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Trends in Relative Survival for Ovarian Cancer From 1975 to 2011

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Abstract

OBJECTIVE—To examine relative survival (a metric that incorporates changes in survival within a population) in women with ovarian cancer from 1975 to 2011.

METHODS—Women diagnosed with ovarian cancer from 1975 to 2011 and recorded in the National Cancer Institute’s Surveillance, Epidemiology, and End Results database were examined. Relative survival, estimated as the ratio of the observed survival of cancer patients (all-cause mortality) to the expected survival of a comparable group from the general population, was matched to the patients with the main factors that are considered to affect patient survival such as age, calendar time, and race. Hazard ratios were adjusted for age, race, year of diagnosis, time since diagnosis, and the interaction of age and years since diagnosis (except for stage II).

RESULTS—A total of 49,932 women were identified. For stage I ovarian cancer, the adjusted excess hazard ratio for death in 2006 was 0.51 (95% confidence interval [CI] 0.41–0.63) compared with those diagnosed in 1975. The reduction in excess mortality remained significant when compared with 1980 and 1985. For women with stage III–IV tumors, the excess hazard of mortality was lower in 2006 compared with all other years of study ranging from 0.49 (95% CI 0.44–0.55) compared with 1975 to 0.93 (95% CI 0.87–0.99) relative to 2000. For women aged 50–59 years, 10-year relative survival was 0.85 (99% CI 0.61–0.95) for stage I disease and 0.18 (99% CI 0.10–0.27) for stage III–IV tumors. For women aged 60–69 years, the corresponding 10-year relative survival estimates were 0.89 (99% CI 0.58–0.98) and 0.15 (99% CI 0.09–0.21).

CONCLUSION—Relative survival has improved for all stages of ovarian cancer from 1975 to 2011.

Over the past three decades, the treatment options for ovarian cancer have expanded. Surgically, the importance of staging for apparent ovarian-confined disease and the benefits

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of tumor cytoreductive surgery for advanced-stage tumors have been recognized.^{1,2} Similarly, platinum analogs have been recognized as active agents against ovarian cancer and are considered first-line therapy, other effective chemotherapeutic drugs have been identified, and new routes and methods to deliver chemotherapy have been validated.^{3–5}

Despite these advances, quantifying the population-level magnitude of improvement in survival for women with ovarian cancer remains challenging. First, improved medical care for acute and chronic conditions has prolonged the life expectancy in general. For example, the average life expectancy increased by more than 6 years, to greater than 78 years of age, from 1975 to 2011.⁶ Second, examining cancer-specific or disease-specific mortality, deaths directly attributable to cancer, is problematic in that coded data on cause of death are often not reliable.^{7,8}

To address these challenges, relative survival, the ratio of the observed survival of cancer patients (all-cause mortality) to the expected survival of a comparable group from the general population, has been described as a useful tool to examine population-level trends in survival from cancer.^{9–11} Relative survival not only accounts for death from intercurrent illness, but also adjusts for changes in survival in the population.^{12,13} Given the paucity of data to describe the changes in survival in ovarian cancer over the past 30 years, we examined relative survival in women with ovarian cancer from 1975 to 2011.

MATERIALS AND METHODS

We utilized data from the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) program.¹⁴ Surveillance, Epidemiology, and End Results is a population-based tumor registry that collects data on all newly diagnosed patients with cancer in geographically defined regions of the United States. Patients diagnosed with ovarian cancer between January 1975 and December 2011 from nine SEER registries that began collecting data in 1975 or earlier including San Francisco–Oakland, Connecticut, Detroit (metropolitan), Hawaii, Iowa, New Mexico, Utah, Seattle (Puget Sound), and Atlanta (metropolitan) were included. The analyses were limited to women of black or white race with exclusion of other racial groups (or unknown race) because the analyses required reliable estimates of population-level expected survival. Patients with unknown stage were also excluded from the analysis. The study relied on deidentified, publicly available data and was deemed exempt by the Columbia University institutional review board.

