Appendix

Supplement to:

Chammartin F, Probst-Hensch N, Utzinger J, Vounatsou P. Mortality atlas of the main causes of death in Switzerland, 2008–2012. Swiss Med Wkly. 2016;146:w14280.

Appendix 1: Cause of death classification according to ICD-10 code

We got inspired by the CDC classification for showing mortality data by geographic areas (CDC, 2009) to group our data into 32 causes of death. Table A1 shows the causes of death together with the corresponding International classification of Diseases (ICD)-10 codes

Table A 1: Definition of the causes of death by the ICD-10 code.

Cause of death	**ICD-10 code**
Cancer	
Breast cancer	C50-C509
Gynecological cancers (cervix uteri, corpus uteri and ovary)	C53-C56
Colorectal cancer	C18-C218
Leukaemia	C91-C959
Lung cancer	C33-C349
Non Hodgkin's lymphoma	C82-C859
Pancreas cancer	C25-C259
Prostate cancer	C61
Stomach cancer	C16-C169
Urinary tract cancer	C64-C689
Other cancer	C00-C159,C17-C179,C22-C249, C26-C329,C37-C499,C51-C52, C57-C609,C62-C639,C69-C819, C86-C866,C88-C887,C90-C903, C96-C97
Cardiovascular diseases	
Heart diseases	
Hypertensive heart disease with or without renal disease	I11-I139, I159
Ischemic heart diseases	I20-I259
Other diseases of heart	I00-I099,I26-I519
Atherosclerosis	I70-I709
Hypertensive disease (hypertension and hypertensive renal disease)	I10,I12-I129
Stroke (cerebrovascular diseases)	I60-I698
Other diseases of circulatory system	I71-I788
External cause of death	
Assault (homicide)	X859-Y099
Intentional self-harm (suicide)	X60-X849,Y87-Y870
Motor vehicle accidents	V02-V049,V09-V090,V092, V124-V149,V19-V194,V20-V799, V81,V82,V835,V872,V89,V892
All other unspecified accidents and adverse effects	V01-V019,V05-V061,V093-V099, V11-V119,V15-V189,V199, V80-V809,V813,V825-V829,V899, V904-X599,Y40-Y86,Y88-Y883
All other external causes	Y10-Y349,Y872,Y89-Y899
Other causes	
Certain conditions originating in the perinatal period	P00-P968
Congenital malformations, deformations and chromosomal abnormalities	Q00-Q999
Chronic respiratory diseases	J40-J47
Alzheimer's disease	G30-G309
Diabetes	E10-E149
HIV	B20-B24
Influenza and pneumonia	J09-J189
Liver diseases	K70-K709,K73-K746
Nephritis, nephrotic syndrome and nephrosis	N01-N079,N17-N19,N25-N26
Peptic ulcer	K25-K289
Pregnancy, childbirth and the puerperium	O00-O998
Sudden infant death syndrom	R95
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	R00-R94,R96-R999
Syphilis	A52-A529
Tuberculosis	A15-A199
All other diseases	A01-A099,A24-A499,A60-B199, B25-B99,D002-E079,E15-G259, G31-H931,I80-J398,J61-K229, K29-K668,K71-K729,K75-M959, N10-N159,N20-N23,N28-N94

Appendix 2: National statistics

Gender-specific age-adjusted death rates are calculated as a weighted average of the age-specific a ($a = 1, ..., 18$) death rate by gender g ($g \in \{Female, Male\}$ as follows:

$$\text{Age-adjusted death rate}_g = \sum_a (\text{weight}_a * \frac{\text{death count}_{ag}}{\text{population}_{ag}}).$$

Hence, similar weights that depend on the age structure of the total population are applied to the standard age-specific rates, readily allowing for gender comparison. Population and weights for the year 2010 in Switzerland are given in Table A2.

Table A 2: Population and percentage (weight) of the population in Switzerland according to the 2010 census, by gender.

