Original Report:
Cancer

Testicular Cancer Incidence and Mortality in New Mexico

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Objective: To examine incidence and survival of testicular cancer in New Mexico, overall and separately for border and non-border counties.

Methods: Incidence and 5-year survival rates for testicular cancer were obtained from the SEER18 database using the SEER*Stat program following established NCI protocols. Incidence data were compared using Student's t-test. Age-adjusted 5-year survival and Kaplan-Meier method were used to estimate survival. Log-rank tests were used to compare survival for New Mexico to the remaining17 geographical areas of the SEER 18 and for the New Mexico border counties to the New Mexico non-border counties. Odds ratios were used to compare testicular stage at diagnosis. Cox proportional hazards regression was performed to account for race/ethnicity, and border status.

Results: From 2000-2015, New Mexico had a testicular cancer incidence rate of 6.3 per 100,000 people, significantly higher than SEER18 (P<.001). The 5-year survival rate in New Mexico did not differ significantly from the SEER18 (P=.3). Border Hispanics had a lower survival rate than border non-Hispanic populations (P=.03). From 2000-2018, New Mexico had a significantly higher proportion of distant cancers than the SEER18 (OR: 1.29, 95% CI: 1.08 to 1.53, P=.005).

Conclusions: The higher incidence of testicular cancer in New Mexico does not appear to have a clear explanation based on the current understanding of risk factors; however, the increased incidence in New Mexico does not appear to be associated with increased mortality. The higher proportion of advanced testicular cancers in New Mexico may represent a delay in diagnosis. The increased mortality rate seen in Hispanic border populations may be due in part to barriers to care. *Ethn Dis*. 2020;30(2):357-364; doi:10.18865/ed.30.2.357

Keywords: Testicular Cancer; New Mexico; US-Mexico Border; Incidence; Survival

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Introduction

Testicular cancer is the most common cancer affecting American males between the ages of 15 and 35.[1] Diagnosis and treatment of testicular malignancy is generally accomplished by performing a radical orchiectomy, with any further treatment being guided by the histology, staging, and risk factors identified.[2] The majority of testicular tumors are identified while still confined to the testis and therefore do not require chemotherapy; however, more advanced testicular malignancies may require cisplatin-based combination chemotherapy, in addition to surgical and radiation therapies.[3] Strong advances in the treatment of testicular cancer have led to a high cure rate.[4] In the United States, the prognosis for testicular cancer is generally favorable, with an overall average expected 5-year-survival rate of 95%.[4] For localized tumors contained to the testis, the 5-year survival rate is 99%.[4]

The incidence of testicular cancer is increasing globally.[5] In the United States, the incidence among White males was 4.0 cases per 100,000 during 1973-1977 according to the Surveillance, Epidemiology, and End Results (SEER) 9 database.[5] The incidence increased to 6.4 per 100,000 from 2003-2007.[5] Many risk factors for testicular cancer have been established, with the most significant being undescended testicle (cryptorchidism),[6] Kleinfelter syndrome,[7] a family his-

tory of testicular cancer,[8] HIV infection,[9] non-Hispanic White race/ethnicity,[5] and estrogen exposure in-utero.[10] In the United States, the incidence rate was highest among White non-Hispanics at 6.57 per 100,000 from 1998-2011.[11] The second most commonly affected race/ethnicity was Hispanics (3.88/100,000), followed by American Indian/Alaskan Natives (2.88/100,000), Asian/Pacific Islanders (1.6/100,000), and African American (1.20/100,000).[12]

This study aims to gain insight into the incidence and 5-year survival rates of testicular cancer in NM to hopefully identify possible avenues for further research.

