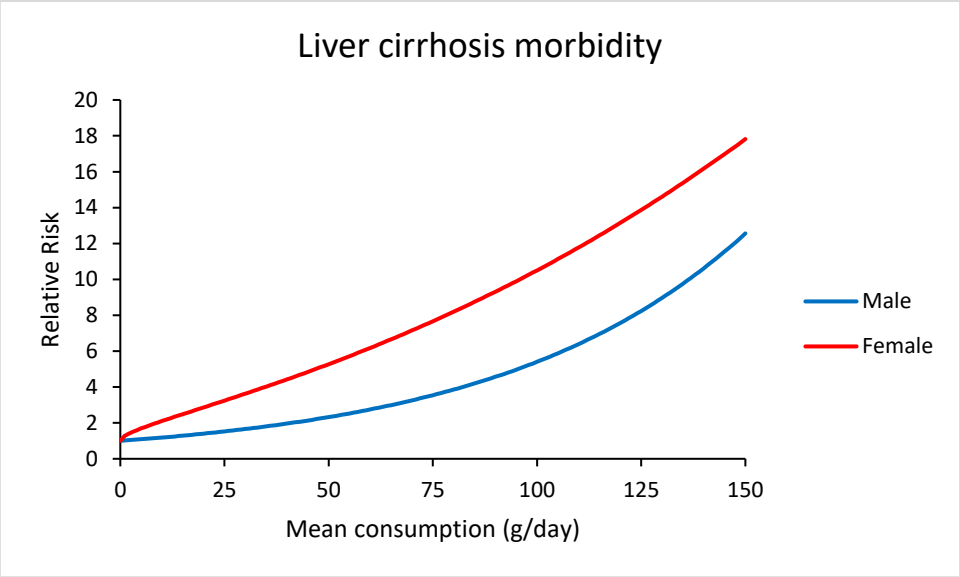
Morbidity

Male

$$ln(RRx)) = 0.01687111x$$

Female

$$ln\big(RR(x)\big) = 0.2351821\sqrt{x}$$



Source (Jürgen Rehm et al., 2010)

Acute pancreatitis

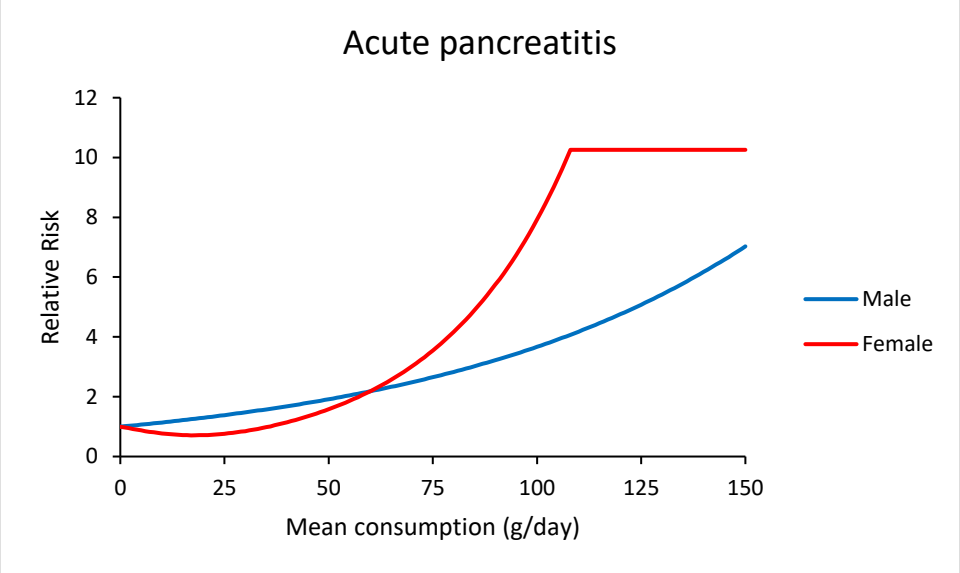
K85 (excl. K85.2, K85.3)