Age category	Age	Female population	Male population	Total population
1	0–4	189871 (4.76%)	200758 (5.18%)	390629 (4.96%)
2	5–9	186442 (4.67%)	196612 (5.07%)	383054 (4.87%)
3	10–14	203197 (5.09%)	213936 (5.52%)	417133 (5.30%)
4	15–19	220240 (5.52%)	231379 (5.97%)	451619 (5.74%)
5	20–24	238828 (5.98%)	246153 (6.35%)	484981 (6.16%)
6	25–29	257836 (6.46%)	263516 (6.80%)	521352 (6.62%)
7	30–34	266170 (6.67%)	268638 (6.93%)	534808 (6.80%)
8	35–39	278833 (6.98%)	280086 (7.22%)	558919 (7.10%)
9	40–44	315984 (7.91%)	318088 (8.20%)	634072 (8.06%)
10	45–49	321169 (8.04%)	329746 (8.50%)	650915 (8.27%)
11	50–54	279627 (7.00%)	286684 (7.39%)	566311 (7.20%)
12	55–59	243362 (6.10%)	243474 (6.28%)	486836 (6.19%)
13	60–64	232996 (5.84%)	226815 (5.85%)	459811 (5.84%)
14	65–69	205331 (5.14%)	191911 (4.95%)	397242 (5.05%)
15	70–74	164340 (4.12%)	139108 (3.59%)	303448 (3.86%)
16	75–79	145628 (3.65%)	110430 (2.85%)	256058 (3.25%)
17	80–84	119759 (3.00%)	74620 (1.92%)	194379 (2.47%)
18	≥ 85	123095 (3.08%)	55472 (1.43%)	178567 (2.27%)
		3992708 (100.00%)	3877426 (100.00%)	7870134 (100.00%)

