MORTALITY RATES DUE TO GYNECOLOGIC CANCERS IN NEW YORK STATE BY DEMOGRAPHIC FACTORS AND PROXIMITY TO A GYNECOLOGIC ONCOLOGY GROUP MEMBER TREATMENT CENTER: 1979-2001

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ABSTRACT

Objective: To describe trends in mortality rates, in New York State, due to cervical, endometrial and ovarian cancer and to assess how these rates varied with proximity to a comprehensive cancer treatment center or population density (rural/urban).

Methods: Data were obtained from the Centers for Disease Control and Prevention (CDC)'s Compressed Mortality Files, Census Bureau records, and online maps. Poisson regression models were fitted to estimate death rates (mean number of deaths per 100,000 women per year) due to gynecologic cancer type. Trends in death rates were compared with respect to driving time to the nearest comprehensive cancer treatment center and population density, controlling for race, county income level, and age at death.

Results: Cervical and endometrial but not ovarian death rates declined over time. For both cervical and endometrial cancers, death rates varied significantly with driving time and between rural and urban counties. In the case of cervical cancer, the decline over time was steeper in rural than in urban counties. For endometrial cancer, the decline steepened with increasing distance from a treatment center.

Conclusion: Improvements in cervical and endometrial cancer mortality from 1979-2001 followed increases in gynecologic cancer treatment research efforts, number of specialists trained to treat such cases, and in the emphasis on gynecologic cancer in the training of physicians in general. Our results are consistent with an interpretation that the progressive actions by leaders in the gynecologic oncology profession during the late 1960's and early 1970's contributed to improvements in mortality rates in subsequent decades.

INTRODUCTION

An effort in the obstetrics and gynecology discipline to develop the sub-specialty of gynecologic oncology and to train specialists in this area began in the mid to late 1960's. In January of 1969, the Society of Gynecologic Oncologists (SGO) was formally created. A goal of the SGO was to promote the training and certification of specialists in gynecologic malignancy[1].

In June of 1972, the American Board of Obstetrics and Gynecology established a specialty Division in Gynecologic Oncology. Authorization to certify for special qualification in this field was approved by the American Board of Medical Specialties in March 1973. The first examination was given in 1974[2]. The objectives of the Division of Gynecologic Oncology included: (a) elevating the standards of education and training; (b) enhancing the recruitment of qualified physicians; and (c) increasing knowledge and thereby improving treatment of women with gynecologic cancers. As of 1979, there were 161 specialists certified in the U.S. In New York State there were 25 certified, 20 of who lived in greater New York City, three in Buffalo, one in Poughkeepsie, and one in Bayside[2]. As of 2001, there were 662 certified gynecologic oncologists in the U.S. Today there are over 1000 members of the SGO, 111 with mailing addresses in New York State and 23 different towns represented[1].

Presumably, these successes in developing the field of gynecologic oncology were accompanied by corresponding increases in emphasis of the specialty in the training of all physicians. Similar developments occurred in the fields of medical and radiation oncology, and there was an increase of all physicians trained in the U.S. from 8,000 new MDs a year in 1960 to 15,000 in 2000[3].

Research and development of new treatments also increased dramatically during this period. For example, the Gynecologic Oncology Group was found in April of 1970. There were

11 original member institutions[4, 5]. The goal of the GOG was "to accelerate progress made in gynecologic oncology"[5]. In New York State, the number of member institutions grew from one (Roswell Park Cancer Institute) in 1970 to 14 current or former members/affiliates in 2006.

These developments increased accessibility to well trained physicians who provide primary, secondary, or tertiary care to patients with gynecologic cancer and to improved treatment/diagnosis. The purpose of this paper is to investigate whether gynecologic cancer mortality rates declined in association to these developments.

METHODS

Data Sources

The "Compressed Mortality File" (CMF) was obtained from the Centers for Disease Control and Prevention (CDC). The CMF is comprised of a county-level mortality file and a county-level population file for all U.S. counties, containing death counts by underlying cause of death, state, county, age category, race, sex, and year. National, state, and county population estimates on the CMF are U.S. Census Bureau estimates of the resident population[6]. We used the New York State portion of the Compressed Mortality File for this study.

Median income for each county in New York State in 2004 was obtained from Census Bureau reports. A list of GOG affiliated cancer treatment centers during the study period was obtained from the GOG Statistics and Data Center. Driving time from each county seat to the nearest county seat of counties with treatment centers was calculated from online maps.

Definitions of Variables

A Population Density/Treatment Center variable (L) categorizes counties by population density level and an indicator of whether the county had a comprehensive cancer treatment center. The cancer treatment centers were located only in highest density counties. Levels of L are defined as < 200, between 200 and 400, > 400 population per square mile without a cancer treatment center, and > 400 population per square mile with a cancer treatment center.

Year (t) indexes years from 1979 through 2001 (t = 0, 1, 2, …, 22)

Race (R) has three categories (White, Black and Other).

Age category (A) defines age groups at any given point in time and, given year, can be interpreted as birth cohort category. We defined age categories that varied with cancer site

because of varying age distributions of deaths due to the three types of cancer studied. The age categories by the three cancer types can be found as Table S1 in the supplementary section.

The CDC CMF grouped deaths by age at death category, where age at death was defined by the age at last birthday prior to death. The Census Bureau groups U.S. residents by age in completed years at the time of the survey.

Driving Time (DT) was calculated as driving hours from the resident's county seat in New York State to the nearest cancer treatment center's county seat, as reported by Mapquest.com. Table S2 contains a list of the 17 GOG cancer treatment centers included in the study. These included all major comprehensive cancer centers in the State of New York and three in neighboring states. All of the 17 centers were in operation during the entire study period, with the exception that the center in Suffolk County began operations in 1980.

Income (I) was defined as county Median Household Income in 2004 for each county.

Number of Deaths (D) is the number of deaths for each cancer type (cervical, endometrial, or ovarian) by county, age category, race, and year.

Only deaths of U.S. residents occurring in the United States were included in the CMF and were reported by county of residence at the time of death.