Male

$$\ln\big(RR(x)\big) = 0.013x$$

Female

$$\ln\big(RR(x)\big) = \begin{cases} -0.0272886 \cdot x & ,x < 3 \\ -0.0272886 \cdot x + 0.0611466 \cdot \dfrac{(x-3)^3}{(40-3)^2} & ,3 \le x < 15 \\ -0.0272886 \cdot x + 0.0611466 \cdot \dfrac{(x-3)^3 - \dfrac{(x-15)^3 \cdot (40-3)}{(40-15)}}{(40-3)^2} & ,15 \le x < 40 \\ -0.0272886 \cdot x + 0.0611466 \cdot \dfrac{(x-3)^3 - \dfrac{(x-15)^3 \cdot (40-3) - (x-40)^3 \cdot (15-3)}{(40-15)}}{(40-3)^2} & ,40 \le x < 108 \\ 2.327965 & ,x \ge 108 \end{cases}$$

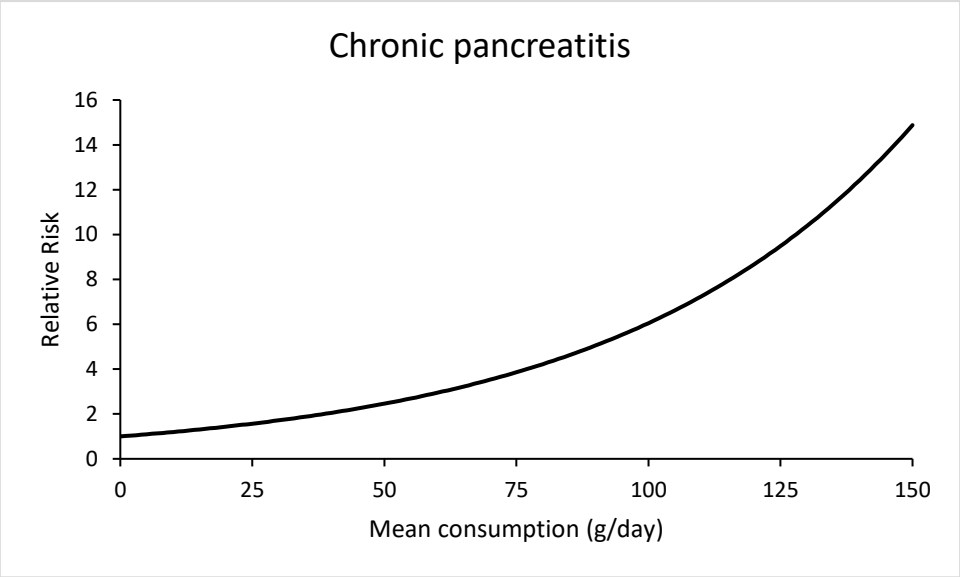


Source (Andriy V Samokhvalov, Rehm, & Roerecke, 2015)

Chronic pancreatitis

K86 (excl. K86.0)

$$\ln\big(RR(x)\big) = 0.018x$$



Source (Andriy V Samokhvalov et al., 2015)

Endocrine diseases

Diabetes mellitus (type II)

