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Racial/ethnic and socioeconomic disparities in mortality among women diagnosed with cervical cancer in New York City, 1995–2006

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Abstract

Background—Though cervical cancer rates have declined due to Pap screening, racial and socioeconomic disparities in cervical cancer incidence and mortality persist. This study assesses the relative impact of race/ethnicity and neighborhood poverty on cervical cancer incidence and mortality in New York City (NYC).

Methods—Invasive cervical cancer cases in NYC from 1995 to 2006 were identified along with demographic and socioeconomic measures. Odds ratios (OR) of late stage diagnosis were estimated using logistic regression. Hazard ratios (HR) of death were calculated using Cox proportional hazards regression.

Results—From 1995 to 2006 cervical cancer incidence and mortality rates decreased in NYC, though black and Hispanic women had higher incidence and mortality rates than white women. Puerto Ricans (OR = 1.55, 95% CI = 1.20–2.01) and blacks (OR = 1.34, 95% CI = 1.15–1.57) were more likely to be diagnosed with late stage disease than whites.

In multivariate analysis, blacks had similar mortality risk (HR 1.07, 95% CI = 0.95–1.20) to whites while Puerto Ricans had increased risk (HR = 1.31, 95% CI = 1.10–1.55), and non-Puerto Rican Hispanics (HR = 0.54, 95% CI = 0.45–0.63) and Asian/PIs (HR = 0.64, 95% CI = 0.52–0.78) had reduced risk. Women living in high poverty neighborhoods had higher mortality than women in higher income neighborhoods (HR = 1.32, 95% CI = 1.16–1.52).

Conclusions—Black and Puerto Rican women in NYC are at greatest risk of dying from cervical cancer. Race/ethnicity is predictive of late stage diagnosis, while both race/ethnicity and neighborhood poverty are important predictors of cervical cancer mortality.

Keywords

Cervical cancer; Race/ethnicity; Poverty; New York City; Survival analysis

Introduction

The American Cancer Society estimates that in 2008, 11,070 women in the United States were diagnosed with invasive cervical cancer and 3,870 died from the disease [1]. In recent decades, the incidence of cervical cancer has dropped significantly in developed countries due to Pap screening, which allows detection of precursor lesions that can be effectively treated before progression to more deadly invasive cervical cancer [2]. Despite success in reducing cervical cancer rates, racial and socioeconomic disparities in cervical cancer incidence and mortality persist.

Many studies have shown that low income women and black and Hispanic women have higher incidence and mortality rates, are often diagnosed with later stage cervical cancer, and are more likely to die from the disease than white women [2–5]. Socioeconomic factors such as low educational attainment, low income, and lack of medical insurance have been identified as barriers to cervical cancer screening, along with cultural and language barriers among immigrant women [5]. In addition, treatment disparities, such as insufficient follow-up of abnormal Pap test, treatment delay, type of treatment received, and quality of care may account for disparities in cervical cancer mortality [6].

Understanding racial/ethnic and socioeconomic disparities in cervical cancer is particularly relevant in urban settings like New York City (NYC); more than half of the city's residents are black, Hispanic or Asian, compared to only one-quarter of the US population, and New Yorkers are more likely to be living in poverty than the national population [7]. The majority of studies of cervical cancer disparities have compared Caucasian, African American, and Hispanic women. Fewer studies have examined cervical cancer among Asians and Pacific Islanders (PI), though Asian women tend to report lower rates of Pap screening than other racial/ethnic groups [8, 9]. Also, health disparities exist within the Hispanic community, though few studies have examined cervical cancer rates in Hispanic subgroups. In NYC, Puerto Rican women have significantly shorter life-expectancy than non-Puerto Rican Hispanics [7]. In addition, life-expectancy is shorter for NYC residents living in lower income neighborhoods than for those living in high income neighborhoods, and blacks and Hispanics are more likely to live in low income neighborhoods [7]. Cancer mortality is also increased in low income neighborhoods in NYC [7].

In this study, we used data from the New York State Cancer Registry (NYSCR) and the New York City Department of Health and Mental Hygiene (NYC DOHMH) to compare cervical cancer incidence and mortality by race/ethnicity and neighborhood poverty in NYC.

Methods

Study population

The study population consists of the 6,257 NYC residents diagnosed with invasive cervical cancer between 1995 and 2006 reported to the New York State Cancer Registry (NYSCR). The NYSCR received Gold level certification from the North American Association of Central Cancer Registries (NAACCR) from 1996 to 2006, attesting to the high quality and completeness of its data.

Demographics and neighborhood SES

Demographic information, such as age, race/ethnicity, marital status, county of residence, and birthplace were obtained from the NYSCR. Using residential address at diagnosis, the associated census block group and zip code were identified for each case, and census data for neighborhood poverty rates were recorded. For approximately 13% of the study population, block group information was missing or the block group population was less than 100 individuals; for these cases ZIP code data were used.