Staging was based on the derived seventh edition of the American Joint Committee on Cancer staging system for patients diagnosed in 2010–2011 and derived sixth edition of the American Joint Committee on Cancer staging for 2004–2009, and SEER-modified third edition of American Joint Committee on Cancer staging for 1988–2003.¹⁴ American Joint Committee on Cancer staging was not recorded before 1988, so we constructed American Joint Committee on Cancer staging based on two-digit extent of disease schemes for patients diagnosed in 1975–1982 and four-digit extent of disease schemes for 1983–1987.¹⁴

Time from ovarian cancer diagnosis to death from any cause was evaluated. Relative survival was estimated by comparing observed survival after diagnosis of ovarian cancer

with expected survival obtained from the general U.S. population matched on age, race, and calendar year with the Ederer II method, available in SEER*Stat.^{15,16} The relative survival models were estimated using annual intervals in the framework of generalized linear models with a Poisson error structure (see the Appendix, available online at <http://links.lww.com/AOG/A636>). Confidence intervals (CIs) were obtained through the complementary log-log transformation.^{17–19}

Separate models were estimated for three stage groups (stage I, II, and III–IV). All models included race, age at diagnosis, diagnosis year, and time since diagnosis. Age at diagnosis was used as a categorical variable, consistent with SEER reporting, as younger than 20 years, 20–49 years, 50–59 years, 60–69 years, 70–79 years, and 80 years and older. Diagnosis year was included as a piecewise linear function of year allowing changes in slope at 1980, 1990, and 2000. Covariate information was updated with each new interval. Years since diagnosis was a time-varying covariate updated in 1-year increments at the end of the yearly interval and was included as a piecewise linear function of year allowing changes in slope at 2, 3, and 5 years after diagnosis to allow rapid change in excess hazards.

We included interactions between age at diagnosis and years since diagnosis for stage I and stage III–IV groups to allow changes in excess hazard after diagnosis to vary across age groups.¹⁸ Interactions between age at diagnosis and years since diagnosis were not included for stage II group because the model with interactions overfit the data. Within the stage II cohort, for each combination of age group and years since diagnosis, there were not enough patients to produce reliable estimates. Deviance statistics were examined to assess the goodness of fit of the relative survival models.¹⁸

Analyses were performed using SAS 9.4. All statistical tests were two-sided, and a *P* value of <.05 was considered statistically significant.

RESULTS

A total of 49,932 women with ovarian cancer diagnosed between 1975 and 2011 who met inclusion criteria were identified (Table 1). The cohort included 11,836 (23.7%) women with stage I tumors, 3,444 (6.9%) with stage II neoplasms, and 34,652 (69.4%) with stage III and IV malignancies. Stage I tumors were most commonly diagnosed in women aged 20–49 years, whereas stage II tumors were most commonly seen in those aged 50–59 years and stage III–IV neoplasms were most frequently identified in women aged 60–69 years. Within the cohort, 3,581 (7.2%) of the patients were black, whereas 46,351 (92.8%) were white.

The excess hazard ratios (HRs) for ovarian cancer are displayed in Table 2. Compared with white women, black women with stage II (HR 1.29, 95% CI 1.05–1.58) and stage III–IV (HR 1.27, 95% CI 1.17–1.37) cancers had increased excess HRs. For all stages of ovarian cancer, we noted reductions in excess mortality over time. Among women with stage I ovarian cancer, the excess HR for women diagnosed in 2006 was 0.51 (95% CI 0.41–0.63) compared with those diagnosed in 1975. The reduction in excess hazard of death for patients treated in 2006 remained statistically significant when compared with patients diagnosed in

1980 and 1985; however, there was not a statistically significant reduction in excess mortality for women in 2006 compared with women diagnosed from 1990 onward.

For women with stage II neoplasms, the excess HR was significantly lower for women diagnosed in 2006 relative to all of the years examined, ranging from 0.57 (95% CI 0.42–0.78) for patients in 1975 to 0.70 (95% CI 0.59–0.83) for those women diagnosed in 2000. Similarly, for women with advanced-stage disease, the excess hazard of mortality decreased over time and was lower in 2006 compared with all other years of the study ranging from 0.49 (95% CI 0.44–0.55) compared with patients diagnosed in 1975 and 0.93 (95% CI 0.87–0.99) when compared with those women diagnosed in 2000.

The excess HR over time analyzed by age is displayed in Table 3. For patients with stage II cancer, the association between age and outcome did not vary with time since diagnosis. Among women with stage I cancers, older age was associated with substantially greater 1-year excess mortality for women 80 years of age or older, but there was no statistically significant association between age and excess mortality at 5 and 10 years. For women with stage III and IV tumors, excess mortality was greater for older women at 1 and 5 years; the effect of age on excess mortality diminished somewhat by 10 years after diagnosis.

