Cancer Stage, Treatment, and Survival among Transgender Patients in the United States

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Key Words: Transgender persons, gender minority, cancer mortality, cancer treatment, cancer stage
Abstract

**Background**: Transgender persons face many barriers to healthcare that may delay cancer diagnosis and treatment, possibly resulting in decreased survival. Yet, data on cancer in this population are limited. We examined cancer stage at diagnosis, treatment, and survival among transgender patients compared to cisgender patients in the National Cancer Database (NCDB).

**Methods**: Gender (male, female, or transgender) was extracted from medical records from patients diagnosed with cancer between 2003–2016. Logistic regression estimated odds ratios (ORs) for the associations between gender and stage at diagnosis and treatment receipt. Cox proportional hazards regression estimated hazard ratios (HRs) for associations between gender and all-cause survival.

**Results**: Among 11,776,699 persons with cancer in NCDB, 589 were transgender. Compared to cisgender patients, transgender patients may be more likely to be diagnosed with advanced stage lung cancer (OR = 1.76, 95% confidence interval [CI] = 0.95, 3.28), less likely to receive treatment for kidney (OR = 0.19, 95%CI = 0.08, 0.47) and pancreas (OR = 0.33, 95%CI = 0.11, 0.95) cancers, and have poorer survival after diagnosis with non-Hodgkin lymphoma (HR = 2.34; 95%CI = 1.51, 3.63), prostate (HR = 1.91, 95%CI = 1.06, 3.45), and bladder cancers (HR = 2.86, 95%CI = 1.36, 6.00). Similar associations were found for other cancer sites, though not statistically significant.

**Conclusion**: Transgender patients may be diagnosed at later stages, be less likely to receive treatment, and have worse survival for many cancer types. Small sample size hampered our ability to detect statistically significant differences for some cancer sites. There is a need for transgender-focused cancer research as the population ages and grows.
The US population that self-identifies as transgender is estimated to be ~1.4 million adults [1]. Transgender is the umbrella term for a diverse group of individuals whose gender identity differs from their sex assigned at birth [2]. Cancer is an understudied topic in transgender health due to the paucity of available data [3]. Until recently, research on cancer in this population was limited to case reports or small studies [4]. There are several reasons why cancer burden may be higher among transgender individuals than their cisgender counterparts. Transgender persons who retain their natal reproductive organs are at risk for reproductive cancers and the risks related to long term use of gender affirming treatment with high dose estrogens or testosterone is currently unknown [3, 5, 6]. Due to societal stigma related to gender minority status, transgender people may also be at risk for cancers associated with elevated levels of smoking and excessive alcohol use in this community [7, 8]. The prevalence of HIV, hepatitis, and human papillomavirus infections is reportedly higher among transgender persons compared to their cisgender, heterosexual counterparts due to high rates of discrimination, economic marginalization, and unmet healthcare needs [9-13]. The increased prevalence of these viruses among gender minority adults may result in an increased incidence of AIDS-related cancers, as well as cancers of the liver and anus [3, 4, 14, 15].

Transgender patients face many barriers to cancer care at both the provider and patient level. Cancer screenings may be missed due to the lack of clinician training and transgender-specific screening guidelines [16, 17]. Transgender patients have also reported discrimination in medical settings [7, 18]. Due to stigma and discrimination, transgender individuals are also less likely to be employed and to have health insurance than cisgender patients [4, 7]. Consequently, there may be delays in cancer diagnoses and treatment, resulting in advanced stage disease at diagnosis and decreased survival among transgender individuals [4]. Information on the cancer
burden in this community will become increasingly important as the population ages and as best practice recommendations become more transgender-inclusive and culturally competent. We sought to examine the association between gender identity and cancer stage at diagnosis, treatment, and survival.