Appendix 3: Additional results

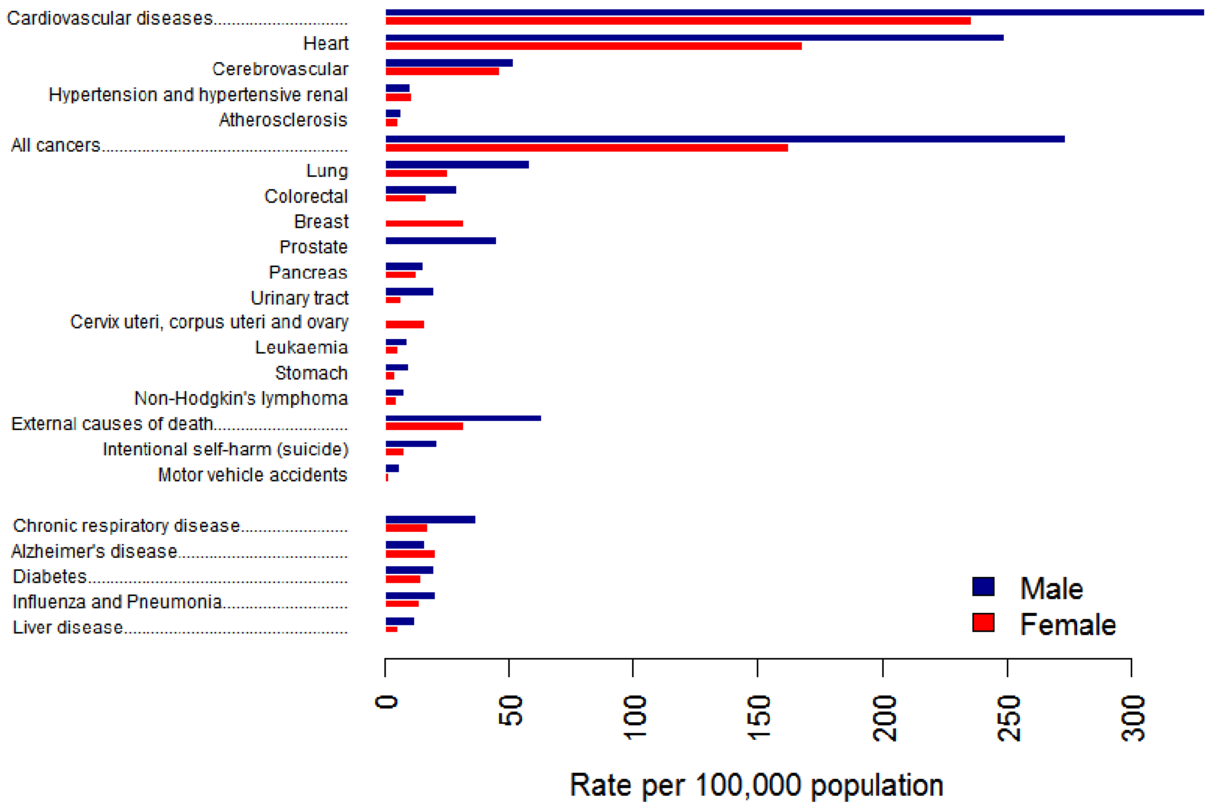


Figure A 1: Age-adjusted death rates by cause and gender.