We then examined relative survival for women with ovarian cancer who were diagnosed in 1990 after stratification by age at diagnosis and stage (Table 4). Among all stages, relative survival decreased with age and with time since diagnosis. The decrease in relative survival was more pronounced for women with advanced-stage tumors and larger between 1 and 5 years than between 5 and 10 years. For women with stage I tumors, relative survival at 1 year ranged from 0.99 (99% CI 0.94–1.00) for women aged 20–49 years to 0.91 (99% CI 0.46–0.99) for those 80 years of age or older. At 10 years, the corresponding relative survival rates were 0.91 (99% CI 0.84–0.95) and 0.69 (99% CI 0.26–0.90). For patients with stage III and IV tumors, relative survival at 1 year ranged from 0.76 (99% CI 0.67–0.82) for those aged 20–49 years to 0.34 (99% CI 0.25–0.44) for the oldest women. By 10 years, relative survival had decreased to 0.28 (99% CI 0.20–0.36) and zero for the corresponding age groups.

Figure 1 displays the cumulative relative survival for patients diagnosed in 1980, 1990, and 2000 adjusted for age, race, year of diagnosis, and time since diagnosis. The figures demonstrate improved relative survival over time. For patients with stage I tumors, the improved survival is most remarkable between 1980 and 1990 ($P<.001$). For stage III–IV malignancies, there was a notable improvement in relative survival between 1980 and 1990 as well as between 1990 and 2000 ($P<.001$). The relatively small number of black women in some stage and year of diagnosis strata limited construction of survival curves for black patients.

DISCUSSION

Our findings suggest that survival for ovarian cancer has improved over time. The improved survival was noted for early-stage and late-stage tumors. The excess risk of death associated with ovarian cancer was greater for black compared with white women, and this racial

disparity was most pronounced for stage III–IV tumors.²⁰ For women with advanced-stage tumors diagnosed in 2006, the risk of death from ovarian cancer was 7% lower than those diagnosed in 2000 and 51% lower than those women diagnosed in 1975.

Although prior work has suggested that survival may be increasing for ovarian cancer, data describing the magnitude of the stage-specific changes in survival are limited.^{21–27} The most recent data from the Annual Report on the Results of Treatment in Gynecological Cancer, which analyzed survival from a number of sources throughout the world, noted that 5-year survival for ovarian increased from 27% in 1958–1962 to 50% in 1999–2001.²² Our findings are notable in that accounting for longer life expectancy as a result of improvements in medical care, relative survival for ovarian cancer has increased by nearly 50% for all stages of the disease.

For early-stage ovarian cancer, there was an improvement in relative survival from 1975 to 1990 after which only more modest changes in survival were noted. For women with apparent ovarian-confined cancers, there has been a greater recognition of the risk of occult metastatic disease and realization of the importance of surgical staging.¹ Additionally, there has been increased use of adjuvant chemotherapy for women with early-stage disease.^{28–30}

Similarly impressive gains in relative survival have been demonstrated over the past 30 years for women with advanced-stage ovarian cancer. During this time, the importance of tumor cytoreductive surgery, either as primary treatment or after neoadjuvant chemotherapy, has been recognized.^{2,31} Likewise, adjuvant therapy for advanced-stage ovarian cancer has evolved with the introduction of platinum and taxane-based therapy, intraperitoneal delivery of chemotherapy, and, more recently, with altered scheduling of chemotherapy with dose-dense treatment.^{3,4,32} Finally, an array of cytotoxic and biologic agents is now available in the recurrent setting.^{33–35}

Although the improved survival for ovarian cancer is promising, the survival gains have been predominately realized through prolonging the life expectancy of women with recurrent ovarian cancer, not through an increased cure rate.²¹ One population-based study that examined changes in survival for a number of solid tumors noted that 80% of the improved survival in women with ovarian cancer was the result of extension of survival time of uncured patients. In contrast, over a study period spanning more than 25 years, the percentage of patients cured increased from 12% to only 14%. This is in contrast to other cancers, like colorectal, in which the cure rate increased from 29% to 47% and testicular cancer in which the cure rate has risen from 23% to 81%.²¹ The inability to increase the number of women with ovarian cancer who are cured stems in large part from the lack of an adequate screening test and surveillance strategies.^{36,37}

Although our study benefits from the inclusion of a large sample of women from throughout the United States, we recognize a number of important limitations. First, the staging criteria for ovarian cancer have changed over time. We used the historic extent of disease codes to classify women based on current staging criteria; however, we cannot exclude the possibility that some women were incorrectly classified and we were not able to capture staging data on all patients.⁹ Similarly, because SEER staging is based on pathologic staging, the increased

use of neoadjuvant chemotherapy may have resulted in some women who responded to chemotherapy being assigned to a lower stage than if they had undergone primary surgery.³⁸ Although this issue would likely not substantially affect our analysis, this is an intrinsic limitation of using SEER data. Similarly, we did not report separate analyses based on histology, which may have differed for women with early-compared with late-stage disease.