Methods

Study Population

We used data from >11 million US patients diagnosed with cancer between 2003–2016 from the National Cancer Database (NCDB), a hospital-based registry sponsored by the American Cancer Society and the American College of Surgeons. Sex was recorded in the medical record as “Male,” “Female,” and “Transsexual” (referred to herein as transgender). This field was updated in 2015 to include the patient’s natal sex (e.g. “Transsexual, natal male”) [19]. However, because only 3 cancer cases were delineated as such, we were unable to analyze transgender cases separately by natal sex. Patients with “Other (hermaphrodite)” were excluded because those with disorders of sex development may have unique cancer risk factors from those of transgender individuals [20]. Patients with missing data for sex were also excluded (Supplementary Figure 1).

Ascertainment of Cancer Outcomes

We examined first, primary cancers with ≥10 cases occurring in transgender adults classified with International Classification of Diseases for Oncology, 3rd Edition codes (Supplementary Table 1). Individuals with missing information for stage, diagnosis date, or last contact date were excluded (Supplementary Figure 1). Cancer stage at diagnosis was defined as
stages 0 (breast and bladder cancers), I, II, III, or IV using the sixth edition of the American Joint Committee on Cancer (AJCC) (https://cancerstaging.org/cstage/Pages/default.aspx) collaborative stage supplemented with AJCC Tumor, Nodes, and Metastasis pathological and clinical staging to compensate the high missingness in 2003 and 2016 due to AJCC staging coding change. The type of first course of treatment including surgery, radiation, and chemotherapy was recorded in NCDB.

Ascertainment of Covariates

NCDB collects information on patient demographics, socioeconomic status and clinical characteristics. These included age at diagnosis (18–44, 45–54, 55–64, or ≥65 years), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic [all races], or other), year of diagnosis (2004–2006, 2007–2010, or 2011–2014), median income level for the patient’s zip code (<$38,000, $38,000–$47,999, $48,000–$62,999, or ≥$63,000), insurance status (private, 18–64-year Medicare/Medicaid, ≥65-year Medicare/Medicaid, uninsured, or Government/unknown), and type of treating facility (community center, comprehensive community center, teaching/research institution, National Cancer Institute network cancer center, integrated network, or other/unknown).

Statistical Analysis

For each cancer site we used multivariable logistic regression to evaluate the associations between gender identity (transgender versus cisgender) and cancer stage at diagnosis (0, I and II versus III and IV) and receipt of cancer treatment (yes versus no). For lymphomas, receipt of treatment was defined as chemotherapy, radiotherapy, or a combination. For all other cancers,
treatment was defined as surgery, radiotherapy, chemotherapy, or any combination of these therapies. Those with missing treatment information were categorized as having no treatment. These models were adjusted for age, race/ethnicity, diagnosis year, and stage at diagnosis (in the treatment model only).

We used Cox proportional hazards regression to examine the association between gender identity (transgender vs. cisgender) and survival for each cancer site, adjusting for age at diagnosis, race/ethnicity, diagnosis year, stage at diagnosis, and treatment receipt. Follow-up was defined from cancer diagnosis until death from any cause, loss to follow-up, or end of 2017. Cases were limited to those cancers diagnosed before 2014 (2003–2013) to allow for enough follow-up time. The Schoenfeld residuals method was used to test the proportional hazards assumption, which was met for all models.

Additional models for stage, treatment, and survival were run further adjusted for type of health insurance. A sensitivity analysis was repeated for the treatment models excluding patients who refused treatment. All analyses were conducted in SAS 9.4.

**Results**

Among the 11,776,699 patients with cancer diagnosed between 2003–2016 in the NCDB, there were 589 patients recorded as transgender (Table 1). Compared to cismen and ciswomen, transgender patients tended to be younger, less likely to be non-Hispanic White, or to have private health insurance (all \( P<0.001 \)). The proportion of total cancers occurring in the anus, liver, and non-melanoma skin, as well as Hodgkin and non-Hodgkin lymphoma, were higher among transgender individuals than cisgender individuals, though the proportion of cancers occurring in the prostate was lower in transgender individuals than cismen (\( P<0.001 \)).
None of the associations between transgender identity and stage at diagnosis were statistically significant for any cancer sites (Table 2), though transgender patients may be more likely to be diagnosed at later stages for cancers of the lung (odds ratio [OR]= 1.76, 95% confidence interval [CI]= 0.95, 3.28) compared to cisgender patients. Transgender patients had lower odds of receiving treatment than cisgender patients for cancers of the kidney (OR= 0.19, 95%CI= 0.08, 0.47) and pancreas (OR= 0.33, 95%CI= 0.11, 0.95; Table 2). Gender identity was not associated with receipt of treatment for any of the other cancer sites. In an analysis where patients who refused treatment were excluded, the results did not differ materially from the main results (Supplementary Tables 2–4).

