EUROPEAN JOURNAL OF CANCER 48 (2012) 921–928

available at www.sciencedirect.com

ScienceDirect

journal homepage: www.ejconline.com

Has there been progress in cancer care in Croatia? Assessing outcomes in a partially complete mortality follow-up setting

A. Znaor [a,b,*], H. Brenner [c], B. Holleczek [d], A. Gondos [c]

[a] Croatian National Cancer Registry, Croatian National Institute of Public Health, Rockefellerova 7, 10000 Zagreb, Croatia
[b] Andrija Stampar School of Public Health, University of Zagreb Medical School, Rockefellerova 4, 10000 Zagreb, Croatia
[c] Division of Clinical Epidemiology and Aging Research, German Cancer Research Center, INF 581, 69120 Heidelberg, Germany
[d] Saarland Cancer Registry, Präsident Baltz-Straße 5, 66119 Saarbrücken, Germany

ARTICLE INFO

Article history:
Available online 21 June 2011

Keywords:
Cancer survival
Cancer registration
South-Eastern Europe

ABSTRACT

Background: We examine the possibility of assessing progress in cancer care with partially complete mortality follow-up information, and report outcomes from Croatia.
Methods: Follow-up based on death certificates indicating cancer as the cause of death was available from the Croatian National Cancer Registry. The effect of partially complete follow-up was first examined with data from the Saarland Cancer Registry by comparing absolute, relative, and cancer death certificate based survival estimates. Survival changes between 2000 and 2006 are reported for 21 common cancers amongst patients aged 15–49 and 50–59 in Croatia.
Results: Survival estimates based on cancer death specific follow-up could well approximate absolute and relative survival for patients aged 15–49, and relative survival for patients aged 50–59: overestimation by more than one standard error occurred 1 and 2 and 5 times, respectively, amongst 21 cancers. In Croatia, significant survival increases occurred for patients aged 15–59 with colorectal and breast cancers, patients aged 15–49 with thyroid cancer and patients aged 50–59 with malignant melanoma and prostate cancer.
Conclusions: Outcome evaluation is limited with partially complete follow-up information. Internationally comparable cancer information continues to lack from South-Eastern Europe, and the provision thereof remains a highly important public health task.

1. Introduction

Cancer survival is a major indicator of the quality of cancer care in a country, and is largely correlated with macro-economic variables, such as the gross national product and total national health care expenditures.[1] While improvements in cancer survival overall and for most of the cancer sites have been achieved at the European level over the past decades, differences between more and less affluent European regions are still prominent. These differences have been attributed to the availability of most up-to-date therapy protocols on one side, and early detection programmes on the other.[2–7]

Unfortunately, there is a dire lack of cancer outcome data from countries in South-Eastern Europe, with Slovenia as the only country in the region that regularly reports population based cancer survival estimates. Cancer survival information from Croatia has not been included in international studies

* *Corresponding author* at: Croatian National Cancer Registry, Croatian National Institute of Public Health, Rockefellerova 7, 10000 Zagreb, Croatia. Tel.: +38514863280.
E-mail address: ariana.znaor@hzjz.hr (A. Znaor).
0959-8049/$ - see front matter
doi:10.1016/j.ejca.2011.05.027

nor published in scientific literature otherwise so far. The main inhibiting factor has been that only partial mortality follow-up information, restricted to deaths certified as occurring due to cancer, has been available to the cancer registry. In this study, we examine the possibility of assessing recent trends in cancer outcomes based on the above outlined partially complete follow-up information and apply this method to report corresponding outcomes from Croatia. The presented method is not aimed to replace the conventional survival analysis, but rather bridge the period until complete mortality data become available.

2. Materials and methods

2.1. *Evaluation of the effect of partially complete mortality follow-up*

The Croatian National Cancer Registry had access to follow-up data based on death certificates indicating cancer as the cause of death only. In order to assess the possibility to use such partially complete follow-up data for assessing changes in cancer outcomes, we first examined the effect of using similarly partially complete follow-up information and complete follow-up information taking data from the Saarland Cancer Registry, as available in a cooperative international cancer survival study (Gondos et al.)[5] as an example. For 21 common cancers, 5-year absolute, relative and cancer death certificate based survival estimates were calculated for the age groups 15–49, 50–59, 60–69 and 70+. For each age group, differences, measured in absolute% units, between the standard survival measures of absolute and relative survival and the estimates based on cancer death certificates only were calculated. It is important to note that calculation of survival based on this type of partially complete mortality follow-up is different from cause specific survival calculation. Although the latter also uses deaths due to cancer as an end-point, information on deaths from other causes is also used, with observations censored when such deaths occur. Ideally, vital status is additionally ascertained by relying on active follow-up to determine loss-to-follow-up as well.