Third, greater utilization of radiologic imaging may have resulted in lead-time bias and possible stage migration. However, the majority of women present with advanced-stage disease and are treated surgically, thus blunting any potential effect from stage migration based on imaging. Imaging may have resulted in some women with advanced-stage disease present with a lower overall tumor burden; however, this is difficult to measure in any study. Despite these limitations, our data suggest that, over the past 35 years, survival for ovarian cancer has improved. Although the survival has improved, further advances are clearly needed and will require further research and improved therapeutic options.

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REFERENCES

1. Young RC, Decker DG, Wharton JT, Piver MS, Sindelar WF, Edwards BK, et al. Staging laparotomy in early ovarian cancer. *JAMA*. 1983; 250:3072–3076. [PubMed: 6358558]
2. Griffiths CT. Surgical resection of tumor bulk in the primary treatment of ovarian carcinoma. *Natl Cancer Inst Monogr*. 1975; 42:101–104. [PubMed: 1234624]
3. McGuire WP, Hoskins WJ, Brady MF, Kucera PR, Partridge EE, Look KY, et al. Cyclophosphamide and cisplatin compared with paclitaxel and cisplatin in patients with stage III and stage IV ovarian cancer. *N Engl J Med*. 1996; 334:1–6. [PubMed: 7494563]
4. Armstrong DK, Bundy B, Wenzel L, Huang HQ, Baergen R, Lele S, et al. Intraperitoneal cisplatin and paclitaxel in ovarian cancer. *N Engl J Med*. 2006; 354:34–43. [PubMed: 16394300]
5. Katsumata N, Yasuda M, Takahashi F, Isonishi S, Jobo T, Aoki D, et al. Dose-dense paclitaxel once a week in combination with carboplatin every 3 weeks for advanced ovarian cancer: a phase 3, open-label, randomised controlled trial. *Lancet*. 2009; 374:1331–1338. [PubMed: 19767092]
6. Life expectancy, United States of America. Available at: https://http://www.google.com/webhp?sourceid=chrome-instant&rlz=1C5ACMJ_enUS518US558&ion=1&espv=2&ie=UTF-8-q=life%20expectancy%20in%20the%20united%20states.
7. Yin D, Morris CR, Bates JH, German RR. Effect of misclassified underlying cause of death on survival estimates of colon and rectal cancer. *J Natl Cancer Inst*. 2011; 103:1130–1133. [PubMed: 21697545]
8. Percy C, Stanek E III, Gloeckler L. Accuracy of cancer death certificates and its effect on cancer mortality statistics. *Am J Public Health*. 1981; 71:242–250. [PubMed: 7468855]
9. Rutter CM, Johnson EA, Feuer EJ, Knudsen AB, Kuntz KM, Schrag D. Secular trends in colon and rectal cancer relative survival. *J Natl Cancer Inst*. 2013; 105:1806–1813. [PubMed: 24174654]
10. Hinchliffe SR, Rutherford MJ, Crowther MJ, Nelson CP, Lambert PC. Should relative survival be used with lung cancer data? *Br J Cancer*. 2012; 106:1854–1859. [PubMed: 22555396]
11. Schonberg MA, Marcantonio ER, Ngo L, Li D, Silliman RA, McCarthy EP. Causes of death and relative survival of older women after a breast cancer diagnosis. *J Clin Oncol*. 2011; 29:1570–1577. [PubMed: 21402602]
12. Henson DE, Ries LA. On the estimation of survival. *Semin Surg Oncol*. 1994; 10:2–6. [PubMed: 8115782]