Transgender patients had two-fold or greater increased risk of death compared to cisgender patients for non-Hodgkin lymphoma (hazard ratio [HR]= 2.34 (1.51 to 3.63)), prostate cancer (HR= 1.91, 95%CI= 1.06, 3.45), and urinary bladder cancer (HR= 2.86, 95%CI= 1.36, 6.00; Table 3). Risk of mortality did not appear to differ between transgender and cisgender patients for other cancer sites.

Discussion

The current study includes nearly 600 transgender patients with cancer in a large national database. Transgender patients tended to be diagnosed with more advanced stage lung cancer and were less likely to receive treatment for kidney and pancreas cancers than cisgender patients. Further, transgender patients with non-Hodgkin lymphoma, prostate cancer, and urinary bladder cancer had worse survival compared to cisgender patients. These disparities persisted even after adjusting for health insurance and excluding individuals who refused treatment. No differences
in stage at diagnosis, receipt of treatment or survival were observed for the other cancer sites
examined.

Cancer screening among transgender patients is lower than their cisgender counterparts
due to several barriers to care [21-24]. Many clinicians are unaware of the unique health needs of
their transgender patients [16, 17]. For instance, physicians may perform cancer screening when
a patients’ gender changes in the medical record (e.g. prostate exams for transwomen) or
erroneously believe that the risk is lower due to assumptions about sexual behavior and gender
identity (e.g. cervical cancer screening for transmen) [23, 25]. Transgender patients also face
substantial financial barriers to healthcare as they are almost three times more likely than
cisgender individuals to be unemployed and thus, more likely to be uninsured or underinsured
[18, 26]. Patients have also reported mistreatment in healthcare settings, with 23% of transgender
people stating that they did not seek healthcare in the past year due to discrimination and stigma
from medical staff [7, 18]. The absence of transgender-specific screening guidelines, lack of
clinician cultural competence, and patients’ fear of discrimination can result in delays in cancer
diagnosis and treatment leading to poorer prognosis in this population [7, 17].

In transwomen, the prostate is not removed as part of gender-affirming surgery because
of possible complications, such as incontinence [27]. Previous research suggests prostate cancer
is rare among transfeminine patients due to treatment with antiandrogen and estrogen therapy,
possibly followed by bilateral orchiectomy [15, 28, 29]. Yet, while the incidence of prostate
cancer may be lower in transwomen than cismen, a growing body of research indicates that
prostate cancer could be more aggressive among transwomen, which may explain our finding of
increased mortality among transgender patients with prostate cancer [28]. Lower levels of serum
testosterone may paradoxically increase the risk for aggressive prostate cancer [30, 31]. Recent
research has also highlighted the role of exogenous estrogen therapy in prostate tumorigenesis [28, 32, 33]. Estrogen mediated through ER-α may have carcinogenic effects on the prostate alone [33] or it may be that a higher estradiol to dihydrotestosterone ratio may promote stromal cell growth [32]. Screening guidelines recommend the same standards for transwomen as cismen [32] even though the use of 5alpha-reductase inhibitors has been shown to decrease serum prostate specific antigen levels leading to under-detection of early lesions [34]. As a result of these findings, it has been suggested that prostate specific antigen levels of 1 ng/ml should be used as an upper threshold of normal or an increase from nadir of 0.3 ng/ml or greater for prostate monitoring in transwomen on antiandrogen therapy [27].