Tumor characteristics

Stage at diagnosis for invasive cervical cancer is recorded by the NYSCR in the following categories: localized; regional, direct extension only; regional, regional lymph nodes only; regional, direct extension and regional lymph nodes; regional, not otherwise specified; distant/systemic; and unstaged/unknown. Tumor histology was categorized according to ICD-O-3 coding as squamous cell carcinoma (8050–8131), adenocarcinoma (8140–8574, 8940), and other/unknown histology (8000, 8010–8045, 8590, 8800–8935, 8950–9560). The majority of cases with other/unknown histology also had unstaged disease. Both tumor grade and size, although reported in the registry, had high percentages of missing data and therefore were not included in analyses.

Treatment data

Treatment records were only available for a subset of the data, years 2003–2006. Based on what was reported to the registry treatment was categorized as: surgery only, radiation only, both surgery and radiation, no surgery or radiation, and missing treatment data. Chemotherapy data were not available because the majority of reports to the registry come from hospitals, but chemotherapy often occurs outside the hospital setting.

Vital statistics

Vital status was ascertained through December 31, 2006 by linking this cohort of women to death records obtained from the NYC DOHMH Bureau of Vital Statistics and the New York State Department of Health, Bureau of Biometrics and Health Statistics. Prior analysis (unpublished data) found death ascertainment resulting from linkage of the Registry to the

NY vital statistics files to be at least 95% complete. The majority of deaths in our study population were due to cervical cancer (62%), and an additional 17% were from other cancers (Table 1). Due to concern about misclassification of cause of death on death certificates, particularly concern that deaths from other cancers were in fact metastases of cervical cancer and not new primary cancers, we chose to report all-cause mortality rather than cervical cancer mortality in multivariate analyses.

Statistical analysis

Yearly population estimates for NYC from the US Census Bureau were used as denominators for incidence and mortality rates. The direct method was used to age-adjust rates using the age composition of the 2000 US standard population [10]. Race/ethnicity was grouped into six mutually exclusive categories: non-Hispanic white, non-Hispanic black, Hispanic-Puerto Rican, Hispanic-Other or not specified, Asian/PI, and other/unknown. Neighborhood poverty was categorized into three groups based on the percentage of households with income less than 200% of the federal poverty level. We chose this cutoff to account for the high cost of living in NYC. Low, moderate, and high categories of neighborhood poverty were created based on approximate tertiles of the data. Low poverty neighborhoods were defined as those with 30% of households below 200% of the poverty level, moderate poverty neighborhoods were those with 30–60% of households below 200% of the poverty level, and high poverty neighborhoods had greater than 60% of households below 200% of the poverty level. For descriptive analyses, age at diagnosis was collapsed into five categories: under 40, 40–49, 50–64, 65–74, and 75 years and older. For regression analyses, age was treated as a continuous variable; additional independent analyses were completed for women under 65 years and 65 years and over at time of diagnosis. Marital status was categorized as not married, married, or unknown.

Stage was collapsed into three summary categories: localized, regional, and distant/systemic.

For regression analyses of stage at diagnosis and mortality, we limited our study population to women diagnosed with first primary invasive cervical cancer (ICD-O-3 codes C530–C539) between 1995 and 2006. Logistic regression was performed to estimate the odds ratio of regional or distant stage disease compared with localized stage. Women without known stage at diagnosis were excluded from this analysis ($N = 931$). Potential confounders, such as histology subtype and year of diagnosis, were evaluated in multivariate logistic regression model. Factors that were not statistically significant in the multivariate model and did not change other effect estimates by more than 10% were excluded from the final model.

For survival analyses, time in months from diagnosis to death from any cause was calculated. Women not known to, have died were censored on December 31, 2006. Unadjusted survival curves were generated using Kaplan–Meier methods and compared using the log-rank test. Bivariate Cox proportional hazards regression models were estimated to assess the association of demographic and tumor characteristics with risk of death, and multivariable Cox proportional hazards regression was used to estimate adjusted hazard ratios (HR) and their 95% confidence intervals. Ties were handled using Efron's method [11]. Survival analyses were repeated in the subset of women diagnosed after 2003 in order to incorporate treatment data. In addition, Cox regression stratified by age at

diagnosis was performed. Separate models were estimated for women younger than 65 years at diagnosis, and for women 65 years and older because we suspected that Medicare eligibility may affect access to screening and treatment.

Interactions of race/ethnicity and age with neighborhood poverty were explored by including cross product terms in the models, and the Wald test was used to determine statistical significance of parameter estimates. SPSS 16.0.01 (SPSS Inc. Chicago, Illinois) and SAS 9.1 (SAS Institute Inc., Cary, North Carolina) were used for analyses. Two-sided p values less than 0.05 were considered statistically significant. This study was approved by the Institutional Review Boards at the New York City Department of Health and Mental Hygiene and the New York State Department of Health.