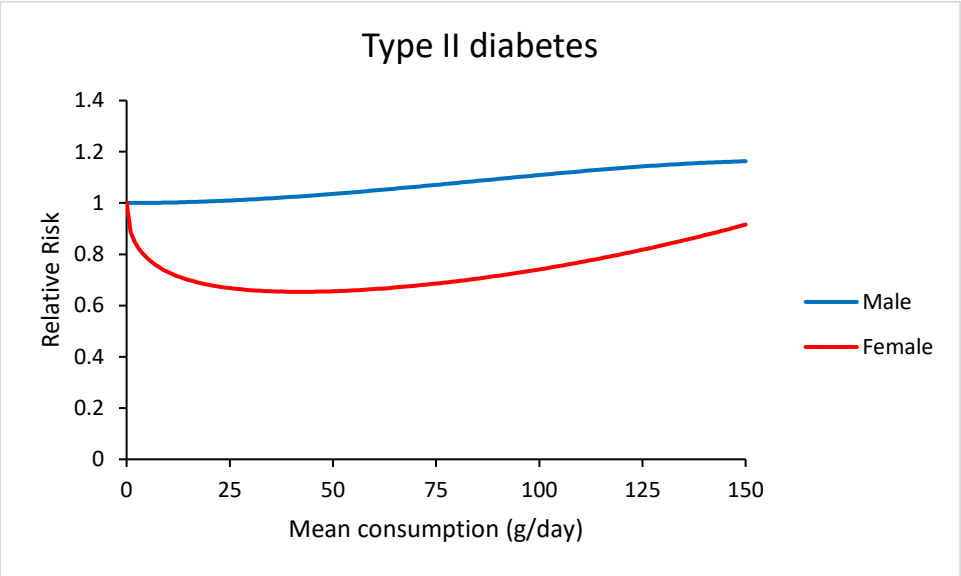
E11

Male

$$\ln\big(RR(x)\big) = 0.00001763703x^2 - 0.0000000728256x^3$$

Female

$$ln\big(RR(x)\big) = -0.1313991\sqrt{x} + 0.01014239x$$



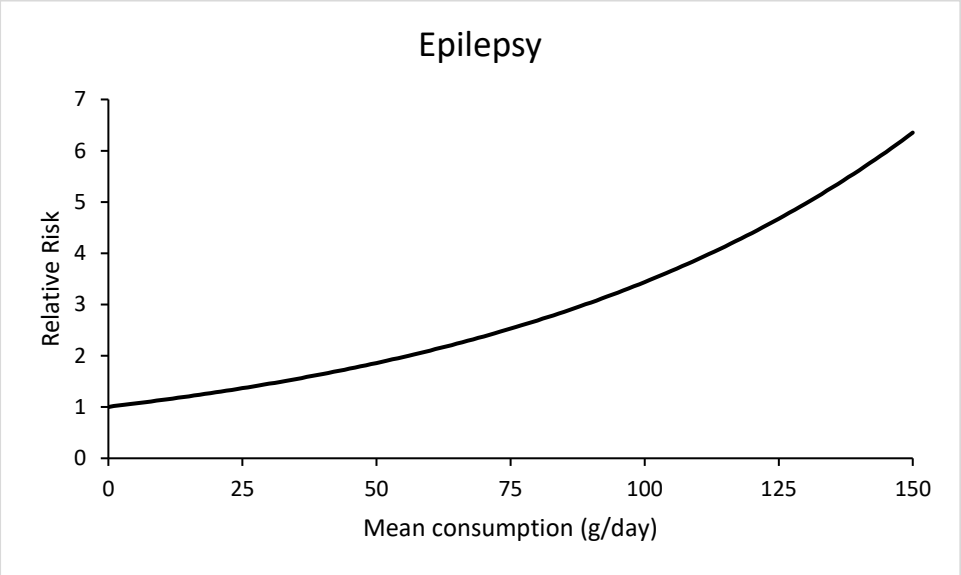
Source (Knott, Bell, & Britton, 2015)