2.2. *Data sources Croatia*

Cancer incidence data were taken from the Croatian National Cancer Registry. The Registry was founded in 1959 and covers the whole Croatian population (4.4 million by the 2001 census). Data are collected from mandatory cancer notifications submitted by primary and secondary health care providers, death certificates, as well as hospital discharge data files (since 1999 onwards). Incidence data have been contributed to Volumes VII–IX of the Cancer Incidence in Five Continents series.[8–10] Follow-up information is collected through the National Bureau of Statistics, and is based on death certificates mentioning cancer. Death certificates mentioning cancer had been entered manually into the registry database until the year 2003, after which electronic mortality data file containing that data became available.

Overall, there were 223,332 incident cancer cases recorded in the period 1995–2006, with follow-up information available up to the end of 2006. After excluding six cases with incorrect ICD code, 327 non-melanoma skin cancers, 1105 cases with missing age, 1141 children (ages 0–14) and 15,935 death certificate only cases, there remained 204,818 cases (92%) for the analysis. Of these, we included the 21 most common cancers in this analysis. Calculations were restricted to morphologically verified cases.

2.3. *Analysis of cancer survival in Croatia*

Due to the lack of follow-up information on non-cancer deaths, survival estimates could be calculated based on the assumption only that cancer was the only cause of death. In order to minimise bias by violation of this assumption, the analysis was restricted to patients younger than 60 years of age at diagnosis. We used the period analysis methodology[11], in combination with modelling. A Poisson regression model, in which the logarithm of the excess number of deaths was modelled as a function of year of follow-up and calendar year, with the logarithm of person-years at risk as offset[12], was used to calculate 5-year survival estimates for the years 2000 and 2006, and p-values for trend in survival over time were derived. The calculations were done separately for the age groups 15–49 and 50–59, except for prostate, for which only the age group 50–59 was used due to the very low number of patients aged <50, and testicular cancer, for which the age groups 15–29 and 30–59 were used. All analyses were carried out using the SAS software package.[13]

For selected cancer sites, accompanying incidence and mortality rates for the period of 1996–2006 were examined for the analysed age groups in order to enable a more complete interpretation of changes in survival estimates. To compute the rates, numbers of incident cases from the Registry database, numbers of deaths from WHO Mortality Database and National Bureau of Statistics population estimates were used.[14,15] Three-year moving averages of age specific rates are presented on the logarithmic scale.

3. Results

Table 1 contains the absolute, relative and cancer deaths certificate based survival estimates calculated using data from the Saarland Cancer Registry for the age groups 15–49 and 50–59. For the age group 15–49, cancer death certificate based survival estimates were usually numerically very close, sometimes even equal to the absolute survival estimates – an overestimation of the absolute survival that exceeded one standard error occurred only for 2 out of 21 cancer sites. Alike, relative survival estimates were also predicted well, and an overestimation exceeding one standard error was found for liver cancer only. For both absolute and relative survival, numerically larger overestimation occurred for a few sites that had very large standard errors for both absolute and relative survival. For the age group 50–59, absolute survival was still well predicted, although overestimation was slightly more common, with 9 out of 21 estimates found to be one standard error above the actual absolute survival. For relative survival, predictions were nearly as good as for the younger age group, with actual relative survival estimates numerically underestimated for 11 out of 21 sites, while overestimations

Table 1 – Age group specific point estimates (PE) of 5-year absolute (ABS), relative (REL), and cancer death certificate based (CDC based) survival, differences between CDC based and absolute and relative survival estimates, in% units, Saarland, 2000–2004. Differences between CDC based estimates and absolute or relative survival estimates that exceed one standard error (SE) are underlined.