Our finding that mortality is elevated among transgender patients with non-Hodgkin lymphoma may be explained by underlying HIV infection. Worldwide the prevalence of HIV infection is high among gender minority adults. In the US it is estimated that 27.7% of transwomen are HIV positive, with the highest prevalence among African American transwomen (56.3%) [10]. HIV infection is associated with an elevated risk of AIDS-defining cancers such as Kaposi sarcoma, non-Hodgkin lymphoma, and cervical cancer as well as non-AIDS-defining cancers [35-38]. HIV is also associated with more aggressive disease and an increased risk of mortality from cancer [39-41]. Coghill and colleagues found that HIV infection was associated with a more advanced stage of disease in patients with cancers of the lung, breast, prostate, and bladder and melanoma of the skin and increased mortality in patients with breast and anal cancers [41].

Little research has been conducted in transgender patients with urinary bladder cancer. An analysis using Surveillance Epidemiology and End Results (SEER) observed a higher proportional incidence of bladder cancer among transgender individuals compared to cismen
women, but not cismen [5]. Another SEER analysis examining sex differences in bladder cancer survival found that ciswomen had lower 5-year survival compared to cismen, in part because ciswomen present with later stage at diagnosis and higher grade lesions [42]. This finding may suggest sex hormones play a role in the aggressiveness of this cancer. Testosterone has been found to promote bladder cancer carcinogenesis while estrogens appear to inhibit carcinogenesis but promote tumor progression [43, 44]. In animal studies, the observed sex difference in bladder cancer carcinogenesis disappeared when male mice were castrated and female mice were treated with testosterone [45]. Because we are unable to identify the natal sex of our transgender urinary bladder cancer cases, we are unable to shed light on the possible hormonal influence on mortality in our study.

While this is the first study of its kind to examine cancer presentation, treatment and survival among transgender individuals, our analysis was hampered by small sample size. The percentage of persons with first, primary cancers who identify as transgender was 0.005%, similar to a study conducted in the North American Association of Central Cancer Registries, which found 0.004% of patients had a transgender gender identity [14]. It is difficult to estimate the expected proportion of cancer in this population as the US transgender population has not been fully enumerated, though an estimated 0.6% of US adults identify as transgender [1]. Furthermore, the transgender population is younger than the general US population and those with cancer are not representative of the general population. Because gender identity was not self-reported by the patients themselves, we may have missed some transgender patients. Though, with over 11 million individuals, the number of transgender patients misclassified as cisgender is likely to be too small to change our results. Finally, the absence of data on sex
assigned at birth for the transgender patients precluded meaningful comparisons to cismen and ciswomen, respectively.

A thorough examination of cancer disparities among gender minorities relies on complete and representative data on both sex assigned at birth and gender identity [5, 46]. Groups such as the American Society of Clinical Oncology have called for the routine collection of these variables in cancer registries, electronic medical records, and clinical trials [4, 46, 47], which will allow for estimates of both cancer risk and more meaningful comparisons between transgender and cisgender patients [5, 46]. As the population ages and grows, there is a need for cancer research focused among transgender individuals.

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**Role of the funders:** The funders had no role in the design of the study; the collection, analysis, and interpretation of the data; the writing of the manuscript; and the decision to submit the manuscript for publication.

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**Data Availability**

The data underlying this article were provided by the American Cancer Society and the American College of Surgeons by permission. Data access can be requested directly from the American College of Surgeons: [https://www.facs.org/quality-programs/cancer/ncdb/puf](https://www.facs.org/quality-programs/cancer/ncdb/puf).

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Table 1. Characteristics of patients in the National Cancer Database by gender identity, 2003-2016