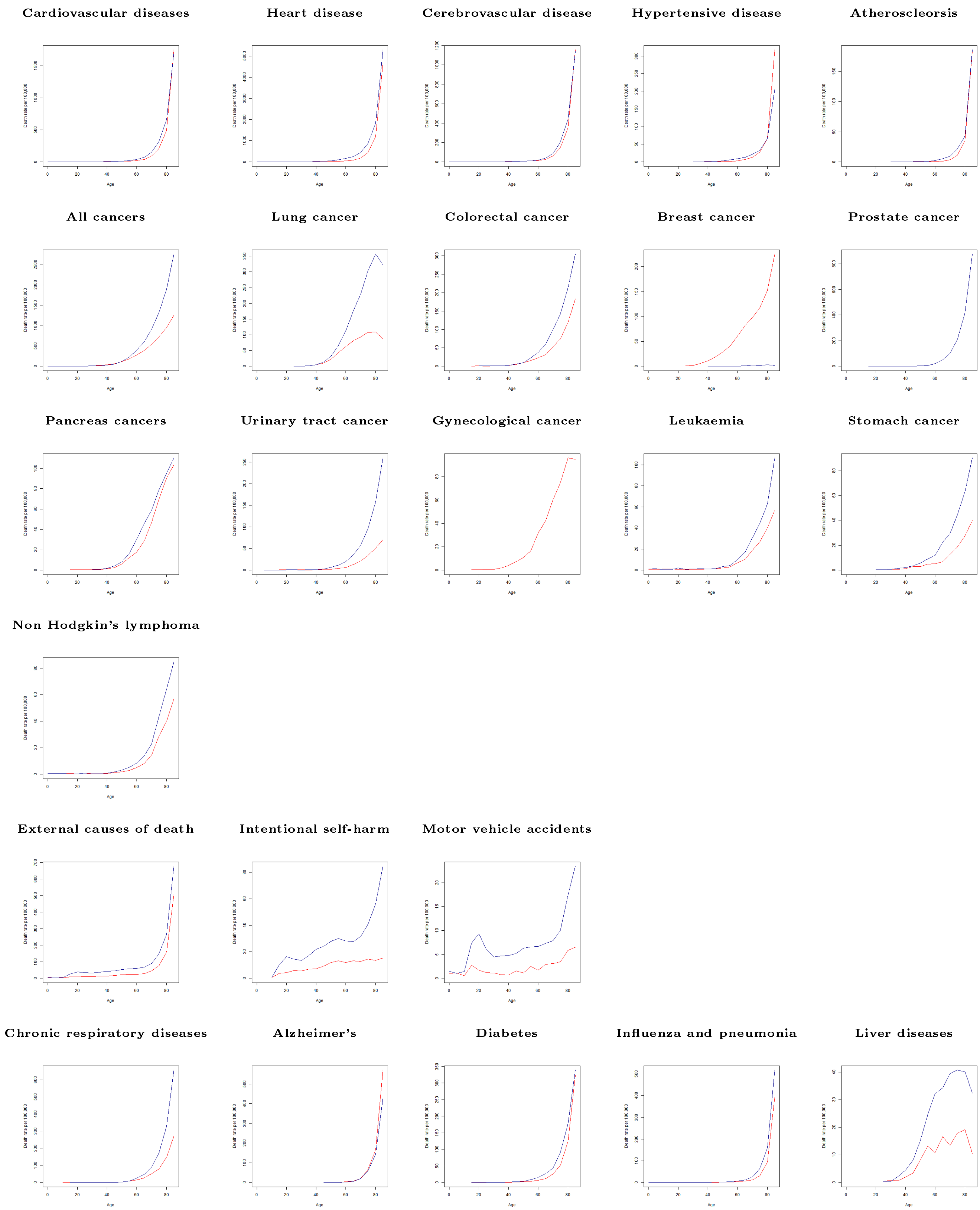


Figure A 2: Death rate per 100,000 population by cause for male (blue) and female (red).

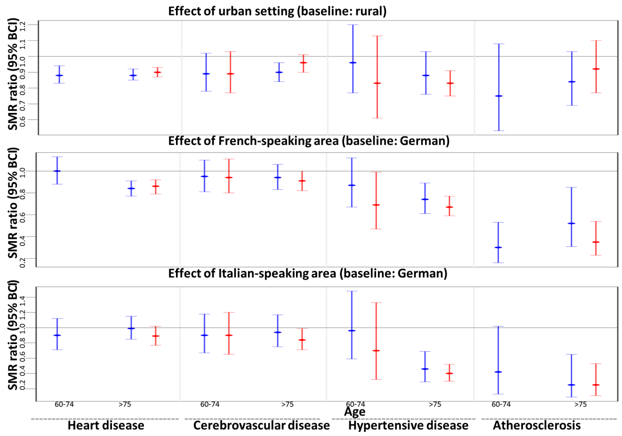


Figure A 3: Effect of differrent covariates on cardiovascular diseases for male (blue) and female (red)

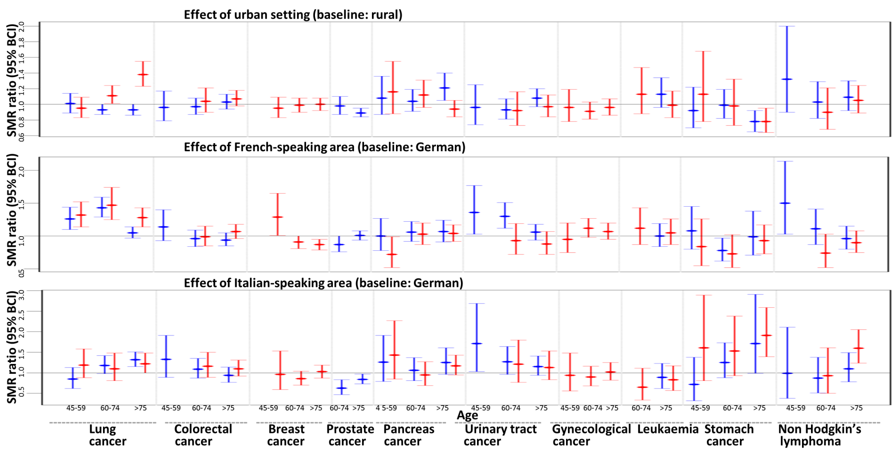


Figure A 4: Effect of differrent covariates on cancer for male (blue) and female (red)