Results

Descriptive statistics

Descriptive characteristics of the study population are shown in Table 1. A total of 5,823 women were diagnosed with first invasive cervical cancer between 1995 and 2006 in NYC. Of women diagnosed during the twelve-year study period, 28% were white, 35% were black, 9% were Puerto Rican, 18% were non-Puerto Rican Hispanics, and 8% were Asian/Pis. Nearly a quarter (24%) of women lived in high poverty neighborhoods. Neighborhood poverty differed significantly by race/ethnicity. White women were far less likely to live in high poverty neighborhoods than other racial groups, ($p < 0.0001$). Thirty percent of blacks, 48% of Puerto Ricans, and 35% of other Hispanics lived in high poverty neighborhoods, compared to only 7% of whites. The mean age at diagnosis was 52.8 ± 15.6 years and was consistent across racial/ethnic groups, with the exception of non-Puerto Rican Hispanics, whose mean age at diagnosis was 48.9 ± 14.5 years, significantly younger than whites ($p < 0.0001$).

Incidence and mortality rates

The age-adjusted incidence of invasive cervical cancer in NYC decreased over the last decade, from 14.9 per 100,000 women in 1995 to 9.9 per 100,000 women in 2006. During 1995–2006, cervical cancer rates declined at a similar rate for White, Black, and Hispanic women. The incidence rate for Asian/Pis decreased between 1995 and 1999 but then leveled off. During this period, minority groups had higher incidence rates than whites. For example, the age-adjusted incidence rate per 100,000 women in 2005 was 8.0 for whites, 14.7 for blacks, 12.3 for Hispanics, and 11.4 for Asian/PI women.

Age-adjusted cervical cancer mortality rates also declined from 1995 to 2006, from 4.4 per 100,000 in 1995 to 3.1 per 100,000 in 2006. However, from 2002 to 2006, while mortality rates declined or remained stable for all racial/ethnic groups, the average age-adjusted mortality rate from invasive cervical cancer in NYC was 2.5 times higher for black women than white women (5.5 vs. 2.2 per 100,000) and twice as high for Hispanic women as white women (4.6 per 100,000). The mortality rate for Asian/PI women in NYC was comparable to that of white women, though this rate is based on fewer than 20 cases and therefore, must be interpreted with caution (2.4 per 100,000).

Stage at diagnosis

The majority of women (44%) were diagnosed with localized disease, nearly a third (31 %) were diagnosed with regional disease, 10% were diagnosed at distant stage, and 16% had tumors reported as unstaged or unknown stage. Cancers are often reported unstaged/unknown in cases with short survival after diagnosis, indicating that full workup for cervical cancer was not performed and therefore, not reported to the cancer registry. Black and Puerto Rican women were less likely to be diagnosed at localized stage, and more likely to be diagnosed with regional, distant, or unstaged disease than whites ($p < 0.001$). Squamous cell carcinoma was the most common histology (70%).

Table 2 shows the odds of being diagnosed with regional or distant cancer compared to localized disease, excluding unstaged cervical cancers ($N = 4892$). After adjusting for neighborhood poverty, age, marital status, and diagnosis year, black women were still 34% more likely to be diagnosed at later stage than white women (OR = 1.34, 95% CI = 1.15–1.57) and Puerto Ricans were 55% more likely to be diagnosed at later stage than whites (OR = 1.55, 95% CI = 1.20–1.51). Other Hispanics and Asian/PIs were not at statistically significantly increased risk of late diagnosis compared to whites (Hispanic: OR = 1.06, 95% CI = 0.88–1.27; Asian/PI: OR = 1.20, 95% CI = 0.96–1.51). In addition, women from high poverty neighborhoods were 15% more likely to be diagnosed at later stage of disease (OR = 1.15, 95% CI = 0.96–1.51). The interaction of neighborhood poverty and race/ethnicity was not statistically significant.

Survival analysis of mortality risk

Risk of death by race/ethnicity and neighborhood poverty was estimated using Cox proportional hazards regression in 5823 cases diagnosed between 1995 and 2006 (Table 3). After adjusting for neighborhood poverty, stage, age, and marital status, the risk of death from cervical cancer for black women was not significantly different than white women (Table 3, HR = 1.07, 95% CI = 0.95–1.20). However, the risk of death among Puerto Ricans was 31% higher than among whites (HR = 1.31, 95% CI = 1.10–1.55) while other Hispanics (HR = 0.54, 95% CI = 0.45–0.63) and Asian/PIs (HR = 0.64, 95% CI = 0.52–0.78) were at reduced risk of death compared to whites. Neighborhood poverty was significantly associated with mortality. Women from high poverty neighborhoods had a 32% higher risk of death than women from low poverty neighborhoods (HR = 1.32, 95% CI = 1.16–1.52). Married women were at reduced risk of death compared to unmarried women (HR = 0.85, 95% CI 0.76–0.95). As expected, later stage diagnosis was associated with greater risk of death.

