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Cancer disparities related to poverty and rurality for 22 top cancers in Florida

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ABSTRACT

We aimed to examine poverty and rurality as potential predictors of cancer health disparities. This cross-sectional study used data from the Florida Cancer Data System on all cancer diagnoses in the years 2014–2018 to determine age-adjusted incidence and mortality (per 100,000 population) for the 22 most common cancer sites within rural and urban counties, and high poverty and low poverty communities. Rural/urban and high/low poverty related cancer disparities were tested for statistical significance using the Rate Ratio statistical test. Overall cancer incidence was significantly lower in rural areas than in urban, but significantly higher in high poverty communities. Rurality and poverty were both associated with disparity in cancer incidence risk for tobacco-related cancers. The overall mortality was 22% higher in high poverty areas compared to low poverty areas. Ten cancer sites had mortality disparity from 83% to 17% higher in high poverty areas. Only three cancer sites, all tobacco-related, had higher mortality in rural areas than urban areas, demonstrating the intersectional nature of inhaled and smokeless tobacco use in rural low-income communities. Cancer and mortality rates in rural and urban areas may be largely driven by poverty. The high disparities related to high poverty areas reflects poor access to preventative care and treatment. Low income communities, rural or urban, will require focused efforts to address challenges specific to each population.

1. Introduction

Poverty drives health disparities more than any other factor (Chokshi 2018). Poverty contributes to disparities in cancer incidence and mortality in numerous ways (Boscoe et al., 2016; Egen et al., 2016; Moss et al., 2020), including through its association with tobacco use, obesity, and lack of access to cancer screening (Moss et al., 2020; Kollman 2018; Henry et al., 2014). Rurality also contributes to disparities in cancer health outcomes(Blake et al., 2017; Long, Hanlon, and Pellegrin 2018) due largely to the high poverty rates in rural areas (Zahnd et al., 2018), and engagement in cancer-initiating behaviors such as tobacco use (Gallaway 2018; Weg et al., 2011; Weaver et al., 2020). There are notable cancer health disparities related to rurality and poverty measured at the county level (Kollman 2018; Singh et al., 2004; DeSantis et al., 2011; Anderson et al., 2014; Patel et al., 2019; O'Connor et al., 2018), however, significant challenges exist for impoverished communities within counties designated as urban and more affluent. Dense communities of socioeconomically vulnerable populations live within high population density counties and thus require a statistical investigation below the county level.

Urban low income communities are highly vulnerable to cancer burden; they face challenges related to the cost of health care and marginalization, including lack of access to housing, insurance, funds and credit for out-of-pocket costs and needed services (Corburn 2017; Loftus et al., 2018; Mehdipanah et al., 2021). Urban areas have a higher poverty burden than rural areas when cost of living is taken into account (Nolan, Waldfogel, and Wimer 2017). Additional barriers to cancer screening for vulnerable populations relate to attitudes, beliefs and fears (Redmond Knight et al., 2015; Gesink et al., 2016; Hunleth et al., 2016), lack of health care providers and cost also prevent screening and early diagnosis in poor communities and contribute to those negative feelings and beliefs (Redmond Knight et al., 2015).

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Florida is the third largest and one of the most diverse states in the US, with sizable populations of Black and Hispanic residents, and the largest and fastest growing population over age 65 in the US (US Census Bureau n.d.). In states like Florida which did not expand Medicaid, lack of insurance is widespread in poor and median income households (Garfield and Damico, n.d.). Florida has the 4th highest population of uninsured residents of all states, with 2.8 million residents going without insurance in 2019 (December 03 and 2020 2020). Low income populations, regardless of rurality, may not be garnering the benefits provided by consistent sources of health care. Patients without consistent sources of accessible and affordable health care have less adherence to recommended cancer screening guidelines, such as pap smears to test for risk of cervical cancer (White et al., 2017; Silver and Kobrin 2020).

Here we examine the cancer incidence and cancer mortality in Florida, comparing rates in rural versus urban areas, and rates in high poverty versus low poverty communities, to determine the relative contribution to health disparities afforded by rurality and poverty.

2. Data/Methods

2.1. Study population and data sources

We obtained demographic and tumor data for patients in Florida with a cancer diagnosis between 2014 and 2018 from the Florida Cancer Data System (FCDS), a statewide population-based registry supported by the Florida Department of Health ("Florida Cancer Registry | Florida Department of Health" n.d.). Diagnoses were classified into cancer sites based ICD 10 codes following Surveillance, Epidemiology, and End Results (SEER) Program 2021 Coding Manual (diagnoses from all years were provided from FCDS as ICD-10) ("Appendix C: Site Specific Coding Modules – 2021 SEER Coding and Staging Manual" n.d.). Patient level mortality data were also obtained from the Florida Department of Health for years 2014–2018, including variables that were converted from the automated underlying cause-of-death coding rules into a fixed format to translate data into a form suitable for linking to the IDC-10 codes. The de-identified patient level cancer incidence data included census tract. The mortality data included residential addresses which were geocoded to point location using industry standard StreetMap Premium from ESRI.com, and the locations were used to obtain census tracts (2010). Percent population in poverty (5-year 2018) was obtained for each census tract from census.gov (US Census Bureau n.d.). Authors note that any published findings and conclusions are those of the authors and do not necessarily represent the official position of the Florida Department of Health.

