FUNNEL PLOTS TO EXPLORE THE QUALITY OF VITAL STATUS FOLLOW-UP IN SWITZERLAND

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Background

- Completeness of registration of deaths is rarely investigated. However, even modest levels of unregistered deaths may lead to overestimation of survival, especially long-term survival [1].
- Substantial efforts are taken to obtain the vital status of cancer patients in Switzerland. Since cantonal health authorities adopt different policies regarding access to population registries, follow-up procedures are quite heterogeneous (from regular automated data linkage to sporadic project-related follow-up by mailing letters to a large number of regional offices).
- The use of funnel plots as graphical tools for outlier detection has recently been extended to population-based cancer data [2].

Objectives

- To compare eight Swiss population-based cancer registries adopting different follow-up procedures with special regard to systematic outlying high survival times.

Data and Methods

We included malignant primary diagnoses from 1999 to 2008 for cancer of the oesophagus (ICD-10 C15), stomach (C16), colon/rectum (C18-20), liver/bile ducts (C22), pancreas (C25), trachea/bronchus/lung (C33-44), breast (C50) and for a group of sites with poor prognosis (C23, C24, C45, C70-72). Cases were provided by eight regional cancer registries, labelled A to H for reasons of anonymity. Cancer registries recorded all incident cancer cases diagnosed in their resident population and assessed cases' survival by active and/or passive follow-up until end of 2011. We assumed that cases survived up to end_2011 if vital status was neither dead nor lost.
Relative survival (RS) was calculated as the ratio of the observed survival of cancer cases and the expected survival of persons in the general population matching in age, sex, calendar year of death and residence. Expected cancer survival was estimated using the Ederer II method. RS ratios were estimated using the strs command (v1.3.7) [3] written for the Stata Statistical Software.
Funnel plots were constructed using the mean log(RS) as target value and thresholds of +/-2 times (95% control limits, CL) and +/-3 times (99.8% CL) of the SE of log(RS).

A. Follow-up procedures adopted by Swiss cancer registries

Cantonal Cancer Registry	Passive Follow-up			Active Follow-up		
	Periodicity	Sources of mortality information	Methods	Periodicity	Source (Population registry)	Methods
A	annually	1. national 2. cantonal	1. national: matching without names 2. cantonal: matching unique ID	annually	cantonal	online access; unique ID
B	annually	1. national 2. cantonal	1. national: matching without names 2. cantonal: matching names	annually	numerous local	postal enquiries
C	annually	1. national 2. cantonal	1. national: matching without names 2. cantonal: matching names	annually	cantonal	online access
D	annually	1. national 2. cantonal	1. national: matching without names 2. cantonal: matching names	annually	cantonal	online access; unique ID
E	annually	1. national 2. cantonal	1. national: matching without names; restricted to deaths caused by cancer 2. cantonal: matching names	annually	numerous local	postal enquiries; limited diagnosis years
F	irregular	1. national 2. cantonal	1. national: matching without names; restricted to main cancer sites or certain diagnosis years 2. cantonal: matching names	irregular	numerous local	postal / phone enquiries; limited cancer sites and/or diagnosis years
G	annually	1. national 2. cantonal	1. national: matching without names 2. cantonal: matching names	annually	cantonal	online access
H	annually	1. national 2. cantonal	1. national: matching without names 2. cantonal: matching names	annually	numerous local	postal enquiries

Tab. 1. Swiss population-based cancer registries generally carry out passive as well as active follow-up at least once per year on all cases. If linkage to national vital statistics serves predominately for case finding (registry E) or is not repeated every year (F), some deaths might be missed. Active follow-up may be compromised if carried out on selected cases only (E, F) or is not repeated each year (F) or must rely on postal enquiries (B, E, F, and H). We conclude that under-registration of deaths is a potential problem in registries E and F.

B. Data quality indicators

Cantonal cancer registry	DCO [%]*								MV [%]**								TNM-M missing [%]#							
	Oesophagus	Stomach	Colon/ rectum	Liver	Pancreas	Lung	Breast	Gall/Meso/Brain	Oesophagus	Stomach	Colon/ rectum	Liver	Pancreas	Lung	Breast	Gall/Meso/Brain	Oesophagus	Stomach	Colon/ rectum	Liver	Pancreas	Lung	Breast	Gall/Meso/Brain
A	1	3	1	6	10	2	1	5	96	95	98	47	61	90	99	80		7	3	16	9	7	2	
B	0	2	0	2	2	1	0	2	98	94	96	50	63	90	99	83	12	14	3	25	13	10	1	71
C										98	98	58	70	91				20	6	65	21	24		
D	1	0	1	2	2	0	0	1	96	98	96	48	69	91	98	87	4	7	3	8	5	3	2	66
E	3	3	3	6	8	3	2	5	95	95	96	67	72	91	97	84	41	35	7	74	52	33	2	77
F	4	4	3	13	22	4	2	6	96	96	97	85	77	96	98	94	18	10	2	26	12	14	2	7
G	0	1	0	0	1	0	1	0	98	94	97	72	78	91	98	88								
H	0	0	0	2	1	0	0	0	97	95	96	56	66	90	98	85			28				2	

*: Diagnoses based on death certificates only (excluded from survival analysis).
**: Diagnoses based on microscopic verification.
#: Insufficient TNM information to infere the M status.

Tab. 2. Critical values potentially biasing survival analyses are marked in red (DCO >10%; missing TNM-M status >25%).
DCO% were generally low, except in registry F (no trace-back) in the case of hepatic and pancreatic cancer. Microscopic verification was high and comparable between registries. Lower percentage of MV hepatic and pancreatic cases was expected due to difficult biopsy. Information about metastatic dissemination (TNM-M) was often missing in registry E for many of the sites analyzed.