Diseases of the nervous system

Epilepsy and status epilepticus

G40-G41

$$\ln\big(RR(x)\big) = 1.22861 \cdot \frac{x + 0.5}{100}$$



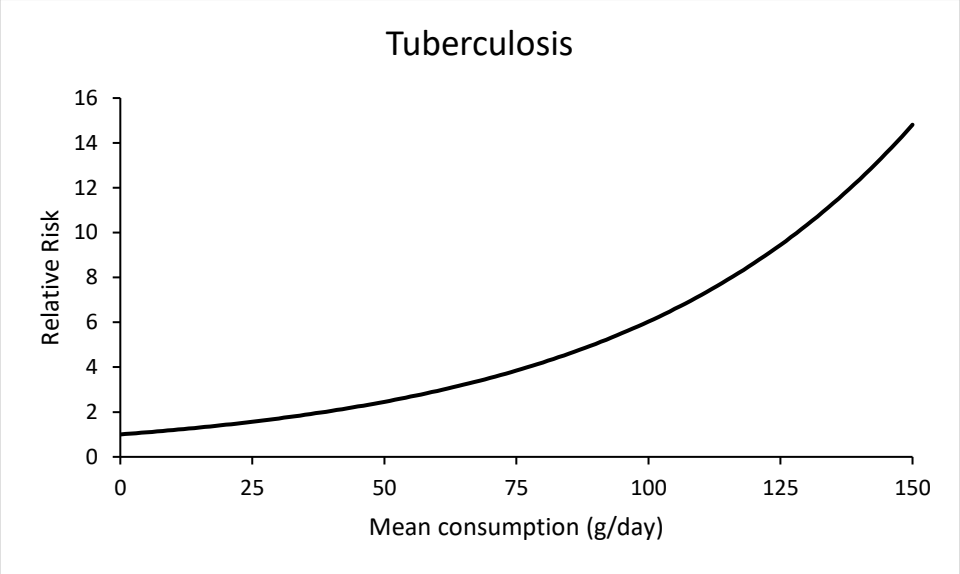
Source (A V Samokhvalov, Irving, Mohapatra, & Rehm, 2010)

Respiratory diseases

Tuberculosis

A15-A19

$$\ln(RR(x)) = 0.0179695 \cdot x$$

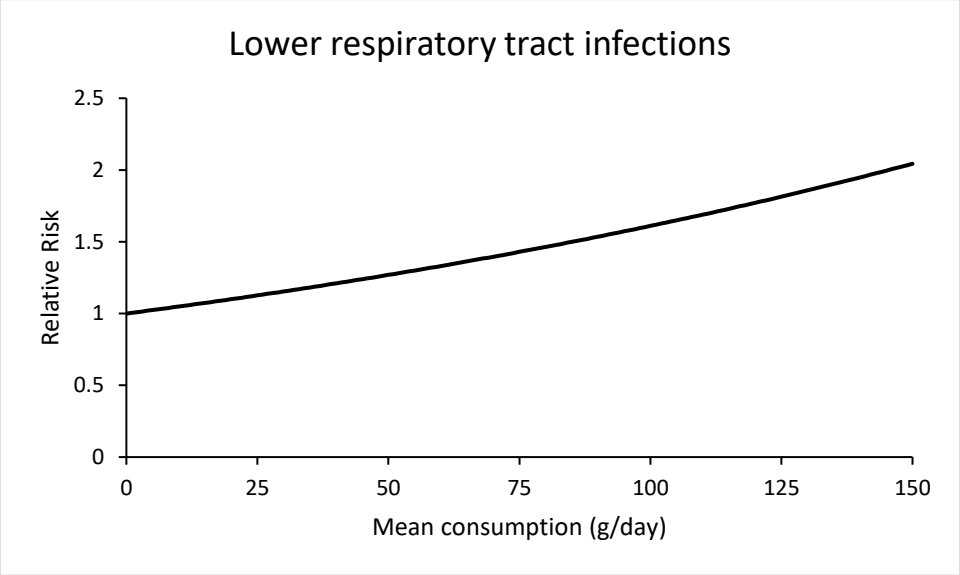


Source (Imtiaz et al., 2017)

Lower respiratory tract infections

J09-J18

$$\ln(RR(x)) = 0.4764038 \cdot \left(\frac{x + 0.0399999618530273}{100}\right)$$



Source (A V Samokhvalov, Irving, & Rehm, 2010)