| Characteristics                        | Transgender (N= 589) | Cismen (N=5,627,603) | P-valueᵃ | Ciswomen (N=6,148,507) | P-valueᵇ |
|----------------------------------------|----------------------|----------------------|----------|------------------------|----------|
| Demographics                           |          |                      |          |                        |          |
| Age at diagnosis (years)               |          |                      | <0.001   |                        | <0.001   |
| 18-44                                  | 129 (21.9)| 415,069 (7.4)        |          | 755,202 (12.3)         |          |
| 45-54                                  | 148 (25.1)| 812,577 (14.4)       |          | 1,103,598 (17.9)       |          |
| 55-64                                  | 168 (28.5)| 1,619,691 (28.8)     |          | 1,481,905 (24.1)       |          |
| ≥65                                    | 144 (24.4)| 2,780,266 (49.4)     |          | 2,807,802 (45.7)       |          |
| Race/Ethnicity                         |          |                      | <0.001   |                        | <0.001   |
| White, non-Hispanic                    | 409 (69.4)| 4,439,481 (78.9)     |          | 4,792,259 (77.9)       |          |
| Black                                  | 94 (16.0)| 626,021 (11.1)       |          | 691,063 (11.2)         |          |
| Hispanic                               | 57 (9.7)| 310,632 (5.5)        |          | 365,393 (5.9)          |          |
| Other                                  | 19 (3.2)| 186,201 (3.3)        |          | 238,817 (3.9)          |          |
| Missing                                | 10 (1.7)| 65,268 (1.2)         |          | 60,975 (1.0)           |          |
| Year of cancer diagnosis               |          |                      | <0.001   |                        | 0.003    |
| 2003-2007                              | 165 (28.0)| 1,968,922 (35.0)     |          | 2,043,803 (33.2)       |          |
| 2008-2011                              | 203 (34.5)| 1,647,431 (29.3)     |          | 1,771,614 (28.8)       |          |
| 2012-2016                              | 221 (37.5)| 2,011,250 (35.7)     |          | 2,333,090 (37.9)       |          |
| Median area income level               |          |                      | 0.07     |                        | 0.02     |
| <$38,000                               | 157 (26.7)| 1,762,459 (31.3)     |          | 1,992,171 (32.4)       |          |
| $38,000-$47,999                        | 165 (28.0)| 1,485,186 (26.4)     |          | 1,627,660 (26.5)       |          |
| $48,000-$62,999                        | 137 (23.3)| 1,309,690 (23.3)     |          | 1,399,673 (22.8)       |          |
| ≥$63,000                               | 125 (21.2)| 1,006,517 (17.9)     |          | 1,067,294 (17.4)       |          |
| Missing                                | <10 (0.8)³| 63,751 (1.1)         |          | 61,709 (1.0)           |          |
| Cancer site                            |          |                      | <0.001   |                        | <0.001   |
| Esophagus                              | 10 (1.7)| 103318 (1.8)         |          | 27498 (0.4)            |          |
| Uterine Corpus                         | 10 (1.7)| --                  |          | 467455 (7.6)           |          |
| Pharynx                                | 11 (1.9)| 90334 (1.6)          |          | 23180 (0.4)            |          |
| Thyroid                                | 12 (2.0)| 92974 (1.7)          |          | 304677 (5)             |          |
| Hodgkin Lymphoma                       | 13 (2.2)| 38392 (0.7)          |          | 31925 (0.5)            |          |
| Brain & Other Nervous System           | 14 (2.4)| 110646 (2)           |          | 86478 (1.4)            |          |
| Other Non-Epithelial Skin              | 14 (2.4)| 25354 (0.5)          |          | 14980 (0.2)            |          |
| Urinary Bladder                        | 15 (2.5)| 186766 (3.3)         |          | 67245 (1.1)            |          |
| Pancreas                               | 16 (2.7)| 155598 (2.8)         |          | 153448 (2.5)           |          |
| Melanoma of the Skin                   | 17 (2.9)| 217743 (3.9)         |          | 169150 (2.8)           |          |
| Kidney & Renal Pelvis                  | 24 (4.1)| 268184 (4.8)         |          | 168479 (2.7)           |          |
| Liver & Intrahepatic Bile Duct         | 26 (4.4)| 137896 (2.5)         |          | 53839 (0.9)            |          |
| Rectum                                 | 26 (4.4)| 202545 (3.6)         |          | 149206 (2.4)           |          |
| Anus, Anal Canal & Anorectum           | 28 (4.8)| 19145 (0.3)          |          | 32861 (0.5)            |          |
| Breast                                 | 35 (5.9)| 19121 (0.3)          |          | 1976243 (32.1)         |          |
| Prostate                               | 36 (6.1)| 1546832 (27.5)       |          | --                    |          |
| Colon                                  | 39 (6.6)| 385231 (6.8)         |          | 414275 (6.7)           |          |
| Non-Hodgkin Lymphoma                   | 47 (8)  | 246405 (4.4)         |          | 215671 (3.5)           |          |
| Lung & Bronchus                        | 79 (13.4)| 822817 (14.6)        |          | 750083 (12.2)          |          |
| Other & Unspecified Primary            | 117 (19.9)| 958302 (17)         |          | 1041814 (16.9)         |          |
| Individual insurance status            |          |                      | <0.001   |                        | <0.001   |
| Any private                            | 281 (47.7)| 4,004,804 (71.2)     |          | 4,463,100 (72.6)       |          |
| 18-64 Medicare/Medicaid                | 198 (33.6)| 561,566 (10.0)       |          | 626,493 (10.2)         |          |
| ≥65 Medicare/Medicaid                  | 40 (6.8)| 652,591 (11.6)       |          | 712,300 (11.6)         |          |
| Uninsured                              | 53 (9.0)| 211,735 (3.8)        |          | 198,890 (3.2)          |          |
| Type of treating health facility       | Yes (n) | Yes (%) | No (n) | No (%) |
|---------------------------------------|---------|---------|--------|--------|
| Government/unknown                    | 17      | 2.9     | 147,724| 2.4    |
| Community center                      | 38      | 6.5     | 505,417| 8.2    |
| Comprehensive community center        | 186     | 31.6    | 2,426,115| 39.5  |
| Teaching/research institution          | 165     | 28.0    | 1,353,454| 22.0  |
| NCI network cancer center             | 90      | 15.3    | 738,115| 12.0   |
| Integrated Network                    | 78      | 13.2    | 792,605| 12.9   |
| Others/Unknown                        | 32      | 5.4     | 332,801| 5.4    |