Cancer	ABS		REL		CDC based		Difference	
	PE	SE	PE	SE	PE	SE	ABS	REL
Age group 15–49								
Oral cavity	53.6	3.5	54.6	3.6	56.9	3.5	3.3	2.3
Oesophagus	21.3	8.6	21.7	8.8	24.8	9.3	3.5	3.1
Stomach	37.2	5.6	37.7	5.6	39.4	5.7	2.2	1.7
Colorectal	68.8	2.9	69.8	3.0	70.6	2.9	1.8	0.8
Liver	29.4	8.8	29.8	8.9	44.2	9.5	14.8	14.4
Pancreas	27.1	7.5	27.4	7.6	33.1	7.8	6.0	5.7
Larynx	68.3	7.6	69.6	7.8	76.2	7.0	7.9	6.6
Lung	19.9	2.4	20.3	2.5	21.1	2.5	1.2	0.8
Melanoma skin	90.2	2.0	91.1	2.1	90.2	2.0	0.0	−0.9
Breast	84.8	1.3	85.7	1.3	85.2	1.3	0.4	−0.5
Cervix	73.9	3.2	74.4	3.2	73.9	3.2	0.0	−0.5
Corpus	86.3	5.2	86.9	5.2	88.6	4.8	2.3	1.7
Ovary	73.6	4.6	74.2	4.7	75.8	4.5	2.2	1.6
Prostate	91.0	6.1	92.0	6.2	91.0	6.1	0.0	−1.0
Testis	98.5	0.9	98.7	0.9	98.5	0.9	0.0	−0.2
Kidney	80.6	4.5	82.0	4.6	80.6	4.5	0.0	−1.4
Bladder	81.4	6.9	81.8	6.9	81.9	6.7	0.5	0.1
Brain	51.5	5.1	51.9	5.1	52.9	5.1	1.4	1.0
Thyroid	99.2	0.8	99.3	0.8	99.2	0.8	0.0	−0.1
NHL	84.2	3.2	85.2	3.2	85.1	3.1	0.9	−0.1
Leukaemia	61.2	5.5	61.8	5.6	62.3	5.5	1.1	0.5
Age group 50–59								
Oral cavity	43.8	2.9	46.0	3.1	52.1	2.9	8.3	6.1
Oesophagus	24.5	4.7	25.8	4.9	36.7	5.2	12.2	10.9
Stomach	49.9	4.6	51.9	4.8	51.6	4.6	1.7	−0.3
Colorectal	63.6	2.1	66.6	2.2	66.6	2.1	3.0	0.0
Liver	14.7	4.5	15.2	4.7	24.1	5.5	9.4	8.9
Pancreas	5.6	2.3	5.8	2.4	9.0	2.9	3.4	3.2
Larynx	64.6	5.9	68.1	6.2	69.1	5.7	4.5	1.0
Lung	18.6	1.7	19.5	1.8	21.1	1.8	2.5	1.6
Melanoma skin	91.0	2.9	94.9	3.0	92.0	2.7	1.0	−2.9
Breast	83.3	1.3	85.6	1.4	83.6	1.3	0.3	−2.0
Cervix	55.4	6.2	56.9	6.4	55.4	6.2	0.0	−1.5
Corpus	86.4	3.3	88.3	3.3	87.4	3.1	1.0	−0.9
Ovary	53.6	5.5	55.1	5.7	54.9	5.5	1.3	−0.2
Prostate	86.7	2.1	92.2	2.2	89.0	1.9	2.3	−3.2
Testis	92.6	7.1	93.3	7.2	100.0	0.0	7.4	6.7
Kidney	79.1	3.6	82.7	3.7	79.9	3.5	0.8	−2.8
Bladder	73.2	4.9	77.0	5.2	75.8	4.7	2.6	−1.2
Brain	24.4	5.8	25.1	6.0	28.1	6.0	3.7	3.0
Thyroid	89.5	4.4	91.3	4.5	89.5	4.4	0.0	−1.8
NHL	71.0	4.2	74.1	4.4	72.9	4.1	1.9	−1.2
Leukaemia	52.6	6.0	54.4	6.2	59.4	5.9	6.8	5.0

beyond 1 standard error occurring for 5 out of 21 sites. Overall, these results suggest that cancer deaths specific survival estimates provide good approximations for both absolute and relative survival for the age group 15–49, and reasonable approximations for relative survival in the age group 50–59. In accordance with theoretical expectations, results were less favourable for older age groups – these are provided as Supplementary Material (Supplementary Table 1). Based on these results, only the two younger age groups were included in the analysis of Croatian data.

Table 2 presents the proportions of morphologically verified cases and cancer site specific numbers of patients diagnosed between 1995 and 2006 and included in the analysis. Overall, the proportion of morphologically verified (MV) cases for both age groups was slightly above 80%, and ranged between 51% for brain malignancies to over 99% for skin melanoma.

