Journal of Clinical Epidemiology 70 (2016) 224–232

Journal of Clinical Epidemiology

Timely disclosure of progress in long-term cancer survival: the boomerang method substantially improved estimates in a comparative study

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Accepted 29 September 2015; Published online 9 October 2015

Abstract

Objective: Monitoring cancer survival is a key task of cancer registries, but timely disclosure of progress in long-term survival remains a challenge. We introduce and evaluate a novel method, denoted ''boomerang method,'' for deriving more up-to-date estimates of long-term survival.

Study Design and Setting: We applied three established methods (cohort, complete, and period analysis) and the boomerang method to derive up-to-date 10-year relative survival of patients diagnosed with common solid cancers and hematological malignancies in the United States. Using the Surveillance, Epidemiology and End Results 9 database, we compared the most up-to-date age-specific estimates that might have been obtained with the database including patients diagnosed up to 2001 with 10-year survival later observed for patients diagnosed in 1997–2001.

Results: For cancers with little or no increase in survival over time, the various estimates of 10-year relative survival potentially available by the end of 2001 were generally rather similar. For malignancies with strongly increasing survival over time, including breast and prostate cancer and all hematological malignancies, the boomerang method provided estimates that were closest to later observed 10-year relative survival in 23 of the 34 groups assessed.

Conclusion: The boomerang method can substantially improve up-to-dateness of long-term cancer survival estimates in times of ongoing improvement in prognosis.

Keywords: Cancer registries; Methods; Period analysis; Survival

1. Introduction

In recent years, there has been major progress in long-term survival for many forms of cancer. Disclosure of such progress by cancer registries [1] should be as timely as possible. However, conventional ways to derive and report long-term cancer patient survival often yielded severely outdated cancer survival statistics, as they referred to patients diagnosed many years ago and did thus not, or only to a very limited extent, capture more recent progress in survival. This is illustrated in Fig. 1 for derivation of 10-year survival by two conventional methods of survival analysis, that is, cohort analysis and complete analysis, in a cancer registry that includes patients diagnosed and followed with respect to survival up to and including 2011. A typical approach often taken in the past would have been to include a cohort of patients diagnosed in a number of calendar years, such as five calendar years, in the past and followed over full 10 years since then. However, as illustrated in Fig. 1A, such an approach would provide 10-year survival for patients diagnosed in 1997–2001 only in our example because 10-year follow-up would not be complete for later diagnosed patients. Such a survival estimate would thus not capture any potential improvement in cancer care that might have been achieved since then and that might have led to substantially higher survival in patients diagnosed after 2001. A somewhat more up-to-date survival estimate could be obtained by also including

Funding: This work was supported in part by a grant from Deutsche Krebshilfe (German Cancer Aid, No. 110446). The sponsors did not have any role in this study.

Conflicts of interest: None.

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http://dx.doi.org/10.1016/j.jclinepi.2015.09.017
0895-4356/

What is new?

Timely disclosure of progress in long-term survival of cancer patients by cancer registries remains a challenge with established methods of survival analysis. We propose a novel method, denoted ''boomerang method'' for deriving more up-to-date long-term survival estimates. We empirically evaluated this method compared to established methods in analyses of recent progress in 10-year survival of cancer patients in the United States. The boomerang method substantially improved up-to-dateness of long-term survival estimates for cancers whose prognosis was strongly improving over time.

patients diagnosed in later years although they could not have been followed for 10 years and censoring survival times at the end of follow-up (Fig. 1B). However, even this ''complete analysis'' might not provide up-to-date survival estimates in case of improvement in survival over time because it is still to a large extent determined by the survival experience of patients diagnosed many years ago.

To provide more up-to-date estimates of cancer patient survival, an alternative approach, denoted period analysis, has been introduced a number of years ago [2]. In this approach, up-to-dateness of survival estimates is enhanced by restriction of the survival analysis to some recent calendar period by left truncation of survival times at the beginning of the period of interest in addition to right censoring at its end. This is illustrated for a period analysis for the years 2007–2011 in our example in Fig. 2A. It has been demonstrated by extensive empirical evaluation that period analysis provides more up-to-date survival estimates than conventional cohort and complete analysis and closely predicts 5-year survival later observed for patients diagnosed in the period of interest [3–5]. As a result, period analysis has meanwhile become a standard analytical approach in many national and international cancer survival studies [6–9].

In the past, the most commonly reported survival measure has been 5-year survival because most cancer-related deaths occur within the initial 5 years after diagnosis. However, with increasing proportions of cancer patients surviving the initial 5 years after diagnosis, longer term survival estimates such as 10-year survival become of increasing interest [10]. Although less so than the conventional techniques of survival analyses, even period analysis may substantially underestimate 10-year survival of recently diagnosed patients in case of ongoing improvement in prognosis [3,4]. This is due to the fact that patients diagnosed many years ago still account for a major proportion of the database included in the analysis as illustrated in Fig. 2A. A more up-to-date estimate of 10-year survival might be obtained by minimizing this contribution as illustrated in Fig. 2B. In this approach, denoted ''boomerang'' approach according to the shape of the shaded area in Fig. 2B, survival experience within the initial 5 years after diagnosis is obtained by a complete analysis of survival for patients diagnosed in the most recent calendars (2007–2011), whereas only survival from year 5 to year 10 after diagnosis is contributed by survival experience of patients diagnosed in earlier years (here: 2001–2006) in a ''period-like'' approach. A summary of the differences in calendar years of diagnosis and calendar years of follow-up included in the various types of analyses is given in Supplementary Table 1/ Appendix B at www.jclinepi.com.

In the following, we illustrate the advantages and limitations of the use of the boomerang approach for deriving up-to-date 10-year survival estimates for patients with common solid cancers and hematological malignancies in the United States.

2. Methods

2.1. Database

Our analysis is based on cancer registry data from the Surveillance, Epidemiology and End Results (SEER) Program. More specifically, the SEER-9 database, which includes data from 1973 to 2011, was used [11]. This database was selected because of its long-standing very high levels of completeness and data quality. For our analyses, we selected four common solid cancers with strongly varying prognosis, that is, breast cancer, colorectal cancer, lung cancer, and prostate cancer, as well as common hematological malignancies for which major progress in prognosis has been achieved in the past two decades [12], and timely disclosure of such progress is of utmost interest. In addition, for these malignancies, longer term survival is of particular interest, given the increasing proportions of patients meanwhile surviving the initial 5 years after diagnosis [3]. The following hematological malignancies (ICD-0-3) were included: acute myeloid leukemia (AML, histology: 9840, 9861, 9866, 9867, 9871–9874, 9895–9897, 9910, 9920), acute lymphoblastic leukemia (ALL, histology: 9826, 9835–9837), chronic myelogenous leukemia (CML, histology: 9863, 9875, 9876), chronic lymphocytic leukemia (CLL, histology: 9823 and topography: C42.0, C42.1, or C42.4), Hodgkin lymphoma (HL, histology: 9650–9667), non-Hodgkin lymphoma (NHL, histology: 9670–9729, 9591, 9823), and multiple myeloma (MM, histology: 9731–9734). Because of major differences in the epidemiology and prognosis of hematologic malignancies in childhood and among adults, our analyses were restricted to patients aged 15 years and older.

2.2. Statistical analysis

To evaluate performance of the boomerang approach compared to the conventional cohort and complete