The cause-of-death variable is the underlying cause-of-death, which is defined by the WHO as "the disease or injury which initiated the train of events leading directly to death, or the circumstances of the accident or violence which produced the fatal injury". Underlying cause of death was determined from ICD-9 (1979-1998) or ICD-10 (1999-2001) codes. ICD-9 codes of 180.0-180.9 and ICD-10 codes of C53.0-C53.9 were classified as cervical cancer deaths. ICD-9 and ICD-10 codes for endometrial cancers were 182.0 and C54.1, respectively. Ovarian cancer codes were 183.0 and C56, respectively.

Pop is the (number of females by county, age category, race, and year.

Population Descriptions

Population descriptions are presented in Table 1.

It should be noted that county rank with respect to median income was strongly consistent over time (Spearman's r = 0.94 between 1989 and 2004).

Statistical Methods

The primary purpose of this paper was to test the null hypotheses that there is no association between proximity of counties to a GOG cancer center, or population density, and each gynecologic cancer mortality rate; controlling for year, age category, race, median household income. The alternative hypotheses to be tested were that mortality rates increased with increasing distance from a treatment center and decreased with increasing population density.

The secondary objectives were to describe longitudinal trends in New York State mortality rates due to endometrial, cervical, and ovarian cancers during the years 1979-2001 by age category, race, median county income, population density, and proximity to a Gynecologic Oncology Group Member Treatment Center and to assess whether population density or proximity effects diminished with time.

To achieve these objectives we fit Poisson regression models[7] for the following three response variables: numbers of deaths due to cervical, endometrial, and ovarian cancer. The explanatory variables in these models were Population Density/Treatment Center (L), Race (R), Age category (A), Driving Time (DT), county median Income (I), and Year (t). Population size (Pop) was used as an "offset variable". See the Appendix for specifics of our model specifications.

153 *Post-hoc* descriptions of significant results from fitting the final models specified were
154 obtained using standardized risk estimates (SR) proposed by Kim, et al (2006)[8]. See Appendix
155 for details of an example calculation and interpretation of standardized risks. Standardized Death
156 Rates were calculated for each level of each significant factor. Differences among standardized
157 risks, called standardized attributable rates (SARs) by Kim, et al, provide comparisons of levels
158 of the factor adjusted for other factors in the model.

159

RESULTS

Table A1 presents the significant effects for each cancer type. See Table A2 of the Appendix for a mathematical description of the fitted models.

Post-Hoc Descriptions of Significant Effects

Post-hoc descriptions of significant effects are presented below by cancer type in the form of standardized death rates per 100,000 women per year. Differences in standardized rates among levels can be calculated to obtain SARs.

Cervical Cancer

Main effects of driving time and median household income are illustrated in Figures 1 and S1, respectively.

Death rate increased with driving time to the nearest comprehensive cancer treatment center. The relationship was nearly linear with an increase of about one death per 100,000 women for a two-hour difference in driving time (P=0.0046).

Death Rate decreased with increased county median income (P<0.0001). The relationship was approximately linear with one excess death associated with each difference of $35,000 median income between two counties.

Significant interaction effects, Population Density/Treatment Center by year, Race by year, and Age by year, are illustrated in Figures 2, S2 and S3. Cervical cancer death rates declined from 1979 through 2001 (P<0.0001). The decline was steeper in less densely populated counties (≤ 400 people per square mile) than in densely populated counties (> 400 people per square mile) (P<0.0001). In 1979, rural counties had an excess of about 1.5 deaths per 100,000 women when compared with urban counties. By 2001, however, the less densely populated counties had lower rates than the urban counties by about one death per 100,000 women.

Blacks had a much higher death rate due to cervical cancer in 1979 than whites or others (7-8 deaths more per 100,000 women per year). There was a closure to about three deaths per 100,000 women per year in 2001, a dramatic improvement although still unacceptable. The disparity between blacks and whites, remained significant in 2001 ($P<0.0001$, Relative Risk=1.79, $SR_{black}=5.57$, $SR_{white}=3.10$).

Cervical Cancer death rates were ordered as expected by age category (i.e., increased rate with increased age) ($P<0.0001$). The disparity between older (≥ 55 years) and younger (< 55 years) diminished over time, with the most notable improvement occurring in women 85 years old or older.

Endometrial Cancer

Main effects of Race ($P<0.0001$) were observed and are presented in Table S3. Differences did not change significantly over time from 1979 through 2001. Similarly, there were differences among counties of varying population densities ($P<0.0001$). See Table 2.

Endometrial cancer death rates declined over time. The decline was moderated by driving time ($P<0.0001$) and income ($P=0.0003$). The moderating effects are illustrated in Figures 3 and S4.

Compared to counties with a comprehensive cancer treatment center (i.e., driving time = 0), counties that were one hour driving time away had an excess of about one death per 100,000 women per year in 1979. The excess was about 2.3 deaths in counties with a two-hour driving time. By 1990, these disparities no longer existed. A reversal of more moderate magnitude appeared to have occurred by 2001.

In 1979, there was a notable increase in endometrial cancer death rates with median household income. A county with median income of $64,000/year, for example, had an excess

number of deaths of about 3/100,000 women/year when compared with a county with median income of $20,000/year. The income effect vanished over time.

Ovarian Cancer

Main effects of Population Density/Treatment Center (P=0.0047), Race (P<0.0001), and Income (P<0.0001) were observed for ovarian cancer. The standardized death rates for population density treatment center categories are presented in Table 3. The standardized death rates by race are presented in Table S4. The main effect of income is illustrated in Figure S5.

Mortality rates due to ovarian cancer were greater among women who resided in higher income counties. The relationship was nearly linear with about 1.4 excess deaths associated with a difference of $40,000 median income.

In contrast to the sharp declines in mortality rates due to cervical and endometrial cancer, ovarian cancer death rates remained relatively constant over time. (See figure S6).

DISCUSSION

Cervical and endometrial cancer mortality rates generally declined during the study period (Figures 2 and 3). Improving rates occurred presumably in association with an increasing accessibility to well trained physicians who provide primary, secondary, or tertiary care to patients with gynecologic cancer and increasing levels of research on the prevention and treatment of gynecologic cancers. As the deployment of well trained physicians and increased educational and research efforts played out over time, one would expect improving diagnoses due to improving attitudes toward health care, in general, and Pap smears in particular; and increased use of DNC treatment, education, and health habits (e.g., smoking cessation and more frequent and regular check ups). Increasingly liberal use of hysterectomy as a treatment also may have occurred. The net effect apparently was a steady decline in mortality rates, particularly for cervical and endometrial cancer, in spite of increasing prevalence of several risk factors (obesity, hormone replacement therapy, and perhaps exposure to environmental risks in some areas).