Table 3 presents model based estimates of 5-year survival for Croatia in the years 2000 and 2006, the change in percent units, and the *p*-value for the test for trend for age group 15–49. Statistically significant increases of survival from colorectal (+8.9% units), breast (+5.3% units) and thyroid (+3.3% units) cancers were found. For melanoma of the skin and Non-Hodgkin lymphoma (NHL), rises of 9.1 and 7.7% units, respectively, were seen, but only the rise seen for melanoma came close to statistical significance. Survival decreased

Table 2 – Proportion and number of morphologically verified (MV) cancer cases included in the analysis by site and age group, Croatia, 1995–2006.

	15–49		50–59	
	MV%	N (MV)	MV%	N (MV)
Oral cavity	79.5	1137	80.7	1885
Oesophagus	76.1	172	76.9	467
Stomach	77.0	745	77.3	1317
Colorectal	81.1	1680	82.7	3338
Liver	59.4	152	65.4	352
Pancreas	61.0	271	59.8	516
Larynx	83.3	518	85.7	1112
Trachea, bronchus and lung	82.3	2248	83.5	5174
Melanoma of the skin	99.5	1316	99.1	900
Female breast	82.4	4401	84.9	4781
Cervix uteri	87.6	1682	89.6	674
Corpus uteri	86.0	417	91.9	1185
Ovary	81.0	957	82.9	920
Prostate	70.8	46	85.5	643
Testis*	75.4	937	68.1	47
Kidney	74.2	561	77.0	849
Urinary bladder	75.4	411	79.6	906
Brain	53.6	744	50.7	498
Thyroid	95.4	1631	94.6	776
Non-Hodgkin's lymphoma	98.2	985	98.7	631
Leukaemia	71.6	650	80.3	557
Total	81.4	21,615	82.2	26,885

* Numbers for the age groups 15–29 and 30–59.

Table 3 – Model-based 5-year cancer survival estimates for Croatia in 2000 and 2006, and test for survival trend, by cancer site, age group 15–49.

Cancer site	icd10	2000		2006		Change	p
		PE[a]	SE[a]	PE[a]	SE[a]	2000–2006	
Oral cavity	0–14	42.8	3.5	47.7	3.4	4.9	0.377
Oesophagus	15	6.7	4.0	8.6	4.6	1.9	0.750
Stomach	16	26.0	3.8	28.8	3.9	2.8	0.642
Colorectal	18–21	46.3	2.9	55.2	2.6	8.9	0.048
Liver	22	24.8	7.5	12.9	5.7	−11.9	0.290
Pancreas	25	19.1	4.8	13.0	4.0	−6.1	0.401
Larynx	32	55.6	5.8	58.3	5.6	2.7	0.750
Trachea. bronchus and lung	33–34	19.2	1.9	17.9	1.8	−1.3	0.665
Melanoma of the skin	43	64.2	3.3	73.3	2.6	9.1	0.062
Female breast	50	77.3	1.6	82.6	1.3	5.3	0.025
Cervix uteri	53	77.1	2.6	80.9	2.2	3.8	0.336
Corpus uteri	54	86.2	3.6	80.6	4.9	−5.6	0.429
Ovary	56	58.9	3.9	64.4	3.5	5.5	0.360
Testis[b]	62	88.0	3.9	92.5	2.5	4.5	0.393
Kidney	64	70.3	4.2	70.4	4.1	0.1	0.987
Urinary bladder	67	79.5	4.8	83.7	3.9	4.2	0.565
Brain	71	56.0	4.0	48.8	4.3	−7.2	0.303
Thyroid	73	96.2	2.4	99.5	0.3	3.3	0.013
Non-Hodgkin's lymphoma	82–85	65.6	3.7	73.3	3.1	7.7	0.163
Leukaemia	91–96	55.9	9.6	56.4	9.5	0.5	0.977

[a] PE = point estimate, SE = standard error.
[b] Results for the age group 15–29.

numerically for liver, pancreas, lung and brain cancers and improved only marginally or remained unchanged for other cancers.

Table 4 presents the results of the analysis for the age group 50–59. A statistically significant increase was observed in the survival of patients diagnosed with prostate cancer (+37% units), malignant melanoma (+13% units), as well as colorectal (+7.7% units) and breast cancer (+5.6% units). A large increase with borderline statistical significance was seen for NHL (+13.7% units), while a statistically non-significant increase of 6% was observed for leukaemia. A statistically significant decrease of lung cancer survival was

Table 4 – Model-based 5-year cancer survival estimates for Croatia in 2000 and 2006, and test for survival trend by cancer site. age group 50–59.