Dose-response curves for partially alcohol attributable acute conditions

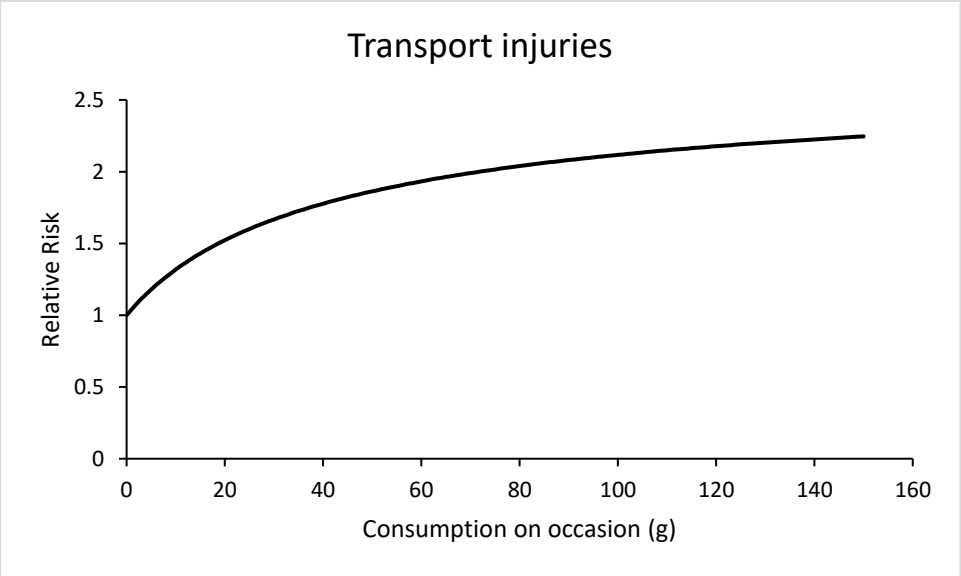
Relative risk of harm for drinkers at consumption level x, measured in grams of ethanol consumed *on a single drinking occasion*, versus non-drinkers. All risk functions are applied to both genders and for both mortality and morbidity except where stated otherwise.

Transport Injuries

V01-V98, Y85.0

$$\mathrm{RR(x)} = \frac{e^{0.837637*(\ln(y)+3.973538882)+1.018824*(y^3-0.00000665184)}}{0.370731 * (1 + e^{0.837637*(\ln(y)+3.973538882)+1.018824*(y^3-0.00000665184)})}$$

$$where\ y = \frac{\frac{x}{12.8} + 1}{100}$$



Source (Cherpitel, Ye, Bond, Borges, & Monteiro, 2015)

Violent injuries

X85-Y09, Y87.1 & Y35

$$RR(x) = \frac{e^{-0.42362*\left(\frac{1}{\sqrt{y}}-5.084489629\right)+0.562549*(y^3-0.0000578783)}}{0.110872 * (1 + e^{-0.42362*\left(\frac{1}{\sqrt{y}}-5.084489629\right)+0.562549*(y^3-0.0000578783)})}$$

$$where\ y = \frac{\frac{x}{12.8}+1}{100}$$

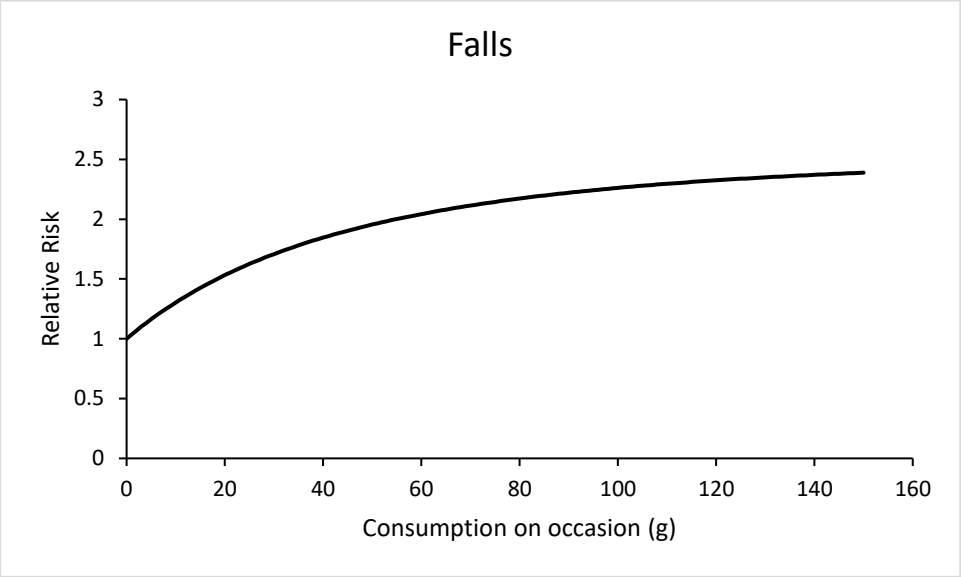
Source (Cherpitel et al., 2015)