In contrast to endometrial and cervical cancer, ovarian cancer mortality rates declined less in our study (Figure S6). In fact, ovarian cancer death rates increased slightly in the two oldest age groups. It is interesting that the percentage change in ovarian cancer mortality rates nationwide from 1979-2001 was -3% compared with -41% and -16% for cervical and endometrial cancer, respectively[9]. Similarly, incidence rates dropped less for ovarian cancer, 6%, than for cervical and endometrial cancer, 38% and 10%, respectively[9]. These discrepancies would be expected if our conjecture about the underlying cause of the decline in cervical and endometrial rates is correct (i.e. increasing accessibility to physicians with specific expertise in gynecologic oncology). Cervical and endometrial cancers are more readily diagnosed in early

stages and are more effectively treatable with less aggressive treatments once diagnosed. Ovarian cancer is a disease in which best outcomes are associated with aggressive operation and aggressive chemotherapy. Perhaps accessibility to specialists who can most effectively provide more aggressive treatments for ovarian cancer has not improved much over the 23 period of this study compared with the improvements in accessibility to effective preventive care and treatment for cervical or endometrial cancer. This interpretation is supported by the fact that improvement in ovarian cancer mortality was not greater than the improvement in incidence, while the changes in cervical and endometrial cancer mortality and incidence indicate greater improvement in mortality rates (-41% and -16%, respectively) than in incidence rates (-38% and -10%, respectively)[9].

A new finding of the current study was that cervical cancer mortality rates (Figure 1) and endometrial rates during the early years (Figure 3) increased with increasing distance from a comprehensive cancer treatment center, even when controlling for population density. The effect of distance on cervical rates did not change significantly over time (Figure 1), while this effect on endometrial mortality diminished significantly with time (Figure 3). A similar interaction effect of population density with time was observed for cervical cancer. It is possible that the effects of driving time are confounded with those of population density level and that these interactions, along with the observed main effects of driving time and population density, respectively, could be manifestations of the same phenomenon: *i.e.*, improving care in previously less well served populations.

The association of endometrial cancer mortality with driving time to the nearest cancer treatment center disappeared by 1990 and even reversed, moderately, by 2001. Cancer treatment centers in New York State are located in highly populated areas. Endometrial cancer incidence is

associated with social, dietary, and environmental factors with effects that may have become manifest over time as an equalization of accessibility to care was achieved. Since the treatment for many patients with endometrial cancer is not very complex, this improvement may reflect better distribution of general gynecologic care and earlier diagnosis and intervention associated with improved education and training of physicians in gynecologic oncology. In support of this conjecture, it is interesting to note that endometrial cancer mortality rates declined by 16% nationwide from 1979 to 2001, while incidence rates nationwide declined less, by 10% [9]. The discrepancy (16%-10% = 6%) suggests that the improvement in endometrial cancer mortality rates observed over time in this study may have been related more to improving and earlier diagnosis and treatment than to improving prevention.

It is interesting to note in Figure 2 that less densely populated counties (≤ 400 people per square mile) had higher cervical cancer mortality rates in 1979 before the full impact of efforts to increase the numbers and expertise of physicians accessible to diagnose and treat cervical cancer. In contrast, the lower density counties had lower rates in 2001. It is possible that there exists an effect of population density in cervical cancer mortality/incidence that is related to environmental or social factors and that became manifest only after an equalization of access to the highest quality of care/surveillance. Greater improvement in smaller communities may have been the result of increased Pap smear screening resulting from improved access to family practitioners, internists and gynecologists who were well trained to diagnose and to promote prevention of gynecologic cancers or from more rapidly changing attitudes about Pap smears in rural counties.

Strong efforts during the late 1960’s and early 1970's to create the SGO, to develop the sub-specialty of gynecologic oncology in order to increase the quantity and quality of physicians

to treat gynecologic cancers, and to increase research efforts have had a positive impact, especially in more rural areas. The development of the discipline of gynecologic oncology (including the SGO, the ABOG division, and the GOG) was followed by quantitative and qualitative improvement in general gynecologic care and better distribution of such care over the 23 years of this study. These improvements presumably contributed, in whole or in part, to the improving mortality rates due to cervical and endometrial malignancies observed in this study.

CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest.

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Table 1 Distributions of Populations and of Deaths due to Cervical, Endometrial and Ovarian Cancer (Year 2001)

	Population Size		Cervical Cancer		Endometrial Cancer		Ovarian Cancer	
	Number	Percent	# of Deaths	% of Deaths	# of Deaths	% of Deaths	# of Deaths	% of Deaths
Age Distributions								
Under 1 Year	125082	1.27						
1-4 years	472337	4.78						
5-9 years	638164	6.46						
10-14 years	655042	6.63						
15-19 years	621870	6.3					1	0.1
20-24 years	631424	6.39					2	0.2
25-34 years	1382106	13.99	8	2.8			9	0.89
35-44 years	1571028	15.91	45	15.73	3	1.33	35	3.48
45-54 years	1365679	13.83	62	21.68	10	4.44	103	10.23
55-64 years	936962	9.49	56	19.58	42	18.67	188	18.67
65-74 years	705740	7.15	40	13.99	72	32	266	26.42
75-84 years	538430	5.45	50	17.48	62	27.56	277	27.51
85+ years	232802	2.36	25	8.74	36	16	126	12.51
Race Distributions								
Black	1867967	18.91	73	25.52	47	20.89	113	11.22
Other	675960	6.84	15	5.24	3	1.33	14	1.39
White	7332739	74.24	198	69.23	175	77.78	880	87.39
County Population Density Distributions								
Level 1	1373079	13.9	46	16.08	32	14.22	164	16.29
Level 2	522683	5.29	10	3.5	11	4.89	67	6.65
Level 3	3154596	31.94	87	30.42	70	31.11	299	29.69
Level 4	4826308	48.87	143	50	112	49.78	477	47.37
Continuous Variables								
Income ($) *			Median = 39,236 **			IQR = 8,308		
Driving Time (Hours) *			Median = 0.925			IQR = 0.69		

* A statistics in these rows describe the population of counties, while those in other rows describe populations of people.