In terms of mortality, only Alaskan Native and Native American males showed statistically significantly higher mortality rates when compared with non-Hispanic White males.[12] While the incidence rate of testicular cancer is highest in the non-Hispanic White population, the incidence rate in the Hispanic population appears to be increasing at a faster rate than in other racial/ethnic groups.[11]

While testicular cancer has been analyzed in the United States as a whole, there is a paucity of literature examining the incidence and survival of testicular cancer in New Mexico (NM). NM has the second highest poverty rate in the United States, and is one of the most diverse states in the United States.[13] This diversity is most clearly observed in the large Hispanic and Native American populations.[13] In addition, NM faces a number of challenges related to health care delivery. Thirty-two of the 33 counties in NM are designated as medically underserved, defined as areas where the ratio of primary care medical provider to individuals is 1:2000 or less.[14] Rural communities in NM are unequally affected by this physician shortage. A report published by the Department of Health and Allied Agencies in 2013[15] reported that while approximately 49% of the NM population lived in three urban counties (Bernalillo, Santa Fe, Dona Ana), a disproportionate percentage of physicians practiced in these counties, including 58% of primary care physicians, 60% of internal medicine specialty physicians, 65% of surgeons, and 65% of other specialists. Previous studies have demonstrated that medically underserved areas have poorer health outcomes in terms of cardiovascular disease,[16] diabetes,[17] and cancer.[18] NM historically has had lower rates of insurance coverage when compared with other states in the United States;[19] however, the implementation of the Affordable Care Act has greatly decreased this discrepancy. Despite greater coverage overall, health discrepancies are still evident, with Hispanic adults being the least likely ethnic/racial group to have coverage in NM.[19] The unique qualities of the state of NM, in particular its diverse population and various barriers to health care delivery, make the state worthy of further investigation. This study aims to gain insight into the incidence and 5-year survival rates of testicular cancer in NM to hopefully identify possible avenues for further research.

Materials and Methods

Institutional Review Board (IRB)

This study was determined to be exempt by the Burrell College of Osteopathic Medicine IRB (IRB# 00491_2019).

Data Source

Data were obtained from the SEER18 registry.[20] The SEER18 registry is one of the most comprehensive databases available for cancer incidence and survival data, providing statistics for much of the United States and accounting for approximately 34.6% of the population from years 2000-2015.

Data Extraction and Characterization

Testicular cancer incidence and 5-year survival rates were obtained using the SEER*Stat 8.3.5.[21] program, following established National Cancer Institute protocols. Observed and age-standardized

rates were obtained for NM and for the remaining 17 geographical areas of the SEER18 registry (SEER18).

The NM data were further categorized based on county as either border or non-border, with border counties classified as being at least partially within 100 kilometers of the US-Mexico border. Based on this definition, the following counties were designated as border counties: Hidalgo, Luna, Dona Ana, Grant, Sierra, and Otero.

Statistics

Incidence data were compared using a Student's t-test for the following groups: NM vs the SEER18; NM Hispanic vs NM non-Hispanic; and the NM border counties vs the NM non-border counties. Age-standardized 5-year survival was calculated using the SEER*Stat 8.3.5 software with the international cancer survival standard 3 population used as the control population.[22] Age-standarized 5-year survival 95% confidence intervals were calculated using SEER*Stat 8.3.5 and were used to determine significant differences in age-adjusted 5-year survival. As there was insufficient data to evaluate age-standardized 5-year survival in the border counties, further analysis was performed using the crude survival data. Individual-level data on cancer cases were used to generate Kaplan-Meier (KM) curves and perform log-rank tests. KM curves were generated using the ggplot2 package for R.[23] The following variables were used in the determination of 5-year survival: "Number of intervals (calculated)" and "End calc vital status (standardized)". The "Number of intervals (calculated)" was the number of months survived post-diagnosis (0 – 60 months). The "End calc vital status (standardized)" was the final status of the individual five years post-diagnosis. There were three possible outcomes for this variable: alive, dead, and untraced. Censoring was performed for the untraced individuals in the data. Log-rank tests were performed to compare survival curves for NM to the SEER18, for NM border counties to the non-border counties, and for NM border non-Hispanics to NM border Hispanics.

Staging data were obtained using the updated SEER*Stat 8.3.6 program and included testicular cancer cases through 2018. The SEER summary staging was used to stratify the staged cancer cases based on TNMS staging into the following categories: localized, regional, or distant.

Odds ratios were calculated for stage of cancer at presentation (defined as either localized, regional, or distant) for NM vs the SEER18, the border vs non-border counties in NM, and the Hispanic vs non-Hispanic border populations in NM. An alpha level of .05 was used to determine statistical significance. Analyses were conducted using R and Excel.