13. 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; 10:339–352. [PubMed: 11697226]
14. [Retrieved July 28, 2014] National Cancer Institute. Surveillance, Epidemiology, and End Results (SEER) program SEER*Stat database: incidence—SEER 18 regs research data + Hurricane Katrina impacted Louisiana cases, Nov 2013 Sub (1973–2011 varying)—linked to county attributes—total U.S., 1969–2012 counties, National Cancer Institute, DCCPS, Surveillance Research Program, Surveillance Systems Branch, released April 2014 (updated 5/7/2014), based on the November 2013 submission. Available at: <http://www.seer.cancer.gov>.
15. Ederer, F.; Heise, H. Technical, end results evaluation section. Bethesda (MD): National Cancer Institute; 1959. Instructions to IBM 650 programmers in processing survival computations.
16. [Retrieved July 28, 2014] Surveillance Research Program, National Cancer Institute SEER*Stat software version 8.1.5. Available at: <http://www.seer.cancer.gov/seerstat>.
17. Estimating and modeling relative survival using SAS. Available at: http://www.pauldickman.com/survival/sas/relative_survival_using_sas.pdf.
18. Dickman PW, Sloggett A, Hills M, Hakulinen T. Regression models for relative survival. *Stat Med.* 2004; 23:51–64. [PubMed: 14695639]
19. Hakulinen T, Tenkanen L. Regression analysis of relative survival rates. *J R Stat Soc Ser C Appl Stat.* 1987; 36:309–317.
20. Terplan M, Schluterman N, McNamara EJ, Tracy JK, Temkin SM. Have racial disparities in ovarian cancer increased over time? An analysis of SEER data. *Gynecol Oncol.* 2012; 125:19–24. [PubMed: 22108636]
21. Huang L, Cronin KA, Johnson KA, Mariotto AB, Feuer EJ. Improved survival time: what can survival cure models tell us about population-based survival improvements in late-stage colorectal, ovarian, and testicular cancer? *Cancer.* 2008; 112:2289–2300. [PubMed: 18393325]
22. Heintz AP, Odicino F, Maisonneuve P, Quinn MA, Benedet JL, Creasman WT, et al. Carcinoma of the ovary. FIGO 26th Annual Report on the Results of Treatment in Gynecological Cancer. *Int J Gynaecol Obstet.* 2006; 95(suppl 1):S161–S192. [PubMed: 17161157]
23. van Altena AM, Karim-Kos HE, de Vries E, Kruitwagen RF, Massuger LF, Kiemeny LA. Trends in therapy and survival of advanced stage epithelial ovarian cancer patients in the Netherlands. *Gynecol Oncol.* 2012; 125:649–654. [PubMed: 22370602]
24. Baldwin LA, Huang B, Miller RW, Tucker T, Goodrich ST, Podzielinski I, et al. Ten-year relative survival for epithelial ovarian cancer. *Obstet Gynecol.* 2012; 120:612–618. [PubMed: 22914471]
25. Akhtar-Danesh N, Elit L, Lytwyn A. Temporal trends in the relative survival among patients diagnosed with ovarian cancer in Canada 1992–2005: a population-based study. *Gynecol Oncol.* 2011; 123:192–195. [PubMed: 21855119]
26. Akeson M, Jakobsen AM, Zetterqvist BM, Holmberg E, Brännström M, Horvath G. A population-based 5-year cohort study including all cases of epithelial ovarian cancer in western Sweden: 10-year survival and prognostic factors. *Int J Gynecol Cancer.* 2009; 19:116–123. [PubMed: 19258952]
27. Hannibal CG, Cortes R, Engholm G, Kjaer SK. Survival of ovarian cancer patients in Denmark: excess mortality risk analysis of five-year relative survival in the period 1978–2002. *Acta Obstet Gynecol Scand.* 2008; 87:1353–1360. [PubMed: 18951210]
28. Colombo N, Guthrie D, Chiari S, Parmar M, Qian W, Swart AM, et al. International Collaborative Ovarian Neoplasm trial 1: a randomized trial of adjuvant chemotherapy in women with early-stage ovarian cancer. *J Natl Cancer Inst.* 2003; 95:125–132. [PubMed: 12529345]
29. Trimbos JB, Vergote I, Bolis G, Vermorken JB, Mangioni C, Madronal C, et al. Impact of adjuvant chemotherapy and surgical staging in early-stage ovarian carcinoma: European Organisation for Research and Treatment of Cancer-Adjuvant ChemoTherapy in Ovarian Neoplasm trial. *J Natl Cancer Inst.* 2003; 95:113–125. [PubMed: 12529344]
30. Young RC, Walton LA, Ellenberg SS, Homesley HD, Wilbanks GD, Decker DG, et al. Adjuvant therapy in stage I and stage II epithelial ovarian cancer. Results of two prospective randomized trials. *N Engl J Med.* 1990; 322:1021–1027. [PubMed: 2181310]