| Receipt of treatment | |<0.001 |<0.001|
|----------------------|---------|--------|--------|
| Yes                  | 473     | 80.3   | 5,409,277| 88   |
| No                   | 116     | 19.7   | 739,230 | 12   |

*Comparing transgender patients to cismale patients. Two-tailed chi-square test.  
*Comparing transgender patients to cisfemale patients. Two-tailed chi-square test.  
*Includes acute lymphocytic leukemia (C91.0); acute myeloid leukemia (C92.0); chronic lymphocytic leukemia (C91.1); larynx (C32.0); multiple myeloma (C90.0); other digestive organs (C26.8 – C26.9, C48.8); other leukemia (C42.0, C42.1, C42.4); other and non-specified primary sites (C96); small intestine (C17); soft tissue (including heart) (C38.0, C47, C49); stomach (C16); testis (C62); tongue (C02); vagina & other genital, female (C52.9, C57.0 – C58.9); and vulva (C51)  
*For Hodgkin lymphoma and non-Hodgkin lymphoma, defined as chemotherapy, radiotherapy, or a combination of both. For all other cancer sites, cancer treatment was defined as surgery, radiotherapy, chemotherapy, or any combination of these therapies.  
*Cells with more than 0 but fewer than 10 individuals are suppressed
Table 2. Associations between transgender gender identity with stage at cancer diagnosis and receipt of cancer treatment by cancer site among patients in the National Cancer Database, 2003 – 2016