Results

Incidence

From 2000-2015, 896 individuals were diagnosed with testicular cancer in NM. In comparison, the remainder of the SEER18 registry

Table 1. Age-standardized testicular cancer 5-year survival rates

		12 Months	24 Months	36 Months	48 Months	60 Months
	N	Age-Standardized (95% CI)	Age-Standardized (95% CI)	Age-Standardized (95% CI)	Age-Standardized (95% CI)	Age-Standardized (95% CI)
NM	896	90.3% (82.8-94.6)	86.4% (78.8-91.4)	85.5% (78.0-90.6)	84.5% (77.0-89.8)	83.8% (76.3-89.1)
SEER18	34,303	94.6% (93.9-95.3)	92.4% (91.6-93.1)	90.9% (90.0-91.6)	89.4% (88.5-90.3)	87.7% (86.7-88.6)
NM Hispanic	385	94.4% (88.8-97.3)	93.7% (88.2-96.7)	92.6% (87.2-95.8)	92.3% (86.9-95.6)	92.0% (86.5-95.3)
NM Non-Hispanic	511	89.7% (79.1-95.1)	84.9% (76.9-90.4)	84.0% (76.0-89.5)	83.8% (75.8-89.3)	82.9% (74.9-88.5)
NM Non-Border Counties	749	90.2% (82.6-94.6)	86.3% (78.7-91.3)	85.3% (77.8-90.5)	84.9% (77.4-90.1)	84.2% (76.7-89.4)

Age-standardized testicular cancer 5-year survival rates with 95% CI for NM, SEER18 registry without NM, NM Hispanic, NM non-Hispanic, and the NM non-border counties.
The NM border counties did not have sufficient cases to be able to calculate the age-standardized 5-year survival rates.
CI, confidence intervals; NM, New Mexico; SEER, Surveillance Epidemiology and End Results.

had 34,303 diagnosed testicular cancers during the same time period. Analysis of these cases revealed that NM had an incidence rate (IR) of 6.3 per 100,000, which was significantly higher than the 5.5 per 100,000 in the SEER18 (P<.001). NM Hispanics had an IR of 5.6 per 100,000, while non-Hispanics had a significantly higher rate of 6.8 per 100,000 (P=.006). There was not a significant difference in IR between the border counties and non-border counties in NM.

In addition, all groups except NM non-Hispanic, demonstrated an increasing trend throughout the study period. This increasing trend was more pronounced in the NM group as compared with the SEER18. In NM, testicular cancer increased from 5.5 cases per 100,000 individuals in the year 2000, to 6.5 cases per 100,000 individuals in the year 2015 (slope=.07). In comparison, the SEER18 increased from 5.3 cases per 100,000 to 5.7 cases per 100,000 (slope=.03).

Survival

As seen in Table 1, age-standardized survival in NM was lower than SEER18 at each time point; however, this relationship was not significant. Crude, non-age-standardized survival (data not shown) demonstrated that NM non-border counties had the lowest 5-year survival (92.1%) and NM border counties demonstrated the highest (96.6%); however, there was not a significant difference between the two groups (P=.07). The NM 5-year survival did not differ significantly from the SEER18 (P=.3). Hispanics living in border counties had a significantly lower survival rate than non-Hispanics living in border counties (P=.03). There was not a significant difference in survival between Hispanics in border counties and Hispanics in non-border counties (P=.9). NM Hispanic and NM non-Hispanic groups were compared, revealing no significant difference (P=.6)

The percentage of alive, dead, and untraced in the non-border and border counties revealed that 42% (61/146) were untraced in the border region. This was higher than the non-border counties with an untraced rate of 35% (261/745); however, there was not a significant difference between the two groups (P=.12).

Staging

Staging of testicular cancer is based on the Tumor, Node, Metastasis and Serum tumor marker (TNMS) classification.[20] Summary staging for NM, SEER18, NM Hispanics, NM non-Hispanics, border counties, non-border counties, border Hispanics, and border non-Hispanics is provided in Table 2. NM demonstrated a significantly higher proportion of distant testicular cancers at presentation when compared with the SEER18 (OR: 1.29, 95% CI: 1.08 to 1.53, P=.005). No significant difference was observed in regional staging (OR: .96, 95% CI: .81 to 1.13, P=.057). NM Hispanics did not show any significant differences in regional (OR: 1.006, 95% CI: .7217 to 1.4023, P=.9718) or distant (OR: 1.38, 95% CI: .98 to 1.95, P=.0678) staged cancers when compared with NM non-Hispanics. Border counties did not demonstrate a significantly different proportion of regional (OR: .86, 95% CI: .50 to 1.35, P=.504) or distant (OR