Falls

W00-W19

$$\mathrm{RR(x)} = \frac{e^{17.84434*(\sqrt{y}-0.1398910338)-17.6229*(y-0.0195695013)}}{0.367446 * (1 + e^{17.84434*(\sqrt{y}-0.1398910338)-17.6229*(y-0.0195695013)})}$$

$$where\ y = \frac{\frac{x}{12.8} + 1}{100}$$



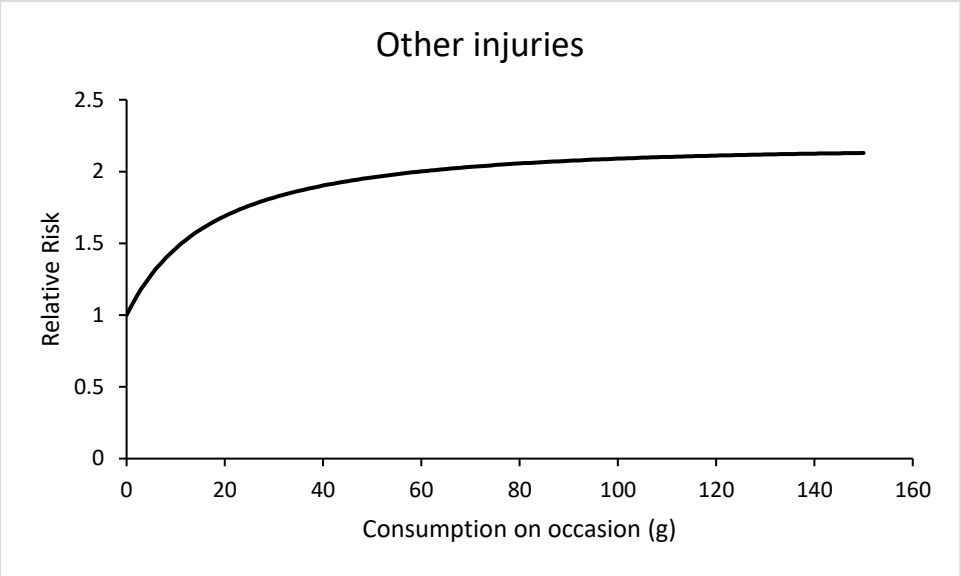
Source (Cherpitel et al., 2015)

Other injuries

W20-W52, W65-W74, Y21, X00-X09, Y26, W75-W99, X10-X33, Y20, Y22-Y25, Y27-Y29, Y31-Y34, X60-X84 (excl. X65), Y87.0,

$$\mathrm{RR(x)} = \frac{e^{-0.28148*\left(\frac{1}{\sqrt{y}}-0.1398910338\right)-2.00946*(y-0.015761462)}}{0.363279 * (1 + e^{-0.28148*\left(\frac{1}{\sqrt{y}}-0.1398910338\right)-2.00946*(y-0.015761462)})}$$

$$where\ y = \frac{\frac{x}{12.8}+1}{100}$$



Source (Cherpitel et al., 2015)

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