** Median household income in 2004.

Table 2 Main effects of Population Density/Treatment Center for Endometrial Cancer

Comparison Category	Reference Category	Relative Risk	P-value	SR for Comparison Category in 2001
Level 1	Level 2	1.02	0.7833	10.96
	Level 3	1.30	<0.0001	
	Level 4	1.19	0.0163	
Level 2	Level 3	1.28	<0.0001	10.79
	Level 4	1.17	0.0496	
Level 3	Level 4	0.91	0.0215	8.41
Level 4	-	-	-	9.24

363 **Table 3 Main effects of Population Density/Treatment Center for Ovarian Cancer**
364

Comparison Category	Reference Category	Relative Risk	P-value	SR for Comparison Category in 2001
Level 1	Level 2	0.97	0.3816	10.68
	Level 3	1.06	0.0057	
	Level 4	1.04	0.0545	
Level 2	Level 3	1.09	0.0039	10.99
	Level 4	1.07	0.0213	
Level 3	Level 4	0.98	0.2004	10.08
Level 4	-	-	-	10.28

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Figure 1: Standardized Death Rate (per 100,000 women per year) due to Cervical Cancer by Driving Time to Nearest Comprehensive Cancer Treatment Center.

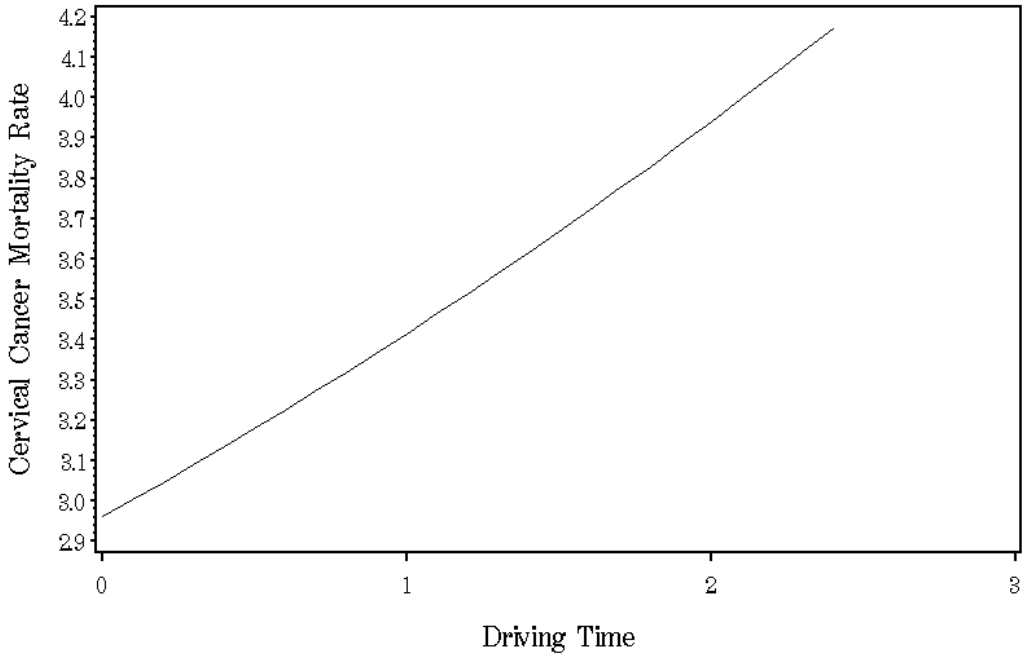


Figure 2: Standardized Death Rate (per 100,000 women per year) due to Cervical Cancer by year, by County Population Density/Treatment Center Level.

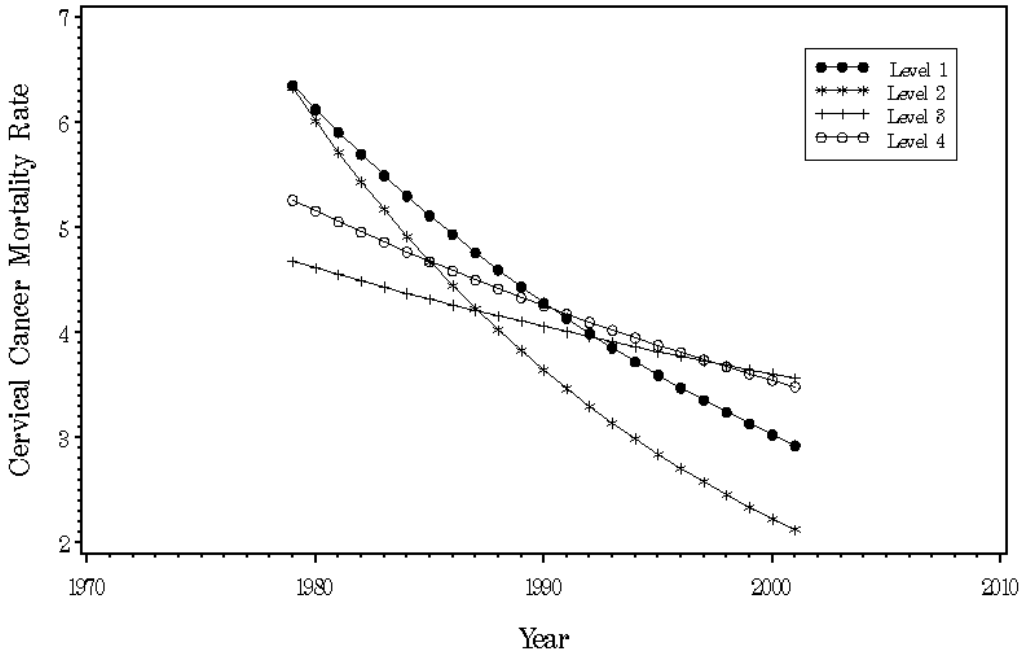
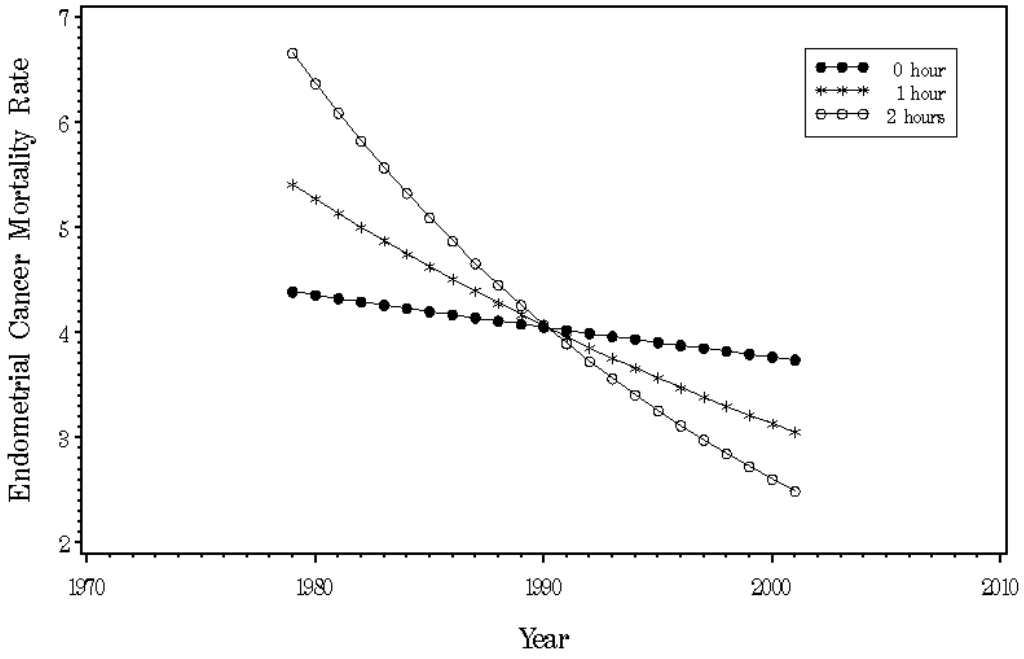