Table 2. Testicular cancer stage at diagnosis

	NM	SEER18	NM Hispanic	NM Non-Hispanic	NM Border Counties	NM Non-Border Counties	Hispanics in Border Counties	Non-Hispanic in Border Counties
Localized	68.4%	70.2%	66.5%	69.9%	69.1%	68.3%	58.6%	78.8%
Regional	16.8%[a]	18.1%	16.4%	17.1%	14.9%	17.2%	19.5%[a]	10.6%
Distant	14.8%	11.7%	17.1%	13.0%	16.0%	14.5%	21.9%[a]	10.6%

a. These results are indicative of significantly higher odds ratios.
SEER summary staging of NM, SEER18, Hispanics in NM, non-Hispanics in NM, border counties, non-border counties, Hispanics in border counties, and non-Hispanic Whites in border counties. A large percentage of testicular cancer cases listed in the SEER18 registry for NM did not have staging data recorded.
NM, New Mexico; SEER, Surveillance Epidemiology and End Results.

1.09, 95% CI: .70 to 1.71, P=.693) staged cancers when compared with the non-border counties.

Consistent with the 5-year survival results, border Hispanics showed more advanced cancer staging than border non-Hispanic populations in regard to regional (OR 2.47, 95% CI: 1.04 to 5.82, P=.039) and distant staging (OR: 2.76, 95% CI: 1.18 to 6.42, P=.019).

Many of the cancers were listed as "blank" signifying that the staging criteria was not met, that the staging may or may not have been done, or that it was not incorporated into the SEER database. Additionally, some cases were listed as "NA", meaning that they were not TNM defined, as may have been seen in the death certificate only cases. The unstaged cancers were excluded from the analysis of the staging data.

Discussion

We observed higher testicular cancer incidence rates in NM compared with the SEER18. An examination of the common risk factors for testicular cancer reveals no clear explanation. In NM, the HIV rates are much lower than the national average. In 2017, the national HIV infection rate was 11.8 per 100,000 and 5.9 per 100,000 in NM.[24] While cryptorchidism is a significant risk factor for testicular cancer, epidemiological studies have not been performed to examine the incidence of cryptorchidism in the NM population. In addition, non-Hispanic men have the highest risk for testicular cancer; however the demographics of NM do not support higher incidence rates based on that alone.[13] Nationally, Hispanics comprise 15.4% of the population, while 72.3% are designated as non-Hispanic.[25] In NM, 43.2% are designated as Hispanic, with 56.8% as non-Hispanic.[13] This is especially true in the border counties where the majority of the population is Hispanic.[26] Thus, attributing any of these risk factors to the increased incidence in NM seems unlikely.

NM demonstrated a significantly higher proportion of distant cancer at diagnosis when compared with the remaining SEER18; however, the more advanced staging at presentation did not appear to imply a higher 5-year mortality rate. As testicular cancer generally has a favorable prognosis, the low mortality overall may have made it difficult to identify a statistically significant difference in deaths between groups due to sparse data. Nonetheless, the higher proportion of distant staged cancers at diagnosis in the NM group as compared with the SEER18 may indicate a delay in diagnosis. NM faces several barriers to care including low insurance coverage, a physician shortage, and a rural population. Perhaps the most obvious barrier to care is the lower rates of insurance coverage in NM when compared with the United States.[27] In 2007, the percentage of uninsured adults in NM was 30.4%, while 18.9% adults nationally were uninsured.[26] The percentage of uninsured in NM has consistently decreased since the institution of the Affordable Care Act in 2010; however, in 2015 the uninsured population in NM was still above the national average at 16.5% and 13.2%, respectively.[26] Previous studies have shown that individuals without insurance have poorer outcomes when diagnosed with cancer, likely due to greater disease progression at time of diagnosis.[18] While outcomes in testicular cancer do not appear to be worse, the lower insurance coverage in NM could result in delayed detection and increased disease progression. Future studies on NM should examine this theory as the health insurance coverage improves in NM.