Cancer site	icd10	2000		2006		Change	p
		PE[a]	SE[a]	PE[a]	SE[a]	2000–2006	
Oral cavity	0–14	34.6	2.5	39.2	2.5	4.6	0.263
Oesophagus	15	12.6	3.1	12.6	3.1	0.0	0.999
Stomach	16	23.9	2.6	27.6	2.7	3.7	0.396
Colorectal	18–21	43.0	2.0	50.7	1.9	7.7	0.017
Liver	22	16.8	4.1	17.9	4.2	1.1	0.878
Pancreas	25	11.4	2.8	10.2	2.6	−1.2	0.784
Larynx	32	51.9	3.4	55.1	3.3	3.2	0.574
Trachea, bronchus and lung	33–34	19.5	1.1	15.5	1.0	−4.0	0.020
Melanoma of the skin	43	59.3	4.2	72.3	3.2	13.0	0.029
Female breast	50	74.3	1.6	79.9	1.3	5.6	0.019
Cervix uteri	53	68.5	4.1	67.5	4.2	−1.0	0.885
Corpus uteri	54	85.9	2.4	86.2	2.3	0.3	0.951
Ovary	56	50.1	3.7	49.1	3.7	−1.0	0.881
Prostate	61	38.5	5.6	74.9	3.3	36.4	0.000
Testis[b]	62	89.2	2.9	89.5	2.9	0.3	0.953
Kidney	64	66.9	3.4	66.8	3.5	−0.1	0.987
Urinary bladder	67	78.4	3.0	79.8	2.8	1.4	0.781
Brain	71	20.9	3.8	24.9	4.0	4.0	0.532
Thyroid	73	94.4	2.5	97.6	1.1	3.2	0.237
Non-Hodgkin's lymphoma	85	52.4	4.9	66.1	4.0	13.7	0.057
Leukaemia	96	41.3	6.4	47.3	6.2	6.0	0.563

[a] PE = point estimate, SE = standard error.
[b] Results for the age group 30–59.

observed, while there were no major changes for the other analysed cancer sites.

Fig. 1 presents age group specific incidence and mortality trends for selected cancer sites. Stomach cancer incidence and mortality have been decreasing after the period 1999–2001 in both age groups, although more markedly amongst younger patients. Colorectal cancer incidence appeared to increase moderately in the first years of the study period, and remained largely stable after the year 2000 in both age groups, while mortality remained stable in both age groups. For lung cancer, both incidence and mortality decreased slightly during the last 4–5 years of the study in the age group 15–49, while rates remained virtually unchanged in the age group 50–59 after the year 2000. Marked increases of skin melanoma incidence in both age groups were accompanied by only smaller increases in mortality. Female breast cancer incidence appeared to increase modestly in the first years of the study, while incidence rates remained stable and mortality rates decreased slightly in both age groups in the first years of the 21st century. Prostate cancer incidence in the age group 50–59 increased more than three-fold, while mortality remained stable throughout the study period.

4. Discussion

The methodological evaluation suggested that partially complete follow-up based on death certificates indicating cancer as the cause of death can be a useful tool to assess cancer outcomes in the absence for complete follow-up information for younger patients. On the basis of such follow-up information, in the period of 2000–2006, a significant increase of 5-year survival was found for female breast and colorectal cancers in both age groups, thyroid cancer in the age group 15–49 and prostate cancer and malignant melanoma of the skin in the age group 50–59 in Croatia. Furthermore, results suggest increasing survival amongst patients with cutaneous melanoma in the age group 40–49 and NHL in both age groups as well. The observed site specific trends are consistent with survival trends seen in international comparative cancer survival studies.[5,16] The accompanying trends in incidence and mortality, which are useful for the comprehensive interpretation of survival trends[17], were consistent with stable or improving survival, and also in accordance with regionally observed trends.[18]

The main limitation of our study was only partially complete follow-up for mortality from causes other than cancer. The proportion of cancer patients dying from causes other than cancer increases with age, as well as with increasing duration of follow-up.[19–21] The effect of partially complete follow-up for mortality, resulting in overestimated survival, is more pronounced in relative than absolute survival and increases with the duration of follow-up and with age.[7] Studies indicate that the attribution of deaths to cancer is complicated: a study of non-cancer deaths of white adult cancer patients[20] demonstrated an excess of non-cancer deaths shortly after diagnosis, which may have been caused by side-effects of the treatment. Furthermore, a study based on data from the SEER Program[22] showed that 41% of deaths of cancer patients within one month from surgery were attributed to causes other than cancer – while the effect on survival was found to be generally modest, they nevertheless suggest potential problems with the correct attribution of deaths