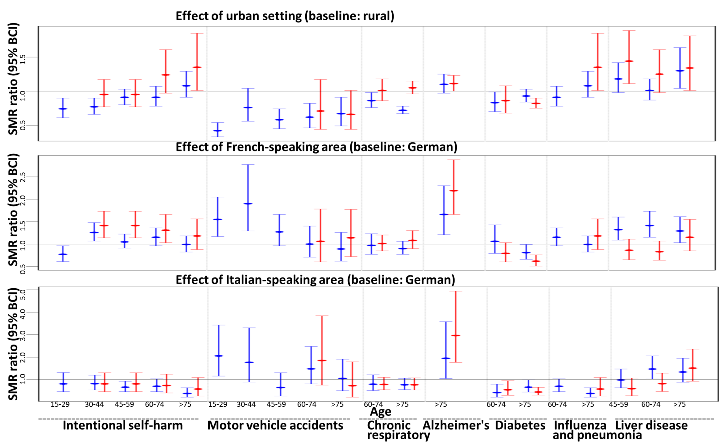
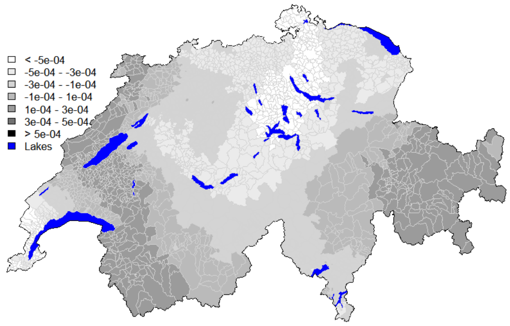
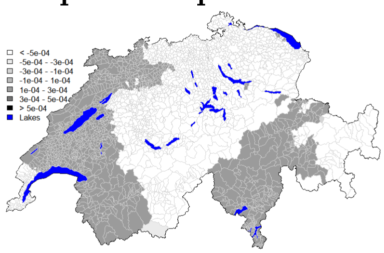


Figure A 5: Effect of different covariates on additional causes of death for male (blue) and female (red).

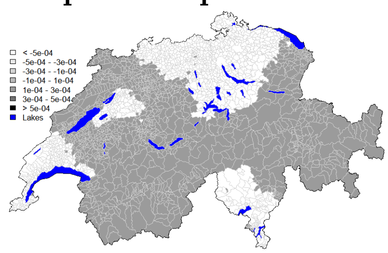
A1) Shared spatial dependence between lung cancer and COPD



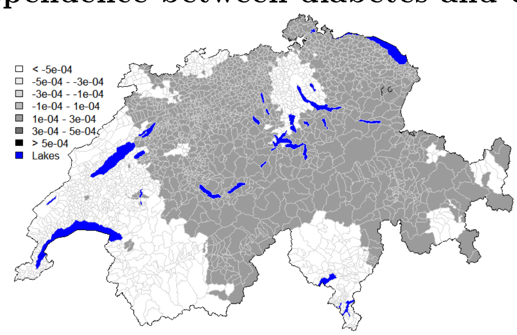
A2) Lung cancer specific spatial dependence



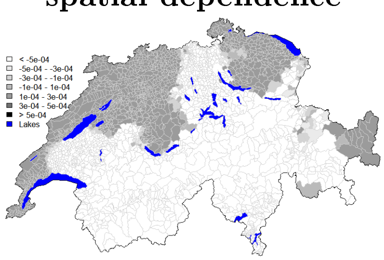
A3) COPD specific spatial dependence



B1) Shared spatial dependence between diabetes and cardiovascular diseases



B2) Diabetes specific spatial dependence



B3) Cardiovascular diseases specific spatial dependence

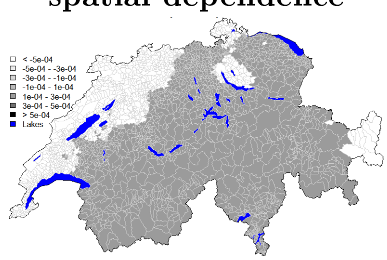


Figure A 6: Shared and disease specific spatial dependence identified by the joint modelling of A) lung cancer and chronic lower respiratory diseases (COPD) and B) diabetes and cardiovascular diseases.

Table A 3: Number of deaths in Switzerland during the period 2008–2012 by cause, age and gender.