NM demonstrated a significantly higher proportion of distant cancer at diagnosis when compared with the remaining SEER18…

In NM, not only is there a deficiency in insurance coverage, but there is also a lack of available providers. Recent studies have shown that 32 of 33 counties in NM have a physician shortage (less than one physician per 2000 residents).[14] Lack of insurance, and lack of physicians likely compound upon each other resulting in increased disease progression. The rural na-

ture of NM likely also contributes to limited access to care.[28] In 2010, 22.6% of the NM population lived in a rural area[29] as compared with 19.1% in the United States.[30] Rural areas often have difficulty recruiting and retaining medical providers. In addition, inadequate transportation, patient financial difficulties, lack of specialty care, and lack of available services are possible barriers to care in rural areas.[31] Overall, rural populations demonstrate poorer health outcomes, along with higher rates of chronic disease when compared with their urban counterparts.[32]

In our study, border Hispanics had a higher mortality rate than their non-Hispanic counterparts. The low number of reported deaths in both the border Hispanic group (4) and the border non-Hispanic group (0) make any definitive conclusions difficult. Nevertheless, higher mortality rate in the Hispanic group may be explained by limited access to care experienced by border Hispanics. Shen et al reported that Hispanics living in border counties have significant barriers to care including lower rates of health coverage and decreased access to doctors.[33] The border counties in NM also have higher rates of poverty, an independent risk factor for poor health outcomes.[34] It is possible that these barriers to care limit early diagnosis. In our dataset, there were higher proportions of regional and distant cancers found in the Hispanic population living in border counties as compared with the non-Hispanic population living in border counties. While more robust analysis of testicular cancer mortality in NM is needed to confidently make the conclusion that Hispanics fare worse, the consistency between the more advanced cancers at diagnosis with worse 5-year survival implies that our results are likely in line with what would be found on a larger scale. It is unclear as to why the Hispanics living in the border region do worse, but this is a fascinating topic that deserves a more robust study with incorporation of the entire US-Mexico border region.

Strengths and Limitations

This study provides unique and novel insights into testicular cancer in the state of NM and discusses some of the potential explanations for the observed differences. To the best of our knowledge, this is the first study to examine incidence and survival data for testicular cancer in NM and along the US-Mexico border. This study utilized the SEER18 registry, which is fairly representative of the US population as a whole. However, SEER does overly represent urban areas, which is not the population of focus. As a retrospective study, it was not possible to sort study outcomes from other comorbidities or health detriments.

This study was limited by the low incidence of testicular cancer in the border counties. From 2000-2015, 896 cases of testicular cancer were recorded in NM. Furthermore, testicular cancer has a relatively low mortality rate. The relative rarity of the disease, coupled with the low mortality rate, made subgroup analysis by county and by racial/ethnic group more difficult due to scant data points. Future studies focused more fully on the border region should ideally include data from California, Arizona, New Mexico, and Texas. This would require gathering information from multiple databases and was beyond the scope of our New Mexico focused study. Additionally, there were many cases of testicular cancer that were untraced, meaning follow up data were not available. Lastly, analysis of stage at diagnosis was limited by the small number of high-grade cancers and the large percentage of unstaged cancers.

Conclusions

Testicular cancer in NM remains a complex story. The higher incidence of testicular cancer in NM is not readily explained by our current understanding of testicular cancer and its most common risk factors. Further, the increased incidence in NM does not appear to be associated with increased mortality when compared with the SEER18 aggregate. However, the higher proportion of distant cancers at presentation in NM when compared with the SEER18 aggregate, possibly suggests a delay in seeking care. Border Hispanics were the only group to demonstrate worse outcomes in terms of 5-year survival and a higher proportion of regional and distant cancers at diagnosis. This suggests that living in the border region may be playing a role in health outcomes regarding testicular cancer mortality in NM.

Conflict of Interest

No conflicts of interest to report.

Author Contributions

Research concept and design: Taylor, Woods; Acquisition of data: Taylor; Data analysis and interpretation: Taylor, McLeod, Gard, Woods; Manuscript draft: Taylor, McLeod, Gard, Woods; Statistical expertise: Gard; Administrative: Taylor, McLeod; Supervision: Taylor, Woods

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