| Cancer site and stage at diagnosis                  | No. transgender cases | OR (95% CI)<sup>a</sup> | Received any cancer treatment<sup>b</sup> | No. transgender cases | OR (95% CI)<sup>c</sup> |
|---------------------------------------------------|------------------------|--------------------------|------------------------------------------|------------------------|--------------------------|
| Anus, Anal Canal & Anorectum                      |                        |                          |                                          |                        |                          |
| I and II                                          | 11                     | 1.00 (Referent)          | No                                       | <10<sup>e</sup>        | 1.00 (Referent)          |
| III and IV                                        | 14                     | 1.61 (0.73 to 3.56)      | Yes                                      | 26                     | 0.62 (0.14 to 2.69)      |
| Breast                                            |                        |                          |                                          |                        |                          |
| 0, I and II                                       | 24                     | 1.00 (Referent)          | No                                       | <10<sup>e</sup>        | 1.00 (Referent)          |
| III and IV                                        | 11                     | 1.80 (0.87 to 3.70)      | Yes                                      | 34                     | 0.97 (0.13 to 7.24)      |
| Kidney & Renal Pelvis                             |                        |                          |                                          |                        |                          |
| I and II                                          | 19                     | 1.00 (Referent)          | No                                       | <10<sup>e</sup>        | 1.00 (Referent)          |
| III and IV                                        | <10<sup>e</sup>        | 0.65 (0.24 to 1.77)      | Yes                                      | 17                     | 0.19 (0.08 to 0.47)      |
| Liver & Intrahepatic Bile Duct                    |                        |                          |                                          |                        |                          |
| I and II                                          | 14                     | 1.00 (Referent)          | No                                       | 13                     | 1.00 (Referent)          |
| III and IV                                        | <10<sup>e</sup>        | 0.76 (0.33 to 1.77)      | Yes                                      | 13                     | 0.65 (0.30 to 1.44)      |
| Lung & Bronchus                                    |                        |                          |                                          |                        |                          |
| I and II                                          | 12                     | 1.00 (Referent)          | No                                       | 20                     | 1.00 (Referent)          |
| III and IV                                        | 63                     | 1.76 (0.95 to 3.28)      | Yes                                      | 59                     | 0.74 (0.47 to 1.24)      |
| Melanoma of the Skin                              |                        |                          |                                          |                        |                          |
| I and II                                          | 11                     | 1.00 (Referent)          | No                                       | <10<sup>e</sup>        | 1.00 (Referent)          |
| III and IV                                        | <10<sup>e</sup>        | 2.11 (0.77 to 5.82)      | Yes                                      | 15                     | 0.34 (0.07 to 1.76)      |
| Non-Hodgkin Lymphoma                              |                        |                          |                                          |                        |                          |
| I and II                                          | 15                     | 1.00 (Referent)          | No                                       | 12                     | 1.00 (Referent)          |
| III and IV                                        | 29                     | 1.59 (0.85 to 2.97)      | Yes                                      | 35                     | 0.87 (0.44 to 1.69)      |
| Pancreas                                          |                        |                          |                                          |                        |                          |
| I and II                                          | <10<sup>e</sup>        | 1.00 (Referent)          | No                                       | <10<sup>e</sup>        | 1.00 (Referent)          |
| III and IV                                        | 10                     | 1.12 (0.41 to 3.08)      | Yes                                      | <10<sup>e</sup>        | 0.33 (0.11 to 0.95)      |

<sup>d</sup> Data not available for prostate cancer.
|            | OR (95% CI) | Transgender | 0, I, and II | III and IV | 0, I, and II | III and IV |
|------------|-------------|-------------|--------------|------------|--------------|------------|
| I and II   | 1.00 (Referent) | No | <10<sup>e</sup> | 1.00 (Referent) | 10 | 1.69 (0.81 to 3.55) | Yes | 30 | 0.82 (0.34 to 2.00) |
| Rectum     |             |             |              |            |              |            |
| I and II   | 1.00 (Referent) | No | 0            | 1.00 (Referent) | 12 | 1.00 (Referent) | Yes | 26 | —           |
| III and IV | 0.80 (0.35 to 1.82) | Yes | 26         | —           | —            |            |
| Urinary Bladder |             |             |              |            |              |            |
| 0, I and II| <10<sup>e</sup> | No | 0            | 1.00 (Referent) | <10<sup>e</sup> | 2.11 (0.76 to 5.89) | Yes | 15 | —           |
| III and IV | <10<sup>e</sup> | Yes | 15         | —           | —            |            |

<sup>a</sup> OR calculated with multivariable logistic regression for the association of being transgender (using cisgender as reference group) with Stages III and IV vs Stage 0 (if applicable), I, and II, adjusted for age at diagnosis (18–44, 45–54, 55–64, or ≥65 years), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, or other), and year of diagnosis (2004–2006, 2007–2010, or 2011–2014). Abbreviations: AJCC, American Joint Committee on Cancer; CI: confidence interval; No, number; and OR, odds ratio.