31. Vergote I, Tropé CG, Amant F, Kristensen GB, Ehlen T, Johnson N, et al. Neoadjuvant chemotherapy or primary surgery in stage IIIC or IV ovarian cancer. *N Engl J Med*. 2010; 363:943–953. [PubMed: 20818904]
32. Katsumata N, Yasuda M, Isonishi S, Takahashi F, Michimae H, Kimura E, et al. Long-term results of dose-dense paclitaxel and carboplatin versus conventional paclitaxel and carboplatin for treatment of advanced epithelial ovarian, fallopian tube, or primary peritoneal cancer (JGOG 3016): a randomised, controlled, open-label trial. *Lancet Oncol*. 2013; 14:1020–1026. [PubMed: 23948349]
33. Gordon AN, Fleagle JT, Guthrie D, Parkin DE, Gore ME, Lacave AJ. Recurrent epithelial ovarian carcinoma: a randomized phase III study of pegylated liposomal doxorubicin versus topotecan. *J Clin Oncol*. 2001; 19:3312–3322. [PubMed: 11454878]
34. Parmar MK, Ledermann JA, Colombo N, du Bois A, Delaloye JF, Kristensen GB, et al. Paclitaxel plus platinum-based chemotherapy versus conventional platinum-based chemotherapy in women with relapsed ovarian cancer: the ICON4/AGO-OVAR-2.2 trial. *Lancet*. 2003; 361:2099–2106. [PubMed: 12826431]
35. Pujade-Lauraine E, Hilpert F, Weber B, Reuss A, Poveda A, Kristensen G, et al. Bevacizumab combined with chemotherapy for platinum-resistant recurrent ovarian cancer: the AURELIA open-label randomized phase III trial. *J Clin Oncol*. 2014; 32:1302–1308. [PubMed: 24637997]
36. Buys SS, Partridge E, Black A, Johnson CC, Lamerato L, Isaacs C, et al. Effect of screening on ovarian cancer mortality: the Prostate, Lung, Colorectal and Ovarian (PLCO) Cancer Screening Randomized Controlled Trial. *JAMA*. 2011; 305:2295–2303. [PubMed: 21642681]
37. Menon U, Gentry-Maharaj A, Hallett R, Ryan A, Burnell M, Sharma A, et al. Sensitivity and specificity of multimodal and ultrasound screening for ovarian cancer, and stage distribution of detected cancers: results of the prevalence screen of the UK Collaborative Trial of Ovarian Cancer Screening (UKCTOCS). *Lancet Oncol*. 2009; 10:327–340. [PubMed: 19282241]
38. Wright JD, Ananth CV, Tsui J, Glied SA, Burke WM, Lu YS, et al. Comparative effectiveness of upfront treatment strategies in elderly women with ovarian cancer. *Cancer*. 2014; 120:1246–1254. [PubMed: 24443159]

Fig. 1. Cumulative relative survival among white women aged 50–59 years diagnosed with ovarian cancer in 1980 (solid black lines), 1990 (dashed red lines), and 2000 (dotted blue lines) based on models adjusted for age, race, year of diagnosis, and time since diagnosis. Stage I (A); Stages II–IV (B).

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Table 1

Characteristics of Patients With Ovarian Cancer Reported to the Surveillance, Epidemiology, and End Results Registry, 1975–2011, Stratified by Stage

Characteristic	Stage I	Stage II	Stage III–IV
No. of patients	11,836 (23.7)	3,444 (6.9)	34,652 (69.4)
Age at diagnosis (y)			
Younger than 20	388 (3.3)	46 (1.3)	194 (0.6)
20–49	4,340 (36.7)	773 (22.4)	5,130 (14.8)
50–59	2,830 (23.9)	833 (24.2)	7,125 (20.6)
60–69	2,162 (18.3)	767 (22.3)	9,272 (26.8)
70–79	1,409 (11.9)	636 (18.5)	8,214 (23.7)
80 or older	707 (6.0)	389 (11.3)	4,717 (13.6)
Race			
Black	800 (6.8)	262 (7.6)	2,519 (7.3)
White	11,036 (93.2)	3,182 (92.4)	32,133 (92.7)
Year of diagnosis *			
1975–1980	1,826 (15.4)	249 (7.2)	5,103 (14.7)
1981–1986	1,985 (16.8)	351 (10.2)	5,809 (16.8)
1987–1992	1,989 (16.8)	595 (17.3)	5,733 (16.5)
1993–1998	1,982 (16.8)	671 (19.5)	5,586 (16.1)
2009–2004	1,836 (15.5)	745 (21.6)	5,920 (17.1)
2005–2011	2,218 (18.7)	833 (24.2)	6,501 (18.8)

Data are n (%).