In addition, we conducted survival analysis for the subset of women diagnosed 2003–2006 for whom treatment information was available (Table 3). In the adjusted model, mortality was higher among women with no surgery or radiation reported and among those missing treatment data compared to women who underwent surgery (No surgery or radiation: HR = 1.62, 95% CI = 1.16–2.27; Missing HR = 3.01, 95% CI = 2.06–4.39). Women missing treatment data were more likely to be older, have unstaged disease, and more likely to live in high poverty neighborhoods. Adjusting for treatment did not have a strong effect on HR estimates of other variables in the model. Although neighborhood poverty was no longer

statistically significantly associated with mortality, the magnitude of the effect was similar to the estimate for the full cohort. In a separate logistic regression model, after controlling for age and stage at diagnosis, receipt of treatment did not differ by race/ethnicity or neighborhood poverty (data not shown). Race/ethnicity was not associated with odds of surgery or odds of radiation. Neighborhood poverty was not associated with odds of surgery, but women from high poverty neighborhoods were less likely to have radiation reported.

Table 4 shows mortality risk stratified by race/ethnicity and neighborhood poverty. Black women from high poverty neighborhoods were 50% more likely to die than white women living in low and moderate poverty neighborhoods (HR = 1.50, 95% CI = 1.22–1.89). Puerto Rican women had a similarly increased risk of dying compared to white women, but this high risk was irrespective of neighborhood poverty. Very few Puerto Rican women lived in low poverty neighborhoods (9.1%) compared to moderate poverty neighborhoods (43.0%) and therefore, the increased risk in the low/moderate group mainly reflects the risk in women living in moderate poverty neighborhoods. The overall test of interaction of race/ethnicity and neighborhood poverty was statistically significant ($p = 0.011$). This interaction was not statistically significant in the subset of women with treatment data, possibly due to the smaller sample size. The magnitude of the joint effects of race/ethnicity and neighborhood poverty in the treatment subset was similar to that of the full cohort.

There, was a significant interaction between age at diagnosis and race/ethnicity (Table 5). In women under age 65, black and Puerto Rican women had significantly increased risk of death compared with white women (HR=1.26, 95% CI = 1.09–1.47; HR = 1.41, 95% CI = 1.13–1.75, respectively). However, in women over 65, black women were at slightly reduced risk of death compared to white women (HR = 0.84, 95% CI = 0.70–1.00), while Puerto Rican women's risk was not significantly different than white women (HR = 1.18, 95% CI = 0.89–1.57).

Discussion

Our results clearly show that racial/ethnic disparities in cervical cancer incidence and mortality persist in NYC. Race/ethnicity appears to be most predictive of later stage of diagnosis of cervical cancer, while both race/ethnicity and neighborhood poverty are important determinants of cervical cancer mortality. Black and Puerto Rican women were more likely to be diagnosed with later stage cervical cancer than white women. Overall, women living in high poverty neighborhoods were more likely to die than women in higher income neighborhoods. Black women from high poverty neighborhoods were 50% more likely to die than white women from low and moderate poverty neighborhoods, while Puerto Rican women were at increased risk of death irrespective of neighborhood poverty. Furthermore, in women younger than 65 years, black and Puerto Rican women were at increased risk of death compared to white women; but in women older than 65, blacks and Puerto Ricans were not at increased risk.

Overall, the incidence of invasive cervical cancer and cervical cancer mortality rates declined in NYC from 1995 to 2006, though rates exceeded SEER estimates [3]. From 2001 to 2005, the age-adjusted incidence rate of invasive cervical cancer in NYC was 10.7 per

100,000 compared to 8.4 per 100,000 as reported by SEER registries. The large non-white population likely accounts for much of NYC's higher incidence and mortality rates compared to SEER estimates. Consistent with previous studies of cervical cancer incidence black, Hispanic, and Asian/PI women had higher incidence rates than whites [12–14]. Black women in NYC had particularly high cervical cancer incidence, with a rate of 14.9 per 100,000 from 2001 to 2005, compared to 10.8 per 100,000 in SEER. The average age-adjusted mortality rate for the period 2002–2005 was 3.5 per 100,000 women in NYC compared to 2.5 per 100,000 women in SEER. Black and Hispanic women had higher mortality rates than white women in NYC, which is similar to patterns reported nationally [15].

Racial/ethnic and socioeconomic disparities in cervical cancer incidence and mortality may result from failures in the process of care at multiple points: from differences in HPV infection rates, failure to screen, failure to follow-up abnormal test results, and failure to obtain timely and appropriate treatment [16, 17]. Given the high rates of cervical cancer mortality among black and Puerto Rican women in NYC, these groups likely have a high burden of HPV infection. NHANES data show higher prevalence of HPV infection among non-Hispanic black women than white women (39.2 vs. 24.2%), and women living in poverty compared with women with higher income (37.5 vs. 24.4%) [18]. Mexican Americans had similar HPV prevalence as whites, but few studies have reported population-based estimates of HPV prevalence in Hispanic women generally. In addition, rates of HIV and AIDS may impact cervical cancer rates in NYC, since blacks and Hispanics have a high burden of HIV/AIDS [7]. A study of cancer incidence among patients with AIDS in New York State estimated the incidence of invasive cervical cancer to be 9.1 times greater in these patients than in the general population; the study cohort was predominantly NYC residents (82%), and a high percentage (44.8%) were black [12]. However, a prior analysis by the NYC DOHMH linked NYC cervical cancer deaths in 2002 to the HIV/AIDS Reporting System (HARS) database, and only a small proportion (2%) of women who died of cervical cancer had HIV/AIDS diagnosis.

