Tobacco-related cancer mortality: projections for different geographical regions in Switzerland

Verena Jürgens[a,b], Silvia Ess[c], Harish C. Phuleria[a,b], Martin Früh[d], Matthias Schwenkglenks[e], Harald Frick[f], Thomas Cerny[d], Penelope Vounatsou[a,b]

[a] Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, Basel, Switzerland
[b] University of Basel, Switzerland
[c] Cancer Registry of St. Gallen & Appenzell, St. Gallen, Switzerland
[d] Department of Medical Oncology-Hematology, Kantonsspital St. Gallen, Switzerland
[e] Institute of Pharmaceutical Medicine (ECPM), University of Basel, Switzerland
[f] Cancer Registry Grisons and Glarus, Kantonsspital Graubünden, Chur, Switzerland

Swiss Med Wkly. 2013;143:w13771

Appendix B

Bayesian APC model formulations

Bayesian Poisson regression models were fitted for each gender and age category. Following the APC approach, the canton-specific effects of age, period and cohort were used to model and predict tobacco-related cancer deaths μ_{ijk} , where population size n_{ijk} of each age group and period was considered as the exposure. As the analysis covered 26 coherent regions, models were further developed including gender- and canton-specific random effects ϕ_k accounting for spatial correlation.

$$\log(\mu_{ijk}) = \log(n_{ijk}) + \alpha_{ik} + \beta_{jk} + \gamma_{j-i,k} + \phi_k$$

In addition, we extended the model to consider under-/over-dispersion assuming that mortality counts follow a Negative Binomial distribution. The Negative Binomial is an extension of the Poisson distribution and it includes an additional parameter to account for the extra-variation.

To complete Bayesian model formulation, priors are specified for the unknown parameters. For the first two groups of the time effects (i.e. age, period and cohort) a normal distribution was considered with mean 0 and vague precision depending on the overall precision of the remaining groups. For the remaining groups, a second-order autoregressive process was assigned allowing for dependence and smoothing [1]. For example, for the age effects the above prior is formulated as follows:

$$\alpha_1 \sim N(0, 1.0E-06\tau_\alpha)$$

$$\alpha_2 \left| \alpha_1 \right. \sim N(0, 1.0E-06\tau_\alpha)$$

$$\alpha_i \left| \alpha_{1,\dots,i-1} \right. \sim N(2\alpha_{i-1} - \alpha_{i-2}, \tau_\alpha), \text{ for } 3 \le i \le I$$

where *I* is the total number of age groups. Uninformative priors were assigned to the precision parameter of each effect. Spatial random effects were assumed to derive from a Conditional Autoregressive (CAR) process [2, 3]. Dependence in space among the cantons was introduced by the conditional prior distribution of the ϕ_k with

$$\phi_k \left| \boldsymbol{\phi}_{q_{q \neq k}} \right. \sim N\left(\frac{\sum_{\substack{q=1 \\ q \neq k}}^{N} c_{kq}\phi_q}{w_k}, \frac{\sigma^2}{w_k}\right)$$

where c_{kq} indicates the degree of spatial influence of canton *k* to the remaining ones, taking the value 1 if they are adjacent and 0 otherwise and w_k represents the number of neighbours of canton *k*.

Model validation

For validation purposes, models were applied for empirical projection of age- and gender-specific tobacco-related cancer mortality at cantonal, national and language region levels in periods with known mortality. Model performance was evaluated by comparing model-based projections with observed data in 1999–2003 and 2004–2008 using the sum of squared residuals (SSR).

$$SSR = \sum_{i,j,k} \frac{(R_{ijk} - \hat{R}_{ijk})^2}{R_{ijk}}$$

where R_{ijk} and $\hat{R}_{ijk}$ are the observed and estimated rates for canton *k*, age group *i* and period *j*, respectively. Table B1 shows the SSR for the two periods of the empirical projection of gender-specific tobacco-related cancer mortality. Regarding the projections at cantonal level, the spatial Poisson model performed best for males. The spatial models showed best predictive ability for females, whereas the Negative Binomial ones gave more precise estimates. Therefore, spatial Poisson and Negative Binomial models were applied to project cantonal age- and gender-specific tobacco-related cancer mortality in Switzerland. For projections at country and language regions, Negative Binomial and Poisson models were applied for males and females, respectively.

Table B1: Results of empirical projections of gender-specific tobacco-related cancer mortality given by the sum of squared residuals for the projected periods.

	National		**Language regions**		**Cantonal**	
	Males	**Females**	**Males**	**Females**	**Males**	**Females**
Bayesian APC						
Poisson	0.71	0.08	3.57	1.98	113	104
Poisson spatial					109	101
Negative Binomial	0.28	0.09	2.73	2.15	145	106
Negative Binomial spatial					175	101

References

1 Bray I. Application of Markov chain Monte Carlo methods to projecting incidence and mortality. J R Stat Soc: Series C (Applied Statistics). 2002;51:151–64.

2 Besag J, York J, Mollié A. Bayesian image restoration with two applications in spatial statistics (with discussion). Ann I Stat Math. 1991;43:1–59.

3 Bernardinelli L, Montomoli C. Empirical Bayes versus fully Bayesian analysis of geographical variation in disease risk. Stat Med. 1992;11:983–1007.