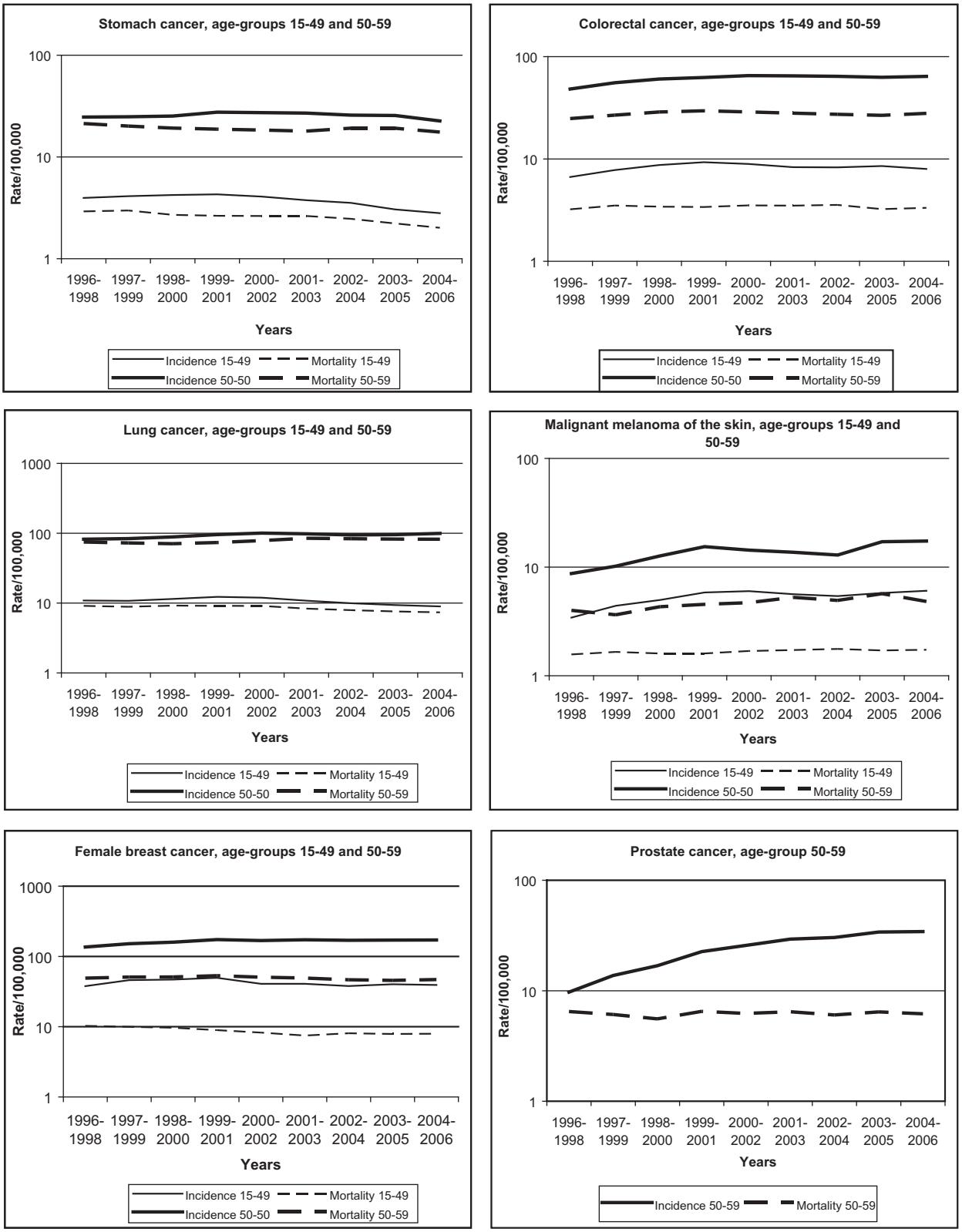

Fig. 1 – Cancer incidence and mortality trends in Croatia, selected common cancers, 1996–2006. Graphs show, on the logarithmic scale, 3-year moving averages of incidence and mortality per 100,000 person years, age groups 15–49 and 50–59.

amongst cancer patients. The complete assessment of vital status is, therefore, essential for the provision of fully reliable survival estimates and trend analysis. As cancer incidence usually rises strongly with age, patients who could be included in this study are but a minority of all cancer patients, and based on the follow-up data available in this study, it

remains impossible to evaluate outcomes in older age groups due to the increasing role of deaths due to other causes.