<sup>b</sup>Cancer treatment is defined as chemotherapy, surgery, and radiotherapy for all sites except lymphoma. Treatment for lymphoma, is defined as chemotherapy and radiotherapy.

<sup>c</sup>OR calculated with multivariable logistic regression for the association of being transgender (using cisgender as reference group) with cancer treatment, adjusted for age at diagnosis (18–44, 45–54, 55–64, or ≥65 years), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, or other), year of diagnosis (2004–2006, 2007–2010, or 2011–2014), and AJCC stage (0-II, III/IV, or unknown).

<sup>d</sup>Sex-specific site uses cismen only as reference group.

<sup>e</sup>Cells with more than 0 but fewer than 10 individuals are suppressed.

<sup>f</sup>An em-dash indicates that the cell size was too small to calculate the OR.
Table 3. Associations between transgender gender identity and mortality after cancer diagnosis by cancer site among patients in the National Cancer Database 2003 – 2013

| Cancer site and gender identity | No. of deaths | HR (95% CI)<sup>a</sup> |
|--------------------------------|---------------|--------------------------|
| Anus, Anal Canal and Anorectum |               |                          |
| Cisgender                      | 16,193        | 1.00 (Referent)          |
| Transgender                    | <10<sup>b</sup> | 1.01 (0.52 to 1.94)      |
| Breast                         |               |                          |
| Cisgender                      | 358,042       | 1.00 (Referent)          |
| Transgender                    | <10<sup>b</sup> | 1.23 (0.59 to 2.58)      |
| Kidney & Renal Pelvis          |               |                          |
| Cisgender                      | 127,260       | 1.00 (Referent)          |
| Transgender                    | <10<sup>b</sup> | 1.72 (0.82 to 3.61)      |
| Liver & Intrahepatic Bile Duct |               |                          |
| Cisgender                      | 111,818       | 1.00 (Referent)          |
| Transgender                    | 19            | 1.06 (0.68 to 1.67)      |
| Lung & Bronchus                |               |                          |
| Cisgender                      | 1,047,162     | 1.00 (Referent)          |
| Transgender                    | 46            | 1.13 (0.85, 1.51)        |
| Melanoma of the Skin           |               |                          |
| Cisgender                      | 78,729        | 1.00 (Referent)          |
| Transgender                    | <10<sup>b</sup> | 1.06 (0.51 to 2.22)      |
| Non-Hodgkin Lymphoma           |               |                          |
| Cisgender                      | 165,989       | 1.00 (Referent)          |
| Transgender                    | 20            | 2.34 (1.51 to 3.63)      |
| Pancreas                       |               |                          |
| Cisgender                      | 212,072       | 1.00 (Referent)          |
| Transgender                    | 12            | 1.37 (0.78 to 2.42)      |
| Prostate                       |               |                          |
| Cisgender                      | 261,123       | 1.00 (Referent)          |
| Transgender                    | 11            | 1.91 (1.06 to 3.45)      |
| Rectum                         |               |                          |
| Cisgender                      | 128,998       | 1.00 (Referent)          |
| Transgender                    | 12            | 1.32 (0.75 to 2.33)      |
| Urinary Bladder                |               |                          |
| Cisgender                      | 118,948       | 1.00 (Referent)          |
| Transgender                    | <10<sup>b</sup> | 2.86 (1.36 to 6.00)      |

<sup>a</sup>Adjusted for age at diagnosis, (18–44, 45–54, 55–64, or ≥65 years), year of diagnosis (2003–2007, 2008–2011, or 2012–2013), race/ethnicity (non-Hispanic White, Black, Hispanic, or other), AJCC stage (0-II, III/IV, or unknown), and treatment (yes or no). Abbreviations: AJCC, American Joint Committee on Cancer; CI, confidence interval; HR, hazard ratio; No, number.

<sup>b</sup>Cells with more than 0 but fewer than 10 individuals are suppressed