Cause of death	**0–14 years old**		**15–29 years old**		**30–44 years old**		**Age category 45–59 years old**		**60–74 years old**		**≥75 years old**		**All-age**	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Cardiovascular diseases	6	2	10	4	102	75	606	380	2214	1413	8906	15213	11844	17087
Heart disease	12	18	68	32	449	130	2558	580	**7386**	2889	**26306**	**39127**	36779	42776
Cerebrovascular disease	5	2	5	4	64	54	296	281	**1196**	**949**	**5933**	**10290**	7499	11580
Hypertensive disease	0	0	0	0	14	4	142	50	**380**	**218**	**995**	**2549**	1531	2821
Atherosclerosis	0	0	0	0	2	2	20	8	**139**	51	**799**	**1418**	960	1479
All cancers	78	46	157	116	711	842	5438	4775	16607	11735	22023	18744	45014	36258
Lung cancer	0	0	2	0	104	90	**1480**	**1011**	**4563**	**2327**	**3902**	**1971**	10051	5399
Colorectal cancer	0	0	5	10	61	54	**509**	388	**1682**	**1019**	**2421**	**2380**	4678	3851
Breast cancer	0	0	0	7	1	270	7	**1209**	13	**2348**	17	**3152**	38	6986
Prostate cancer	0	0	1	0	4	0	125	0	**1388**	0	**5138**	0	6656	0
Pancreas cancer	0	0	0	3	35	27	**389**	**280**	**1191**	**882**	**1093**	**1680**	2708	2872
Urinary tract cancer	2	1	3	2	18	15	**274**	95	**964**	**370**	**1844**	**986**	3105	1469
Gynecological cancer	0	0	0	10	0	91	0	**464**	0	**1297**	0	**1707**	0	3569
Leukaemia	19	11	33	19	43	30	132	86	**497**	**340**	**776**	**782**	1500	1268
Stomach cancer	0	0	2	1	53	37	**244**	**145**	**557**	**235**	**727**	**546**	1583	964
Non Hodgkin's lymphoma	5	2	11	4	30	14	**140**	81	**389**	**263**	**713**	**795**	1288	1159
External causes of death	119	60	1226	361	1651	540	2196	844	1954	921	3693	4627	10839	7353
Intentional self-harm	11	2	**509**	163	**767**	**282**	**1165**	**475**	**810**	**379**	**669**	**281**	3931	1582
Motor vehicle accidents	43	20	**280**	60	**200**	39	**257**	71	**197**	76	**184**	**98**	1161	364
Chronic respiratory diseases	0	1	3	0	11	3	162	144	**1354**	**868**	**3996**	**3112**	5526	4128
Alzheimer's	0	0	0	0	0	0	13	13	216	270	**2049**	**4985**	2278	5268
Diabetes	0	0	7	6	29	15	198	79	**716**	**404**	**2100**	**3102**	3050	3606
Influenza and pneumonia	8	8	6	4	30	17	107	62	**370**	196	**2379**	**3221**	2900	3508
Liver diseases	0	0	1	2	107	43	**655**	**332**	**972**	**400**	**461**	**308**	2196	1085

Death counts highlighted in bold indicate age categories that were analyzed and contribute to more than 5% of the total population deaths.

Appendix 4: Spatial analysis at municipality level
Likelihood assumption

Several likelihood functions were explored to model death counts, namely the "Poisson", the "negative binomial" and the "zero inflated negative binomial" distributions.

The Poisson distribution is widely used to model count data. It is the simplest distribution that assumes the variance to be equal to the mean. Thus, our data Y_{ij} were assumed to follow a Poisson distribution $Y_{ij} \sim Poisson(\lambda_{ij} E_{ij})$, where Y_{ij} is the number of deaths due to disease i at municipality j ($j = 1, ..., 2352$), λ_{ij} is the expected number of deaths and E_{ij} represents the expected number of deaths in the general population.

However, count data are often over-dispersed and might have a larger variance than assumed by the Poisson distribution. Thus, a negative binomial distribution $Y_{ij} \sim NegBin(\mu_{ij,r})$, where $\mu_{ij} = r/(r + \lambda_{ij} E_{ij})$ and the parameter r captures the over-dispersion might be more appropriate.