Figure 3: Standardized Death Rate (per 100,000 women per year) due to Endometrial Cancer by year, by Driving Time.



Appendix

Model Specification

Assuming that deaths occur according to a piecewise Poisson Process with a per person per year death rate λ_t in the t^{th} year, we have that the number of deaths in the t^{th} year has a Poisson distribution with mean $\mu(t) = \lambda(t)P_t$, where P_t represents population size in year t. We shall model the Poisson distribution parameters, λ_t, as a log-linear function of covariates (e.g., County Population Density/Treatment Center Level, Race, Age, Driving Time, Income and Year). The log link is the canonical link for a Poisson generalized linear model and is the link chosen here.

Initially a model with main effects and two-way interactions, involving year was fitted. Let D_{ijkct} be the number of deaths among women in the c^{th} county in the i^{th} county population density/treatment center level, j^{th} race, and k^{th} age category, in the t^{th} year. Further, let K denote the number of age categories (note: K will be specific to cancer site).

The initial model specification was:

$$\begin{aligned} D_{ijkct} &= \exp\{(\log(P_{ijkct}) + \beta_0 + \beta_1 DT_c + \beta_2 I_c + \beta_3 L_{jk1} + \beta_4 L_{jk2} + \beta_5 L_{jk3} + \beta_6 R_{ik1} \\ &\quad + \beta_7 R_{ik2} + \alpha_1 A_{ij1} + \ldots\ldots + \alpha_K A_{ijK} + (\beta_8 + \beta_9 DT_c + \beta_{10} I_c + \beta_{11} L_{jk1} + \beta_{12} L_{jk2} \\ &\quad + \beta_{13} L_{jk3} + \beta_{14} R_{ik1} + \beta_{15} R_{ik2}) \times t\} + \varepsilon_{ijkct} \\ &= P_{ijkct} \times \exp(lp_{ijkt}) + \varepsilon_{ijkct} \\ &= P_{ijkct} \times R_{ijkt} + \varepsilon_{ijkct} \end{aligned}$$

Where R_{ijkt} is the expected/smoothed death rate (per person per year) in a county in the $(i, j, k)^{th}$ stratum at time t.

A backward selection strategy was used to obtain a more parsimonious model on which to base inferences. The strategy is summarized as follows:

1. Identify the effect with the largest P-value greater than 0.05 that is not contained in significant higher order interactions, and delete it from the model;
2. Fit the new model and identify the next effect to delete as in (1);
3. Continue until no effects can be deleted from the model.

The resulting model was fitted and used for inferences. A summary of significant effects in the resulting models is given in Table A1. The resulting model fits are presented in Table A2.

Post-hoc Descriptions of Significant Results

Suppose, for example, we want to illustrate the driving time by year interaction, effect on endometrial cancer mortality rates, controlling for county population density/treatment center level, race, and age. Let $W_{ijkt_0} = \frac{P_{ijkt_0}}{P_{...t_0}}$, where $P_{...t_0}$ is the number of women in New York State in year 1979. Then, for driving time DT and year t, the standardized risk is defined by $SR_{DT} = \sum \hat{R}_{ijkt} W_{ijkt_0}$, where $\hat{R}_{ijkt}$ is the predicted value, *i.e.* $\hat{D}_{ijkct} / P_{ijkt}$, given driving time DT and year t, where $\hat{D}_{ijkct}$ is the exponential of the estimated value of the linear predictor, lp_{ijkt}, given a average driving time of 0.92 hour and a average income of $42,538. Standardized rates are reported throughout as deaths per 100,000 women per year.

Table A1 Significant Effect P-values

Factor	Cancer Type		
	Cervical	Endometrial	Ovarian
Population Density/Treatment Center (L)	<.0001	<.0001	0.0047
Race (R)	<.0001	<.0001	<.0001
Age (A)	<.0001	<.0001	<.0001
Driving Time (DT)	0.0046	0.0014	*
Income (I)	<.0001	<.0001	<.0001
Year (t)	<.0001	0.0587**	0.0014
L*Year	<.0001	*	*
R*Year	<.0001	*	*
A*Year	0.0052	*	<.0001
DT*Year	*	<.0001	*
I*Year	*	0.0003	*

* Dropped from model due to non-significant.