A certain proportion of cancer and non-cancer deaths may have been missed in our study, and the calculated absolute survival estimates may be higher than the true survival should be. Furthermore, the performance of the applied method may be compromised if age specific all cause mortality is much higher in Croatia than in the Saarland. However, differences in cumulative all cause mortality were small, with differences below 0.2% units for women and 1.8% units for men for the ages 15 to 49 and below 0.3% and 3.2% units for women and men, respectively, for the ages 50–59.[14] Nevertheless, potential differences between death certification procedures may exist between various populations. For cancer sites with the lowest survival, such as oesophagus, liver, pancreas and lung cancer, there is little temporal and geographical variation in survival estimates across Europe. The 5-year survival estimates of 13% for pancreas cancer and 17.9% for lung cancer calculated for the age group 15–49 for 2006 in this study are lower than the European average 5-year absolute and relative survival estimates calculated for age group 15–44 in the Eurocare-4 study for the cohort of 1995–99.[6] In the age group 50–59, the 5-year estimate of lung cancer survival of 15.7% is very similar to the European average 5-year absolute survival for corresponding age groups (45–54 and 55–64), while the difference for pancreas cancer survival (10.2% versus 7.4% and 5.3%) suggests an overestimation of around 4% units in our study.[6] Taking 4% units survival overestimation and an expected observed survival of 6%, it follows that 90 out of 94 deaths (ca. 96%) were captured. Alike, for liver cancer, the observed 17.9% absolute survival for the age group 50–59 in this study is ca. 6% units higher than the corresponding average 5-year absolute survival estimates of the age groups 45–54 and 55–64 in the Eurocare-4 study, suggesting that 82 out of 88 deaths (ca. 93%) were captured. With increasing survival, a similar proportion of missed deaths would have a smaller numerical effect. These additional comparisons provide further indication that the method performed well in this analysis. Overall, we believe that while the calculated estimates can be reasonably considered as the upper limit of absolute survival in the examined population, estimates are likely to closely reflect, particularly for 2006, the observed survival of 15–59 year old cancer patients in Croatia. Nevertheless, it remains critical to achieve the regular updating of all-cause mortality information for all patients in future and to work towards generally improved data quality, particularly for those cancer sites that have low histological verification proportions so far.

Despite long established cancer registration principles[23,24] and European initiatives to implement statutory cancer registration[25], there remains a large room for improvement in the coverage and quality of cancer registration in most Eastern and South-Eastern European countries. With a high prevalence of modifiable cancer risk factors[26], and consequently high proportions of avoidable cancers[27], efficient means for identifying priorities and monitoring progress in cancer prevention through high-quality cancer registration are vitally important in these areas of Europe.

In conclusion, efforts should be made not only to reduce the gap in cancer survival between this area and the rest of Europe by introducing population-based preventive programmes and improving accessibility to optimal cancer care, but also to reduce the gap in expenditures for cancer epidemiology and registration, thereby providing the means for efficient cancer control across Europe.

Conflict of interest statement

None declared.

Acknowledgements

This study was financially supported by the Croatian Ministry of Science, Education and Sport grant no. 005-1080315-0294, and in part by a grant from German Cancer Aid (Deutsche Krebshilfe, grant no. 108257).

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.ejca.2011.05.027.