In our study, black and Puerto Rican women were more likely than white women to be diagnosed with late stage cancer, which is consistent with prior reports [4, 5]. Late stage at diagnosis reflects failure of timely screening [13]. Approximately 55–60% of cervical cancer cases occur in women who report inadequate screening [5, 19]. According to the Community Health Survey, whites, blacks, and Hispanics in NYC self-report high rates of Pap screening (~ 80%) while Asian women report rates of Pap screening ranging from just under 60% to a high of 68% from 2002 to 2006 [20]. These rates are similar to Pap screening rates reported nationally in the Behavioral Risk Factor Surveillance System (BRFSS) [19]. Lower Pap screening rates in Asian women may account for high incidence of invasive cervical cancer seen in this group. The consistently high screening rates reported by black and Hispanic women in NYC may suggest that in addition to screening, follow-up of abnormal Pap tests and access to care after diagnosis are issues of concern in terms of cervical cancer incidence and mortality in these groups. However, many studies have found significant overreporting of Pap screening, and minority groups and low income women are more likely to misreport screening [21], so the true screening rates in NYC may be lower than reported.

Even after adjusting for stage at diagnosis, the risk of death following cervical cancer diagnosis differed by race/ethnicity and neighborhood poverty, suggesting that screening alone does not fully account for racial/ethnic and socioeconomic differences in cervical cancer mortality. Failure to follow-up abnormal Pap tests, access to care, treatment, and comorbidities are also important determinants of cervical cancer survival [17, 19]. We performed survival analysis stratified by age at diagnosis because we hypothesized that Medicare eligibility may affect access to care and thus risk of death. In women younger than 65 years, black and Puerto Rican women were at increased risk of death compared to white women; but in women older than 65, blacks and Puerto Ricans were not at increased risk. Similarly, a study linking SEER and Medicare cohorts found no association between race/ethnicity or neighborhood SES and cervical cancer mortality in women over age 65 [22]. These results suggest that equal access to screening and treatment under Medicare coverage reduces racial disparities in cervical cancer death.

Though low income and underinsured women under the age of 65 may receive cervical cancer screening free of charge through the National Breast and Cervical Cancer Early Detection Program (NBCCEDP), physician referral and having a regular health care provider increase the likelihood of screening, and Medicare eligible women may be more likely to have regular care [8, 23]. Furthermore, among participants of the NBCCEDP, only 44% of women with low-grade Pap abnormalities were followed up with colposcopy as recommended, and black women were more likely to be lost to follow-up [24].

Previous studies have reported conflicting results on the associations of race/ethnicity with cervical cancer mortality [25]. Some studies have found race/ethnicity to be an independent predictor of cervical cancer mortality [26, 27], while others have suggested that clinical factors, neighborhood SES, and insurance status may account for observed racial/ethnic differences [28–31]. In our analysis, we also examined the joint effects of race/ethnicity and neighborhood poverty to better understand the synergistic effects of these factors and to highlight groups at highest risk of dying following cervical cancer diagnosis. We found that blacks from high poverty neighborhoods were at particularly high risk of death compared to whites living in low and moderate poverty neighborhoods, Puerto Ricans were at increased risk of death regardless of neighborhood poverty level, and other Hispanics and Asian/Pis were at decreased risk compared to whites irrespective of neighborhood poverty level.

Many studies have compared survival for black and white women, but fewer studies have examined cervical cancer survival specifically among Asian/Pis and Hispanics. Three studies found lower mortality in Asian women than whites [14, 32, 33], but only one of these studies adjusted for age, stage of diagnosis, and SES [14]. Two studies showed lower risk of death among Hispanic women with cervical cancer compared to white women, after adjusting for demographic and clinical factors [26, 27].

In what has been termed the “Hispanic paradox,” Hispanics tend to have better health outcomes than non-Hispanic whites, despite having higher poverty rates, less education, and less health insurance coverage [34]. Our results reflect this pattern for non-Puerto Rican Hispanics, but not for Puerto Ricans. The difference in mortality risk among Puerto Rican

and other Hispanic groups in our study may reflect both historical patterns of immigration and the effects of acculturation.

Puerto Ricans, the largest Hispanic group in NYC, began immigrating in large numbers in the 1940s [35]. By the 1970s, as manufacturing jobs disappeared, Puerto Ricans were among the city's poorest residents, and many lived in public housing. Migration of Dominicans, South Americans, and Mexicans began later, in the 1970 and 1980s. These populations settled in different neighborhoods, experienced different socioeconomic conditions, and were less likely to reside in public housing. In the 1990s, many middle class Puerto Ricans left the city for suburbs and nearby states, while lower income Puerto Ricans tended to remain in the city [35]. This may explain why the majority of Puerto Ricans in our study lived in high poverty neighborhoods, and why Puerto Ricans in our study had poorer outcomes than other Hispanics.