** Year was not removed from model because it was involved in significant interactions.

Table A2 Estimated Models* by Cancer Type

Cancer Type	Estimated Linear Predictor (final model)
Cervical	$\hat{l}p_{ijkt} = 3.1845+0.1882*L_{jk1}+0.1848*L_{jk2}-0.1182*L_{jk3}+1.0562*R_{ik1}+0.1209*R_{ik2}$ $-3.7351*A_{ij1}-1.7397*A_{ij2}-1.0463*A_{ij3}-0.7446*A_{ij4}-0.5829*A_{ij5}-0.3883*A_{ij6}$ $+0.1428*DT-0.0082*I+(-0.0336-0.0165*L_{jk1}-0.0309*L_{jk2}+0.0064*L_{jk3}$ $-0.0214*R_{ik1}-0.0187*R_{ik2}+0.0306*A_{ij1}+0.0293*A_{ij2}+0.0220*A_{ij3}+0.0211*A_{ij4}$ $+0.0159*A_{ij5}+0.0147*A_{ij6})*Year$
Endometrial	$\hat{l}p_{ijkt} = 2.4200+0.1716*L_{jk1}+0.1552*L_{jk2}-0.0937*L_{jk3}+0.3017*R_{ik1}-1.1543*R_{ik2}$ $-3.7228*A_{ij1}-1.0606*A_{ij2}-0.3521*A_{ij3}-0.0968*A_{ij4}+0.2084*DT+0.0121*I$ $+(0.0140-0.0187*DT-0.0005*I)*Year$
Ovarian	$\hat{l}p_{ijkt} = 3.6826+0.0386*L_{jk1}+0.0669*L_{jk2}-0.0196*L_{jk3}-0.2973*R_{ik1}-0.8332*R_{ik2}$ $-3.9000*A_{ij1}-1.1198*A_{ij2}-0.4821*A_{ij3}-0.1151*A_{ij4}+0.0513*A_{ij5}+0.0032*I$ $+(0.0101-0.0158*A_{ij1}-0.0317*A_{ij2}-0.0211*A_{ij3}-0.0107*A_{ij4}-0.0040*A_{ij5})*Year$

* Cause specific death rates can be estimated as $\hat{R}_{ijkt} = \exp(\hat{l}p_{ijkt})$.

The example SR considered in the Appendix (i.e. the standardized death rate in year t, given driving time DT to the nearest GOG cancer treatment center.) is interpreted as the death rate among people at a driving time DT in year t that would be expected if the population of people at that driving time in that year distributed into population density/treatment center, race, and age categories in the same way as the entire population of New York State in 1979. The difference between standardized rates at two different driving times in a given year, therefore, measure the effect of driving time on death rates unconfounded by population density/treatment center, race, and age distribution.

Supplemental Tables and Figures

In this section, we present tables and figures to describe the significant effects of the control variables in our study: race, county median income, and age at death. These effects are discussed in the paper. The tables and figures of this accompanying section provide additional descriptions in tabular or graphical form.

Table S1 Age categories by cancer types

Cancer Type	Age Categories (years)
Cervical	5-34, 35-44, 45-54, 55-64, 65-74, 75-84, 85+
Endometrial	20-54, 55-64, 65-74, 75-84, 85+
Ovarian	1-44, 45-54, 55-64, 65-74, 75-84, 85+

421 **Table S2 GOG Cancer Treatment Centers**

Treatment City	Treatment State	Treatment County	Treatment County Seat	Treatment Center
New Haven	CT	New Haven	New Haven	Yale University, New Haven
Hackensack	NJ	Bergen	Hackensack	Northern New Jersey CCOP, Hackensack
Albany	NY	Albany	Albany	Albany Medical College, Albany
Brooklyn	NY	Kings	Brooklyn	State University of New York at Brooklyn
Buffalo	NY	Erie	Buffalo	1. Roswell Park Cancer Institute; 2. State University of New York, Buffalo
Manhasset	NY	Nassau	Mineola	North Shore University Hospital, Manhasset
New Hyde Park	NY	Nassau	Mineola	Long Island Jewish Medical Center, New Hyde Park
New York	NY	New York	Manhattan	1. Memorial Sloan-Kettering Cancer Center; 2. Mount Sinai School of Medicine; 3. New York Medical College; 4. New York University Medical Center; 5. The New York Hospital, Cornell Medical Center, New York City
Rochester	NY	Monroe	Rochester	University of Rochester Medical Center, Rochester
Stony Brook	NY	Suffolk	Riverhead	State University of New York at Stony Brook, Stony Brook
Syracuse	NY	Onondaga	Syracuse	State University of New York at Syracuse, Syracuse
Burlington	VT	Chittenden	Burlington	Fletcher Allen Health Care, Burlington

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423 **Table S3 Main effects of Race for Endometrial Cancer**

424

Comparison Category	Reference Category	Relative Risk	P-value	SR for Comparison Category in 2001
Black	Other	4.29	<0.0001	12.27
	White	1.35	<0.0001	
Other	White	0.32	<0.0001	2.86
White	-	-	-	9.08

425

426 **Table S4 Main effects of Race for Ovarian Cancer**

427

Comparison Category	Reference Category	Relative Risk	P-value	SR for Comparison Category in 2001
Black	Other	1.71	<.0001	7.89
	White	0.74	<.0001	
Other	White	0.43	<.0001	4.62
White	-	-	-	10.63