REFERENCES

1. Micheli A, Coebergh JW, Mugno E, et al. European health systems and cancer care. *Ann Oncol* 2003;**14**(Supp 5):v41–60.
2. Berrino F, Sant M, Verdecchia A, et al. *Survival of cancer patients in Europe. The EUROCARE study. IARC Scientific publications No. 132*. Lyon: International Agency for Research on Cancer; 1995.
3. Berrino F, Capocaccia R, Esteve J, et al. *Survival of cancer patients in Europe: the EUROCARE-2 study. IARC Scientific Publications No 151*. Lyon: International Agency for Research on Cancer; 1999.
4. Sant M, Aareleid T, Berrino F, et al. EUROCARE-3: survival of cancer patients diagnosed 1990–94–results and commentary. *Ann Oncol* 2003;**14**(Supp 5):v61–v118.
5. Gondos A, Bray F, Brewster DH, et al. Recent trends in cancer survival across Europe between 2000 and 2004: A model-based period analysis from 12 cancer registries. *Eur J Cancer* 2008;**44**(10):1463–75.
6. Sant M, Allemani C, Santaquilani M, et al. EUROCARE-4. Survival of cancer patients diagnosed in 1995–1999. Results and commentary. *Eur J Cancer* 2009;**45**(6):931–91.
7. Brenner H, Hakulinen T. Implications of incomplete registration of deaths on long-term survival estimates from population-based cancer registries. *Int J Cancer* 2009;**125**:432–7.
8. Parkin DM, Whelan SL, Ferlay J, Raymond L, Young J, editors. *Cancer Incidence in Five Continents, Vol. VII. IARC Scientific Publications No. 143*. Lyon: International Agency for Research on Cancer; 1997.
9. Parkin DM, Whelan SL, Ferlay J, Teppo L, Thomas DB, editors. *Cancer Incidence in Five Continents, Vol. VIII. IARC Scientific Publications No. 155*. Lyon: International Agency for Research on Cancer; 2002.
10. Curado MP, Edwards B, Shin HR, editors. *Cancer Incidence in Five Continents, Vol. IX. IARC Scientific Publications No. 160*. Lyon: International Agency for Research on Cancer; 2007.

11. Brenner H, Gefeller O, Hakulinen T. Period analysis for 'up-to-date' cancer survival data: theory, empirical evaluation, computational realisation and applications. *Eur J Cancer* 2004;**40**:326–35.
12. Brenner H, Hakulinen T. Up-to-date and precise estimates of cancer patient survival: model-based period analysis. *Am J Epidemiol* 2006;**164**(7):689–96.
13. SAS 9.1. SAS Institute Inc. Available: http://sas.com/Last accessed:12 October 2010.
14. National Bureau of Statistics – Republic of Croatia. *Statistical Yearbook of the Republic of Croatia 1996–2007*. Zagreb: National Bureau of Statistics; 1997–2008.
15. World Health Organization, Mortality database. Available: http://www.who.int/whosis/whosis/Last accessed: 3 May 2010.
16. Verdecchia A, Guzzinati S, Francisci S, et al. Survival trends in European cancer patients diagnosed from 1988–1999. *Eur J Cancer* 2009;**45**(6):1042–66.
17. Dickman PW, Adami HO. Interpreting trends in cancer patient survival. *J Intern Med* 2006;**260**(2):103–7.
18. Karim-Kos E, de Vries E, Soerjomataram I, et al. Recent trends of cancer in Europe: a combined approach of incidence, survival and mortality for 17 cancer sites since the 1990s. *Eur J Cancer* 2008;**44**(10):1345–89.
19. Parkin DM, Hakulinen T. Analysis of survival. In: Jensen OM, Parkin DM, MacLennan R, Muir CS, Skeet RG, editors. *Cancer registration: principles and Methods. IARC Scientific Publications No 95*. Lyon: International Agency for Research on Cancer; 1991. p. 159–76.
20. Brown BW, Brauner C, Minnotte MC. Non-cancer deaths in white adult cancer patients. *J Natl Cancer Inst* 1993;**85**(12):979–87.
21. Gamel JW, Vogel RL. Non-parametric comparison of relative versus cause-specific survival in Surveillance, Epidemiology and End Results (SEER) programme breast cancer patients. *Stat Methods Med Res* 2001;**10**:339–52.
22. Welch HG, Black WC. Are deaths within 1 month of cancer-directed surgery attributed to cancer? *J Natl Cancer Inst* 2002;**94**:1066–70.
23. Bray F, Parkin DM. Evaluation of data quality in the cancer registry: principles and methods Part II. Completeness. *Eur J Cancer* 2009;**45**:756–64.
24. Parkin DM, Bray F. Evaluation of data quality in the cancer registry: principles and methods Part I: comparability, validity and timeliness. *Eur J Cancer* 2009;**45**:747–55.
25. European Parliament. European Parliament Resolution on Combating Cancer in the Enlarged European Union. EP reference number: B6-0132/2008/P6-TA-PROV(2008)0121.Available: http://www.europarl.europa.eu/sides/getDoc.do?type=TA&reference=P6-TA-2008-0121&language=EN Last accessed: 9 November 2010.
26. Zatoński W, Didkowska J. Closing the gap: cancer in Central and Eastern Europe (CEE). *Eur J Cancer* 2008;**44**(10):1425–37.
27. Sjoeromataram I, de Vries E, Pukkala E, Coebergh JW. Excess of cancers in Europe: a study of eleven major cancers amenable to lifestyle change. *Int J Cancer* 2007;**120**(6):1336–43.