In the presence of large amount of zero counts, a zero inflated negative binomial distribution that captures the excess of zeros that cannot be accounted for by the over-dispersion parameter can be assumed such as:

$$Y_{ij} \sim \begin{cases} 0 & \text{with probability } p_{ij} \\ NegBin(\mu_{ij}, r) & \text{with probability } 1 - p_{ij} \end{cases}$$

Generalised linear regression model

Standardised mortality ratios (SMR) were modeled on the log scale, such as $log(\lambda_{ij}) = log(E_{ij}) + \alpha_i + \psi_{ij} + \epsilon_{ij}$, where α_i is a disease-specific constant, ψ_{ij} is a conditional autoregressive (CAR) spatially-structured random term and ϵ_{ij} an unstructured random effect.

Following Besag et al. (1991) formulation, we assigned a conditional prior distribution on the ψ_j, such as:

$$\psi_j \,|\psi_{k,j \neq k,\sigma^2} \sim N(\tfrac{1}{w_j} \sum_{j \sim k} \psi_k, \tfrac{\sigma^2}{w_j}),$$

where w_j is th number of neighbours of municipality j, $j \sim k$ indicates that municipalities j and k are neighbours and σ^2 is the conditional prior variance.

Age and gender standardization was done through the expected number of deaths E_{ij}. Thus, $E_{ij} = \sum_{a_1 g} (DR_{ia_1 g} * (\sum_t n_{ja_1 gt}))$, where $n_{ja_1 gt}$ is the 2010 population and $DR_{ia_1 g}$ is the death rate for municipality $j (j = 1, ..., 2352)$, age category a_1 ($a_1 \in$ {0-4, 5-9, ..., ≥ 85}), gender g ($g \in \{Female, Male\}$) and time t ($t \in \{2008, 2009, ..., 2012\}$), i.e. $DR_{ia_1g} = \frac{\sum_{jt} Y_{jtia_1g}}{\sum_{jt} n_{jta_1g}}$.

We also developed gender and age group-specific models that account for urbanisation (urban *vs* rural) and linguistic areas (French, Italian and Romansch *vs* German). We divided the total population into 6 age groups a_2 ($a_2 \in \{$0-14, 15-29, 30-44, 45-59, 60-74, $\geq 75\}$). Thus, SMRs were modeled such as: $log(\lambda_{ija_2g}) = log(E_{ija_2g}) + X_{ij}^T \beta_{ia_2g} + \psi_{ija_2g} + \epsilon_{ija_2g}$, where X is the matrix of explanatory variables that includes urbanisation, linguistic areas and a constant. Expected number of death E_{ija_2g} was calculated as: $E_{ija_2g} = \sum_{a_1 \cap a_2} (DR_{ia_1g} * (\sum_t n_{ja_1gt}))$.

Similarly, we developped shared component model (Knorr-Held and Best, 2001) by jointly modelling two causes of death i ($i = 1, 2$) as follows: $log(\lambda_{ij}) = log(E_{ij}) + \alpha_i + \psi_{ij} + \epsilon_{ij} + \delta_k \phi_j$, where ϕ_j is the CAR spatially-structured random term that is shared by both causes of deaths i and δ_k is a cause of death specific weight.

Model fit and implementation

Model parameters were estimated through integrated nested Laplace approximations (INLA) (Rue et al., 2009) and stochastic partial differential equations approach (Lindgren et al., 2011) for fast Bayesian inference. All models were fitted in R (version 3.0.2) (R Core Team, 2014) witht the INLA package. We used the poisson, nbinomial and zeroinflated-binomial1 likelihood models implemented in the R INLA package to fit the corresponding regression models. Spatial and non spatial random effects were fitted with the bym model for latent Gaussian field. We assigned uninformative Gaussian prior for the constant α; i.e. $\alpha \sim N(0, 100)$ and logGamma distribution for the log of the overdispersion parameter r, $log(r) \sim logGamma(1, 100)$. For the shared component model, we modeled spatial effects with the besag model and non-spatial effects with the independent random variables model, respectively. We chose flat log-normal distribution for δ_2 and fixed δ_1 to 1 to overcome identifiability problems.

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