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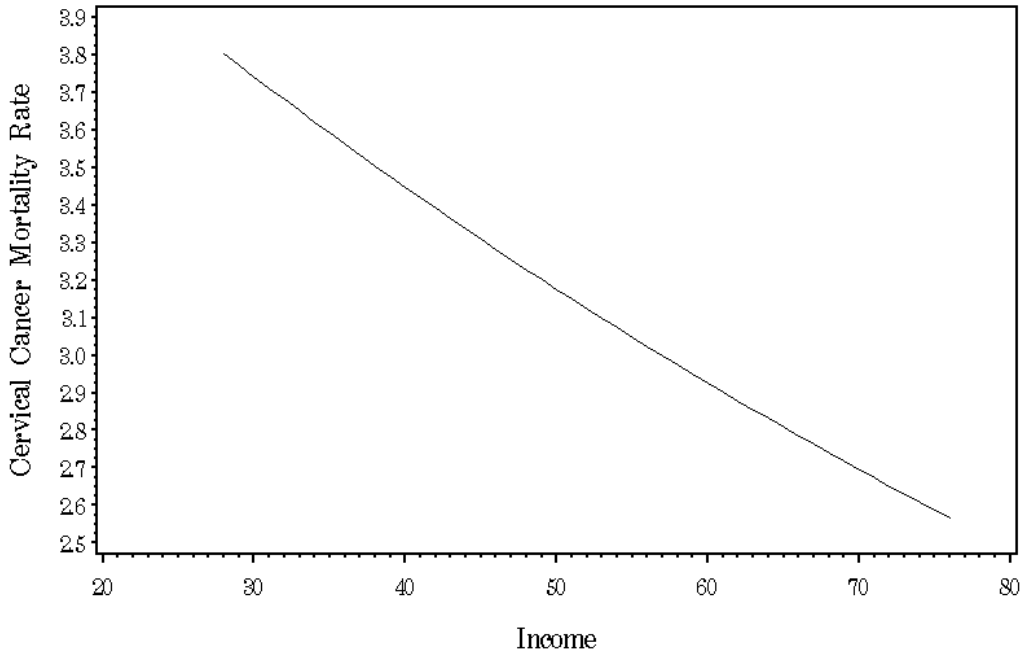
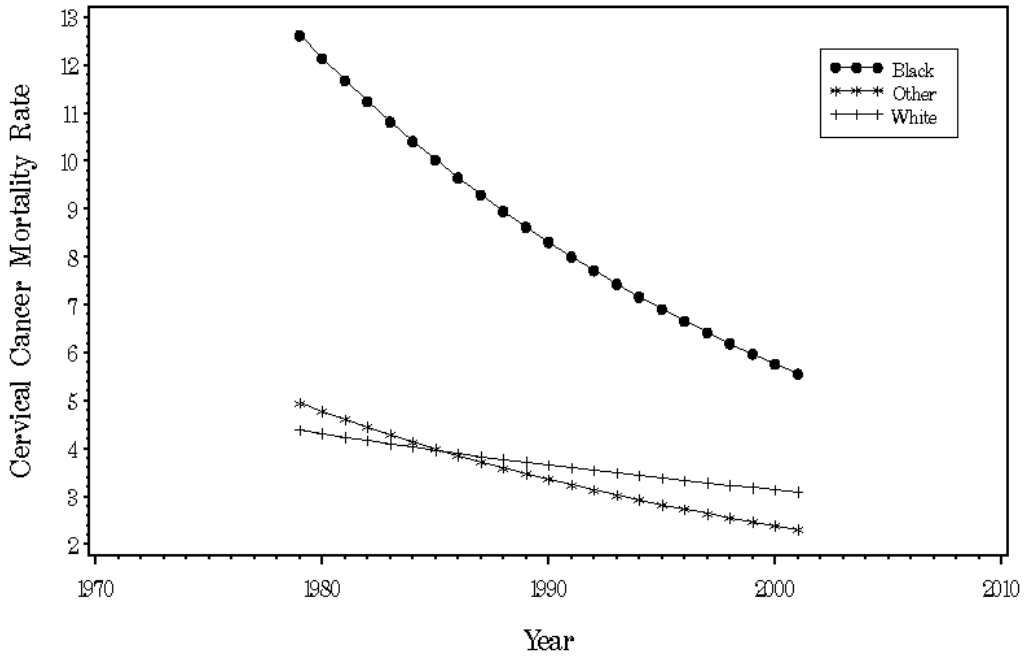
Figure S1: Standardized Death Rate (per 100,000 women per year) due to Cervival Cancer by Median Income in County of Residence.



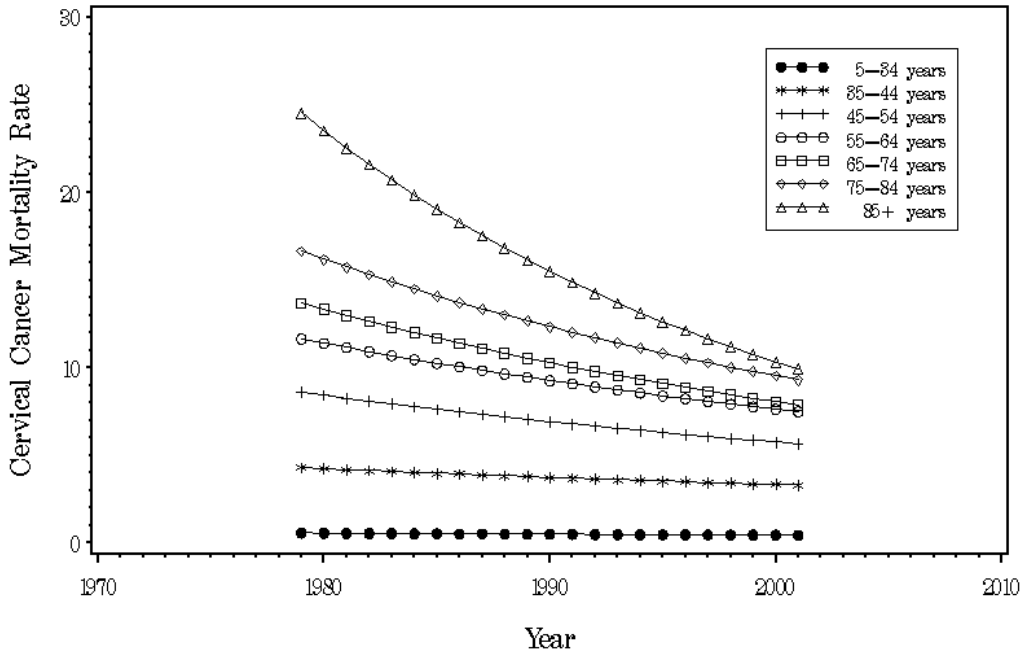
429

Figure S2: Standardized Death Rate (per 100,000 women per year) due to Cervical Cancer by year, by Race.