Acculturation among Latinos has been associated with greater prevalence of chronic conditions and more negative health behaviors, such as smoking, that may increase cervical cancer mortality [34, 36]. Because of their earlier migration and their status as American citizens, Puerto Ricans in NYC are more fully acculturated to the American lifestyle, and this may translate to poorer health and increased mortality. These differences highlight the need to look more closely at differences within racial categories. A few studies showed different cervical cancer incidence and mortality rates for Asian subpopulations [14, 33, 37], but the relatively small number of Asian women in our study population prevented evaluating risk for subgroups of Asian women in NYC. More recent effects of immigration on cervical cancer may also exist, though harder to identify because immigration status is not well documented in our data.

Our study has many strengths. Because of NYC's large and diverse population and the completeness of data of the Cancer Registry, we were able to examine cervical cancer incidence and mortality rates, stage at diagnosis, and survival for multiple racial/ethnic groups simultaneously. To our knowledge, this is the first study examining cervical cancer survival specifically in Puerto Rican women. Our study in NYC also allows comparison of cancer rates in racial groups living in the same metropolitan area, allowing more consistency in the meaning of SES measures than in analyses combining data from multiple state registries. Census block level poverty was obtained for nearly all participants; this neighborhood measure has been validated and has been found to be meaningful in its own right and is not just a proxy for individual economic position [38].

Several limitations in our analysis should be considered when interpreting results. First, individual level SES information is not collected by the Cancer Registry, and area-based measures may not fully capture the socioeconomic conditions experienced by women in our study. Second, we reported all-cause mortality as our primary outcome due to concern about misclassification of cause of death on death certificates. However, models using cervical cancer mortality yielded very similar results, given that the majority of deaths in our study population were due to cervical cancer. Third, the treatment data in our study were incomplete. We had access to treatment data for women diagnosed 2003–2006, but treatment records were missing for 15% of cases. Treatment occurring outside of reporting

hospitals is known to be underreported, and therefore, some women in the ‘no surgery or radiation’ group may be misclassified. In addition, we did not have access to chemotherapy data, which often occurs outside the hospital setting. Because of this, we cannot make strong inferences about the effect of treatment in our study. However, after controlling for age and stage at diagnosis, receipt of treatment did not differ by race/ethnicity or neighborhood poverty, and the analysis in the subset of women with treatment data yielded similar point estimates to those of the full cohort. Finally, screening history, insurance coverage, delay in treatment, follow-up after positive Pap test, and comorbidities are important issues affecting cervical cancer survival that could not be assessed in this study.

In summary, in our analysis, race/ethnicity was predictive of late stage at cervical cancer diagnosis, while both race/ethnicity and neighborhood poverty were associated with overall mortality. In NYC, black and Puerto Rican women were at increased risk of being diagnosed with late stage cervical cancer and of dying from their disease. Women living in high poverty neighborhoods also had higher mortality than women from higher income areas, and black women living in high poverty neighborhoods were at particularly high risk. Blacks and Puerto Ricans younger than 65 had higher mortality than whites, while blacks and Puerto Ricans aged 65 and older, who are eligible for Medicare, had similar mortality to whites, suggesting that access to care may affect mortality risk. Future studies which examine more detailed treatment information, insurance status, comorbidity, and health behaviors would help to elucidate the underlying causes of racial/ethnic and socioeconomic disparities. Our study suggests that improved screening promotion, particularly among minority and low income women, should remain a priority. However, given the high screening rates reported in NYC, other interventions targeting access and utilization of care, improved follow-up of abnormal Pap results, timely and appropriate treatment, and HPV vaccination should be considered to further reduce cervical cancer incidence and mortality rates.