C. Outlier detection using Funnel plots

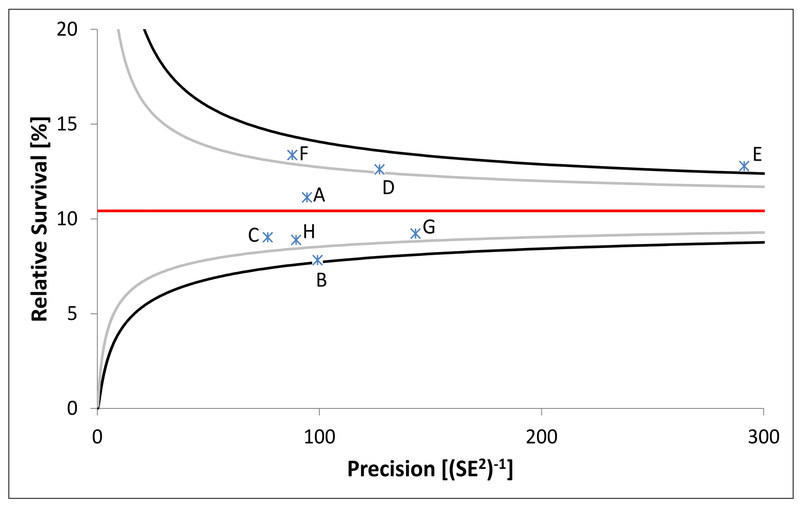

Fig. 1. Example of a funnel plot (target value in red; 99.8% control limit in black; 95% control limit in grey). Data shown are 10-year RS (age-standardized; all TNM stages included) after lung cancer diagnosis for eight Swiss cancer registries (see → in Tab. 1).

Localisation	Cantonal Cancer Registries A	B	C	D	E	F	G	H	RS analysis type	Years after diagnosis*
Oesophagus	0	0	nd	0	0	2	0	-3		5
Stomach	2	0	0	0	0	0	0	0		10
Colon/rectum	0	0	-2	0	3	3	0	0		10
Liver	0	-2	-2	0	0	0	0	0	Age-standardized	5
Pancreas	0	0	0	0	2	2	0	-3	All stages included	5
Lung	0	-2	0	2	3	2	0	0		10
Breast	0	0	nd	0	3	2	0	-3		10
Gall_Mesoth_Brain	0	0	nd	0	2	0	0	0		10
Oesophagus	nd	-2	nd	0	0	0	nd	nd		5
Stomach	0	0	0	0	0	0	nd	nd		10
Colon/rectum	0	0	0	0	0	2	nd	0		10
Liver	0	-3	0	0	0	0	nd	nd	Age-standardized	5
Pancreas	0	-2	0	0	0	2	nd	nd	TNM M0	5
Lung	0	-2	0	0	0	0	nd	nd		10
Breast	0	0	nd	0	3	2	nd	-3		10
Gall_Mesoth_Brain	nd	-2	nd	0	0	0	nd	nd		5
Oesophagus	nd	-3	nd	0	0	0	nd	nd		3
Stomach	-2	-2	0	0	0	0	nd	nd		3
Colon/rectum	0	0	0	0	2	0	nd	0		5
Liver	-3	0	nd	0	nd	0	nd	nd	Age-standardized	3
Pancreas	0	0	0	0	0	0	nd	nd	TNM M1	3
Lung	0	0	0	0	0	0	nd	nd		5
Breast	0	-2	nd	0	-2	0	nd	0		10
Gall_Mesoth_Brain	nd	0	nd	0	0	0	nd	nd		3
Oesophagus	0	0	nd	0	0	0	0	nd		5
Stomach	0	0	0	0	0	0	0	0		5
Colon/rectum	0	0	-2	0	3	2	0	0		10
Liver	0	0	0	0	0	nd	nd	-3	Age 80+	3
Pancreas	0	0	0	0	0	0	-2	0	All stages included	3
Lung	0	0	0	0	0	0	0	0		5
Breast	0	0	nd	0	3	0	0	-2		10
Gall_Mesoth_Brain	0	0	nd	0	0	0	0	0		3

nd: not analysed

*: last time interval after diagnosis with at least 5 cases to be included in the estimate of cumulative survival.

unexpected low RS — unexpected high RS

-3	-2	0	2	3
<3 SE	<2 SE	target ±2 SE	>2 SE	>3 SE

Tab. 1. Summary of colour coded observations from 32 funnel plots.

- Registries E and F are systematically flagged for unexpected high survival.
- Flags were fewer in subgroups M1 and 80+. This could be related to cancer being mentioned more often in death certificates if the time between diagnosis and death is short, and thus more complete passive FU.
- Flags were also fewer in subgroup M0. Precision was generally low in subgroups (M0, M1, 80+), and control limits wide, thereby reducing the ability to detect outlying values.

Summary

- We compared survival in eight population-based cancer registries under conditions sensitive to incomplete registration of deaths: long-term survival and assuming patient survival in the absence of registered death.
- Under-registration of deaths possibly occured in registries E and F to a degree warranting further investigation.

Conclusion

- Funnel plots were able to flag unexpected high relative survival coinciding with follow-up procedures that potentially under-register deaths.

References

1. Brenner H and Hakulinen T. (2009). Implications of incomplete registration of deaths on long-term survival estimates from population-based cancer registries. *Int. J. Cancer*: **125**, 432-437.
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3. Dickman PW, Coviello E and Hills M. Estimating and modelling relative survival. *The Stata Journal* (in press).