* Year of diagnosis is broken down to 6-year periods.

Table 2

Stage-Specific Excess Hazard Ratios for Death Among Patients Diagnosed With Ovarian Cancer*

Characteristic	Stage I	Stage II	Stage III–IV
Black, relative to white	1.12 (0.91–1.38)	1.29 (1.05–1.58)	1.27 (1.17–1.37)
Age at diagnosis (y)			
Younger than 20 relative to 50–59	—	0.16 (0.06–0.42)	—
20–49 relative to 50–59	—	0.72 (0.62–0.85)	—
60–69 relative to 50–59	—	1.18 (1.01–1.38)	—
70–79 relative to 50–59	—	1.91 (1.63–2.23)	—
80 or older relative to 50–59	—	2.90 (2.37–3.55)	—
Year of diagnosis			
2006 relative to 2000	0.85 (0.70–1.03)	0.70 (0.59–0.83)	0.93 (0.87–0.99)
2006 relative to 1995	0.87 (0.75–1.03)	0.67 (0.58–0.77)	0.82 (0.77–0.87)
2006 relative to 1990	0.90 (0.75–1.09)	0.64 (0.54–0.76)	0.72 (0.67–0.77)
2006 relative to 1985	0.79 (0.67–0.92)	0.68 (0.58–0.79)	0.69 (0.65–0.73)
2006 relative to 1980	0.69 (0.57–0.83)	0.72 (0.57–0.91)	0.66 (0.61–0.71)
2006 relative to 1975	0.51 (0.41–0.63)	0.57 (0.42–0.78)	0.49 (0.44–0.55)

Data are hazard ratio (95% confidence interval).

Bold indicates $P < .05$.

* Estimates are based on models that adjust for race, age, year of diagnosis, and year since diagnosis. Interactions between age and year since diagnosis are included for stage I and stage III–IV.

Table 3

Excess Hazard Ratios for Death Among Patients Diagnosed With Ovarian Cancer for Stage I and Stage III–IV as a Function of Age at Diagnosis by Year Since Diagnosis Adjusting for Race, Age, Year of Diagnosis, and Year Since Diagnosis

Age Group	Stage I	Stage III–IV
1-y excess HR		
Age at diagnosis (y)		
Younger than 20 relative to 50–59	0.37 (0.15–0.92)	0.34 (0.18–0.63)
20–49 relative to 50–59	0.73 (0.55–0.96)	0.74 (0.66–0.82)
60–69 relative to 50–59	1.02 (0.73–1.43)	1.31 (1.20–1.43)
70–79 relative to 50–59	1.34 (0.91–1.96)	1.80 (1.65–1.97)
80 or older relative to 50–59	3.41 (2.33–5.01)	2.71 (2.45–2.98)
5-y excess HR		
Age at diagnosis (y)		
Younger than 20 relative to 50–59	0.08 (0.01–0.78)	—*
20–49 relative to 50–59	0.43 (0.20–0.94)	0.58 (0.37–0.91)
60–69 relative to 50–59	1.09 (0.44–2.67)	1.23 (0.83–1.82)
70–79 relative to 50–59	1.03 (0.28–3.72)	2.75 (1.78–4.27)
80 or older relative to 50–59	—*	6.40 (2.90–14.14)
10-y excess HR		
Age at diagnosis (y)		
Younger than 20 relative to 50–59	1.10 (0.04–27.31)	—*
20–49 relative to 50–59	1.74 (0.81–3.71)	0.91 (0.50–1.62)
60–69 relative to 50–59	0.57 (0.23–1.40)	1.91 (1.07–3.39)
70–79 relative to 50–59	1.22 (0.22–6.72)	0.72 (0.29–1.80)
80 or older relative to 50–59	—*	0.87 (0.05–14.48)

HR, hazard ratio.

Data are HR (95% confidence interval).

Bold indicates $P < .05$.