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Table 1

Characteristics of NYC women diagnosed with invasive cervical cancer 1995–2006

	Total N = 5,823 %	White N = 1,630 %	Black N = 2,033 %	Puerto Rican N = 395 %	Other Hispanic N = 1,147 %	Asian/PI N = 484 %	Other N = 134 %
	100.0	28.0	34.9	6.8	19.7	8.3	2.3
Age at Diagnosis (years; mean ± SD)	52.8 ± 15.6	54.0 ± 16.5	54.0 ± 15.5	53.5 ± 15.2	48.9 ± 14.5	53.7 ± 14.4	46.2 ± 14.3
Age at diagnosis (years)							
<40	21.9	20.9	18.7	19.8	30.7	15.7	38.1
40–49	24.9	21.7	25.1	24.8	26.6	31.8	20.9
50–64	29.2	30.8	29.5	29.6	26.4	28.1	29.9
65–74	13.1	12.8	15.0	14.9	10.4	13.4	6.0
75+	10.9	13.8	11.8	10.9	5.8	11.0	4.5
Nativity							
US born	35.2	49.8	47.8	17.7	15.1	2.5	9.0
Foreign born	36.0	20.0	27.3	76.7	45.5	78.1	7.5
Unknown	28.9	30.2	24.9	5.8	39.4	19.4	83.6
Neighborhood poverty ^a							
High poverty	24.1	6.9	29.9	47.8	35.1	14.1	16.4
Moderate poverty	47.6	40.9	50.2	43.0	51.3	55.2	46.3
Low poverty	27.7	51.7	19.0	9.1	13.4	30.2	35.1
Marital status							
Single, never married	35.1	26.6	43.1	40.3	39.9	17.8	23.9
Married	31.7	38.2	23.9	23.0	31.0	53.7	23.1
Divorced/widowed	25.1	29.8	25.2	29.3	19.3	22.2	12.7
Unknown	8.1	5.5	7.8	7.3	9.8	6.4	40.3
Stage							
Localized	43.5	47.0	39.2	37.2	48.5	45.0	38.8
Regional	30.5	27.7	32.5	34.2	30.4	32.2	17.2
Distant or systemic	10.0	10.0	11.6	12.7	7.1	9.9	3.0
Unstaged/Unknown	16.0	15.3	16.8	16.0	14.0	12.8	41.0
Histology							
Squamous cell carcinoma	70.0	65.3	72.9	72.9	71.5	68.8	67.9

	Total N = 5,823 %	White N = 1,630 %	Black N = 2,033 %	Puerto Rican N = 395 %	Other Hispanic N = 1,147 %	Asian/PI N = 484 %	Other N = 134 %
	100.0	28.0	34.9	6.8	19.7	8.3	2.3
Adenocarcinoma	18.3	22.5	13.3	16.5	20.1	21.1	23.1
Other/unspecified	11.6	12.2	13.7	10.6	8.5	10.2	8.9
Vital status (as of December 31, 2006)							
Not deceased	67.4	65.3	60.9	49.9	81.0	76.0	96.3
Died, cervical cancer	20.2	20.3	23.8	33.4	13.2	15.3	2.2
Died, other Cancer	5.6	6.6	6.5	6.8	3.1	4.3	0.0
Died, non-cancer	6.8	7.8	8.8	9.9	2.7	4.3	1.5
	N = 1738	N = 450	N = 583	N = 87	N = 374	N = 200	N = 44
First course treatment (2003–2006 only)							
Surgery only	40.2	45.1	36.4	33.3	42.3	42.0	27.3
Radiation only	13.1	12.7	13.7	18.4	11.5	15.0	4.5
Both surgery & radiation	5.6	4.2	6.2	4.6	6.4	7.0	2.3
No surgery or radiation	26.5	26.0	28.0	29.9	26.7	25.0	9.1
Missing	14.6	12.0	15.8	13.8	13.1	11.0	56.8

^aHigh poverty: >60% households below 200% poverty; Moderate poverty: 30–60% households below 200% poverty; Low poverty: <30% households below 200% poverty

Table 2
Logistic regression: odds of diagnosis at later stages (regional or distant; *N* = 4892)

	<i>N</i>	%	Unadjusted ^a			Model 1 ^b		
			OR	95% CI	<i>p</i> -value	OR	95% CI	<i>p</i> -value
Race/ethnicity								
White	1,381	28.2	1.00	Reference		1.00	Reference	
Black	1,692	34.6	1.40	(1.22, 1.62)	<0.001	1.34	(1.15, 1.57)	<0.001
Puerto Rican	332	6.8	1.57	(1.23, 2.00)	<0.001	1.55	(1.20, 2.01)	0.001
Other Hispanic	986	20.2	0.96	(0.82, 1.14)	0.656	1.06	(0.88, 1.27)	0.528
Asian/PI	422	8.6	1.17	(0.94, 1.45)	0.169	1.20	(0.96, 1.51)	0.117
Neighborhood poverty								
Low poverty	1,361	27.8	1.00	Reference		1.00	Reference	
Mod poverty	2,336	47.8	1.03	(0.90, 1.17)	0.699	0.94	(0.84, 1.13)	0.719
High poverty	1,170	23.9	1.20	(1.03, 1.41)	0.020	1.15	(0.96, 1.37)	0.129

^aUnadjusted logistic models

^bLogistic model adjusted for age, diagnosis year, marital status, race, and neighborhood poverty

