Recent increase in cancer survival according to age: higher survival in all age groups, but widening age gradient

Hermann Brenner* & Volker Arndt
Department of Epidemiology, German Centre for Research on Ageing, Heidelberg, Germany

Received 16 February 2004; accepted in revised form 24 May 2004

Key words: aging, cancer registries, medical oncology, survival.

Abstract
A major increase in long-term survival of cancer patients in the 1990s has recently been demonstrated. It is unclear, however, to what extent this increase has been shared by cancer patients at various ages. Using the 1973–2000 data base of the Surveillance, Epidemiology, and End Results programme, recent increase in 10-year relative survival of cancer patients in the US was assessed for 4 major age groups and 15 major cancer sites by comparing results of a period analysis for the 1996–2000 period with results of a cohort analysis for patients diagnosed in 1986–1990. Period estimates of 10-year relative survival for all forms of cancer combined in 1996–2000 were 66.1%, 58.8%, 56.3% and 47.1% for age groups 15–54, 55–64, 65–74 and ≥75 years, respectively. They were 7.4%, 10.4%, 7.8% and 3.0% units higher than the respective 1986–1990 cohort estimates for these age groups. The increase in 10-year relative survival strongly varied by cancer site, but it was generally less pronounced in older than in younger patients. We conclude that long-term survival expectations of cancer patients have increased in all age groups in the 1990s. However, for most common forms of cancer, the age gradient in survival has either persisted or widened.

Introduction
Long-term survival rates for many forms of cancer have substantially increased in the past decades, but most previous data pertained to patients diagnosed before the 1990s. That a further major increase has been ongoing in the 1990s has recently been demonstrated for various European countries and the US by means of a new method of survival analysis, denoted period analysis [1–5], which has been introduced by Brenner and Gefeller a few years ago [6]. It is unclear, however, to what extent the recent increase has been shared by cancer patients in various age groups. In particular, it is unknown, whether the strong age gradient in prognosis which has been seen for many forms of cancer in previous reports [7–9], has persisted in recent years. The aim of this analysis was to assess recent developments of long-term survival by major cancer sites and major age groups in the US using the period analysis methodology.

Material and methods
This analysis is based on data on cancer incidence and survival in 1986–2000 from the 1973–2000 public use database of the Surveillance, Epidemiology, and End Results (SEER) programme of the United States National Cancer Institute [10]. Data from nine population-based cancer registries (Connecticut, New Mexico, Utah, Iowa, Hawaii, Atlanta, Detroit, Seattle-Paget Sound, and San-Francisco-Oakland), which together cover a population of about 30 million people, are included. Our analysis is restricted to patients diagnosed with a first primary invasive cancer above age 15 between 1 January, 1986 and 31 December, 2000. Patients with unknown month of diagnosis (0.6%) or length of follow-up (1.5%) were excluded, as were patients who were reported to the registries by death certificate only (1.2%) or by autopsy only (0.3%). We restricted our analysis to patients above age 15 because...
childhood cancers, which account for less than 2% of all cancers, differ from adulthood cancers in many respects.

To assess recent improvement in long-term survival rates, period estimates of 10-year survival for the 1996–2000 period were calculated [6] and compared to 10-year survival estimates derived by traditional cohort analysis for patients diagnosed in 1986–1990 and followed with respect to vital status until the end of 2000 [11, 12]. The difference between the two types of analyses is illustrated in Figure 1. The cohort estimates would not capture potential major improvement in survival of patients diagnosed in the 1990s. The period analysis of 10-year survival for the 1996–2000 period provides a more up-to-date estimate of 10-year survival. It is based on the survival experience of patients diagnosed between 1986 and 2000, but only the survival experience in 1996–2000 is used in the analysis. This is based on the survival experience of patients diagnosed between 1986 and 2000, but only the survival experience in 1996–2000 is used in the analysis. This is achieved by left truncation of observations at the beginning of 1996 in addition to right censoring at the end of 2000. Hence, survival during the 1st year following diagnosis is obtained from patients diagnosed in 1995–2000, conditional survival during the 2nd year is obtained from patients diagnosed in 1994–1999, and so on, until conditional survival during the 10th year following diagnosis, which is obtained from patients diagnosed in 1986–1991. The conditional survival estimates during single years following diagnosis are then multiplied to come up with the period estimate of cumulative 10-year survival.

The 1996–2000 period estimates of 10-year survival quantify the 10-year survival expectations of patients diagnosed in 1996–2000 assuming that the conditional survival rates by follow-up year after diagnosis observed in this period remain constant over time. Although 10-year survival rates of patients diagnosed in 1996–2000 will be definitively known only 10 years from now (when these patients have been followed for 10-years), results of a period analysis for 1996–2000 can be expected to predict these 10-year survival rates quite closely, as extensive empirical evaluations of the period analysis methodology have shown [13–15]. Nevertheless, they may still be too pessimistic in case of ongoing increase in survival over time.

Ten year survival rates were estimated by four major age groups: 15–54, 55–64, 65–74, and ≥75 years. In addition to 10-year survival estimates of patients with all forms of cancer combined, analyses were carried out for 15 major forms of cancer, which together account for about 83% of all cancers. Data are presented for all ethnic groups, and, apart from gynecological cancers and cancer of the prostate, both sexes combined.

To focus on cancer related prognosis, relative rather than absolute survival rates are presented. Relative survival rates indicate so-called net survival of patients with cancer. They can be interpreted as expected survival rates of cancer patients in the hypothetical situation in which cancer is the only cause of death [12].