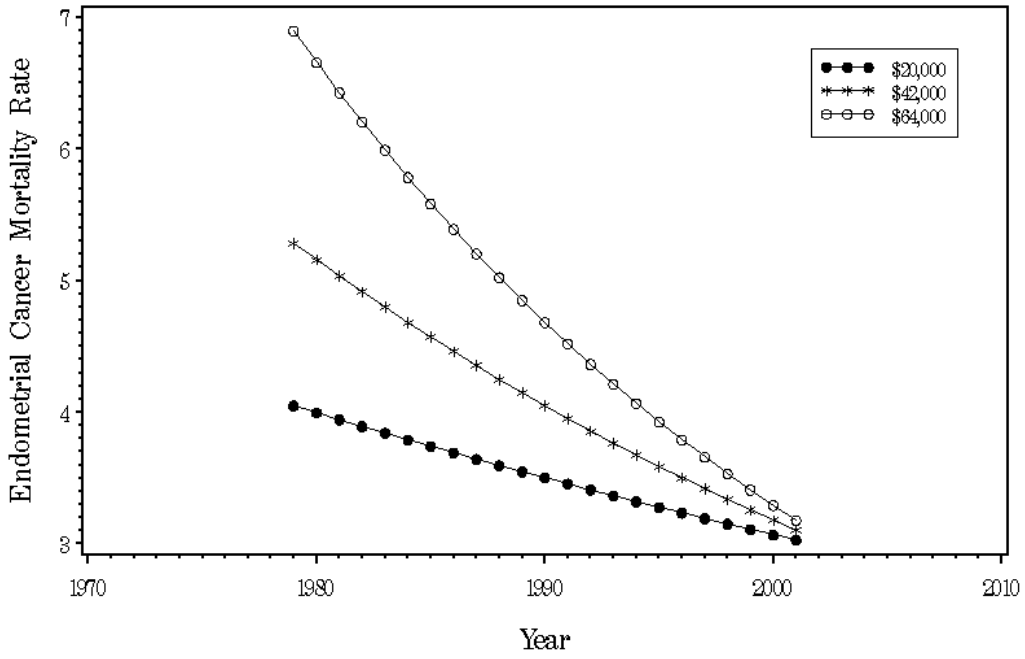
430

Figure S3: Standardized Death Rate (per 100,000 women per year) due to Cervical Cancer by year, by Age.



431

Figure S4: Standardized Death Rate (per 100,000 women per year) due to Endometrial Cancer by year, by Income.



432

Figure S5: Standardized Death Rate (per 100,000 women per year) due to Ovarian Cancer by Median Income in County of Residence.

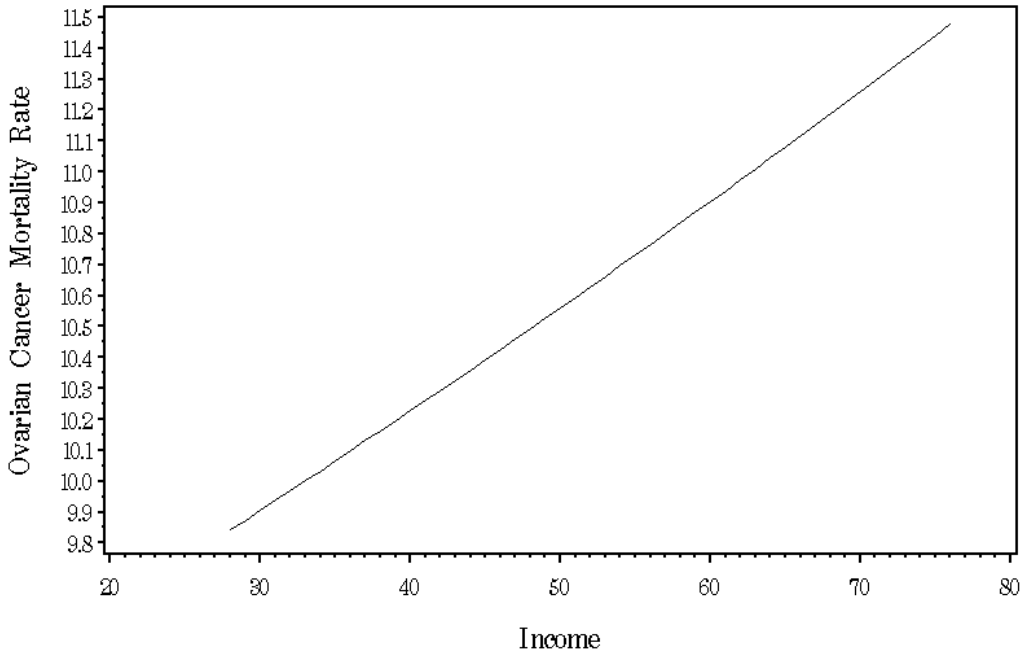


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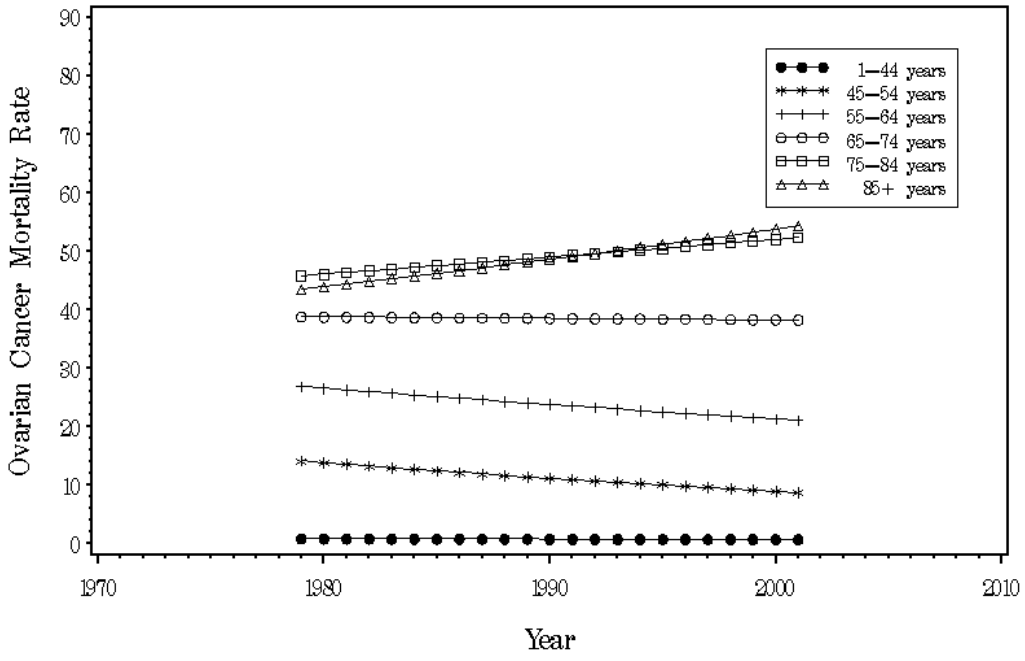
Figure S6: Standardized Death Rate (per 100,000 women per year) due to Ovarian Cancer by year, by Age.



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