Table 3

Mortality among NYC women diagnosed with invasive cervical cancer

Variable	Full cohort 1995–2006 N = 5,823		Full cohort 1995–2006 N = 5,823		Subset with treatment 2003–2006 N = 1,738	
	HR	95% CI	Unadjusted	Fully adjusted ^a	HR	95% CI
Race/ethnicity						
White	1.00	Reference	1.00	Reference	1.00	Reference
Black	1.19	(1.07, 1.33)	1.07	(0.95, 1.20)	0.96	(0.73, 1.26)
Puerto Rican	1.50	(1.27, 1.76)	1.31	(1.10, 1.55)	1.93	(1.29, 2.89)
Other Hispanic	0.51	(0.43, 0.59)	0.54	(0.45, 0.63)	0.67	(0.46, 0.97)
Asian/PI	0.71	(0.58, 0.87)	0.64	(0.52, 0.78)	0.56	(0.36, 0.90)
Neighborhood poverty						
Low poverty	1.00	Reference	1.00	Reference	1.00	Reference
Mod poverty	1.13	(1.01, 1.26)	1.14	(1.01, 1.27)	1.00	(0.76, 1.31)
High poverty	1.30	(1.15, 1.47)	1.32	(1.16, 1.52)	1.20	(0.88, 1.64)
Stage						
Localized	1.00	Reference	1.00	Reference	1.00	Reference
Regional	3.02	(2.68, 3.41)	2.59	(2.29, 2.93)	2.56	(1.83, 3.59)
Distant	9.68	(8.46, 11.08)	8.18	(7.14, 9.38)	8.87	(6.14, 12.81)
Unstaged/unknown	2.36	(2.04, 2.73)	2.29	(1.98, 2.66)	1.71	(1.11, 2.64)
Marital status						
Not married	1.00	Reference	1.00	Reference	1.00	Reference
Married	0.65	(0.58, 0.72)	0.85	(0.76, 0.95)	0.84	(0.65, 1.09)
Unknown	0.64	(0.53, 0.77)	0.75	(0.62, 0.91)	0.24	(0.13, 0.47)
Treatment						
Surgery only					1.00	Reference
Radiation only					1.33	(0.91, 1.95)
Both surgery and radiation					1.48	(0.86, 2.55)
No surgery or radiation					1.62	(1.16, 2.27)

Variable	Full cohort 1995–2006 N = 5,823	Full cohort 1995–2006 N = 5,823	Subset with treatment 2003–2006 N = 1,738
	Unadjusted	Fully adjusted ^a	Fully adjusted ^b
	HR 95% CI	HR 95% CI	HR 95% CI
Missing			3.01 (2.06, 4.39)

^aCox proportional hazards model adjusted for age (continuous), race, neighborhood poverty, stage, and marital status

^bCox proportional hazards model adjusted for age (continuous), race, neighborhood poverty, stage, marital status, and treatment

Table 4Mortality by race and neighborhood poverty in women diagnosed 1995–2006 ($N = 5,823$)

	Low/mod poverty ^a		High poverty ^a	
	HR	95% CI	HR	95% CI
White	1.00	Reference	1.01	(0.73, 1.40)
Black	1.01	(0.90, 1.15)	1.50	(1.29, 1.73)
Puerto Rican	1.42	(1.14, 1.76)	1.52	(1.22, 1.89)
Other Hispanic	0.60	(0.50, 0.72)	0.57	(0.44, 0.72)
Asian/PI	0.71	(0.57, 0.87)	0.46	(0.27, 0.79)

 p -interacton = 0.0111

Cox proportional hazards model adjusted for age (continuous), stage, marital status

^aLow/moderate poverty 60% households below 200% poverty; High poverty: >60% households below 200% poverty

Table 5
Mortality among women in NYC diagnosed with invasive cervical cancer, stratified by age at diagnosis ($N = 5,823$)

	Under 65 years ($N = 4,426$)			65 years and older ($N = 1,397$)		
	HR	95% CI	p-value	HR	95% CI	p-value
Race						
White	1.00	Reference		1.00	Reference	
Black	1.26	(1.09, 1.47)	0.002	0.84	(0.70, 1.00)	0.050
Puerto Rican	1.41	(1.13, 1.75)	0.002	1.18	(0.89, 1.57)	0.247
Other Hispanic	0.60	(0.49, 0.74)	<0.0001	0.44	(0.32, 0.59)	<0.0001
Asian/PI	0.72	(0.55, 0.93)	0.013	0.55	(0.40, 0.76)	<0.001
Poverty						
Low poverty	1.00	Reference		1.00	Reference	
Mod poverty	1.20	(1.03, 1.39)	0.018	1.03	(0.86, 1.24)	0.724
High poverty	1.35	(1.13, 1.60)	0.001	1.28	(1.03, 1.60)	0.029
Marital status						
Not Married	1.00	Reference		1.00	Reference	
Married	0.82	(0.72, 0.93)	0.002	1.01	(0.82, 1.24)	0.920
Unknown	0.62	(0.48, 0.81)	<0.001	0.98	(0.75, 1.29)	0.898
Stage						
Localized	1.00	Reference		1.00	Reference	
Regional	3.16	(2.71, 3.68)	<0.001	1.83	(1.49, 2.25)	<0.001
Distant	9.82	(8.29, 11.64)	<0.001	5.58	(4.43, 7.03)	<0.001
Unstaged/Unkn	2.30	(1.90, 2.79)	<0.001	1.92	(1.51, 2.44)	<0.001

Cox proportional hazards model adjusted for age (continuous), race, neighborhood poverty, stage, and marital status Overall p interaction race and age categorized younger than 65 years and 65 years or older = 0.0274, Overall p interaction poverty and age categorized younger than age 65 and 65 years or older = 0.0983