* Estimates are not computed as a result of the small number of deaths in each 1-year interval.

Table 4

Cumulative Observed Relative Survival and 99% Confidence Interval for White Women Diagnosed With Ovarian Cancer in 1990

Age at Diagnosis (y)	Years Since Diagnosis	Stage I		Stage II		Stage III-IV	
		Observed Survival	Relative Survival	Observed Survival	Relative Survival	Observed Survival	Relative Survival
Younger than 20	1	1.00 (— [*])	1.00 [†] (— [*])	1.00 (— [*])	1.00 [†] (— [*])	1.00 (— [*])	1.00 [†] (— [*])
	5	1.00 (— [*])	1.00 [†] (— [*])	1.00 (— [*])	1.00 [†] (— [*])	1.00 (— [*])	1.00 [†] (— [*])
	10	1.00 (— [*])	1.00 [†] (— [*])	1.00 (— [*])	1.00 [†] (— [*])	0.67 (0.00–0.97)	0.67 (0.00–0.97)
20–49	1	0.99 (0.90–1.00)	0.99 (0.87–1.00)	0.93 (0.65–0.99)	0.94 (0.65–0.99)	0.75 (0.63–0.84)	0.76 (0.64–0.84)
	5	0.92 (0.83–0.97)	0.93 (0.83–0.97)	0.87 (0.60–0.96)	0.87 (0.59–0.96)	0.37 (0.26–0.49)	0.38 (0.26–0.49)
	10	0.90 (0.80–0.95)	0.91 (0.80–0.96)	0.83 (0.56–0.94)	0.85 (0.56–0.95)	0.27 (0.17–0.38)	0.28 (0.18–0.39)
50–59	1	0.96 (0.79–0.99)	0.97 (0.77–1.00)	0.88 (0.55–0.97)	0.88 (0.55–0.97)	0.79 (0.69–0.86)	0.80 (0.69–0.87)
	5	0.89 (0.71–0.96)	0.91 (0.70–0.97)	0.67 (0.36–0.85)	0.68 (0.36–0.86)	0.30 (0.21–0.40)	0.31 (0.21–0.41)
	10	0.79 (0.60–0.90)	0.85 (0.61–0.95)	0.50 (0.23–0.72)	0.54 (0.24–0.77)	0.16 (0.09–0.25)	0.18 (0.10–0.27)
60–69	1	0.99 (0.82–1.00)	0.99 (0.62–1.00)	0.76 (0.42–0.92)	0.77 (0.42–0.93)	0.70 (0.62–0.77)	0.71 (0.63–0.78)
	5	0.88 (0.73–0.95)	0.94 (0.66–0.99)	0.57 (0.26–0.79)	0.61 (0.27–0.83)	0.22 (0.16–0.29)	0.23 (0.17–0.31)
	10	0.76 (0.59–0.87)	0.89 (0.58–0.98)	0.43 (0.16–0.67)	0.49 (0.17–0.76)	0.12 (0.07–0.18)	0.15 (0.09–0.21)
70–79	1	0.93 (0.76–0.98)	0.95 (0.69–0.99)	0.67 (0.38–0.84)	0.69 (0.39–0.86)	0.49 (0.41–0.57)	0.51 (0.42–0.59)
	5	0.67 (0.48–0.81)	0.77 (0.53–0.90)	0.44 (0.20–0.66)	0.51 (0.22–0.74)	0.11 (0.07–0.17)	0.14 (0.08–0.20)
	10	0.49 (0.31–0.65)	0.74 (0.42–0.90)	0.19 (0.04–0.40)	0.29 (0.06–0.58)	0.06 (0.03–0.11)	0.09 (0.04–0.16)
80 or older	1	0.84 (0.47–0.96)	0.91 (0.22–1.00)	0.15 (0.01–0.47)	0.17 (0.01–0.49)	0.31 (0.20–0.43)	0.34 (0.22–0.47)
	5	0.47 (0.18–0.72)	0.69 (0.14–0.93)	0.08 (0.00–0.38)	0.11 (0.00–0.48)	0.02 (0.00–0.08)	0.03 (0.00–0.12)
	10	0.21 (0.04–0.47)	0.69 (0.14–0.93)	0.08 (0.00–0.38)	0.11 (0.00–0.48)	0.00 (— [*])	0.00 (— [*])

* The statistic could not be calculated.

[†] The cumulative relative survival is greater than 1.00 and has been adjusted.