Average annualized cancer incidence and cancer mortality were age standardized (based on 2000 US population weights) ("Standard Populations (Millions) for Age-Adjustment - SEER Population Datasets" n.d.) and calculated per 100,000 person-years (Klein 2001). Reoccurrences were defined as same site occurrence within two calendar years and were removed. Age-adjusted cancer incidence and mortality were calculated for each cancer, following SEER cancer type classifications ("Appendix C: Site Specific Coding Modules – 2021 SEER Coding and Staging Manual" n.d.).

We identified the top 20 cancers in Florida for incidence and the top 20 cancers for mortality (age-adjusted per 100,000). Prostate, cervical, uterine and female breast (in situ excluded) cancer incidence and mortality were calculated using only the relevant sex population in the denominator. A total of 22 cancer sites appear on at least 1 of these top 20 lists. This paper will investigate the disparity in incidence and mortality of these 22 cancer sites (Table 1). This study met the University of Florida Institutional Review Board data curator's guidelines for protection of human subjects concerning their safety and privacy.

Rural counties were identified with the definition used by the Florida legislature for rural initiatives and resource allocation. Florida Statutes 288.0656 identifies rurality based on population $< 75{,}000$, or $<$ 125,000 with three or more economic distress factors ("Statutes & Constitution:View Statutes: Online Sunshine" n.d.). Non-rural counties are referred to as urban. All census tracts (2010) were ranked from highest and lowest percent poverty (2018, US Census 5-year dataset). Florida's 2018 US Census 5-year poverty rate was 14.8 % (2018 US Census, state of Florida 5-year poverty rate). Census tracts were designated as either higher poverty or lower poverty using the cut-off 14.8 %. Age-adjusted cancer incidence and mortality rates were then calculated for *rural* and *urban* areas, as well as *high poverty* and *low poverty* areas in the state of Florida.

Table 1
Top 20 Cancers for age-adjusted incidence and top 20 for age-adjusted mortality rates in Florida, per 100,000, 2014–2018. Incidence data from Florida Cancer Data System, Mortality data from Florida Department of Health.

Florida age-adjusted incidence and mortality, 2014–2018					
Incidence			Mortality		
Rank	Site	Incidence	Rank	Site	Mortality
	All Sites	497.5		All Sites	140.8
1	Breast	122.1	1	Lung	34.9
2	Prostate	105.3	2	Breast	18.4
3	Lung	58.8	3	Prostate	15.9
4	Colorectal	38.5	4	Colorectal	12.4
5	Uterine	25.9	5	Pancreas	10.2
6	Melanoma	25.0	6	Liver	6.2
7	NH-Lymphoma	23.4	7	Ovary	5.9
8	Bladder	20.4	8	Leukemia	5.8
9	Leukemia	19.0	9	NH-Lymphoma	4.7
10	Kidney	15.5	10	Uterine	4.5
11	Oral & Pharynx	14.5	11	Bladder	4.2
12	Pancreas	13.7	12	Brain	3.9
13	Thyroid	12.9	13	Esophagus	3.5
14	Ovary	11.6	14	Kidney	3.1
15	Cervical	9.3	15	Myeloma	2.8
16	Myeloma	8.5	16	Oral & Pharynx	2.6
17	Liver	8.3	17	Stomach	2.5
18	Brain	6.2	18	Cervical	2.5
19	Stomach	6.1	19	Melanoma	2.2
20	Testis	4.92	20	Larynx	1.1

2.2. Statistical methods

In order to investigate the degree of disparity in cancer incidence risk related to rurality and poverty, and to identify the statistical significance of a particular disparity, we employed the *Rate Ratio*, also called the *Incidence Ratio Density* statistical test (Moss, Liu, and Feuer 2017; Tiwari, Li, and Zou 2010). We will refer to the rate ratio as the risk ratio (RR), as it demonstrates the disparity in cancer risk between two populations. The SEER Program of NCI has implemented this modified F-interval and has made it available to compare the age-adjusted rates for two nonoverlapping regions from the SEER*STAT software ("SEER*Stat Software" n.d.). This test provides reliable estimates of the cancer incidence ratio to reveal differences across two different populations. It is based on F-approximations and uses normal approximations to produce new confidence intervals (CIs) for each risk ratio. The RR method is more conservative than traditional F statistic approximations. The RR is calculated with Confidence Intervals with significance of $p \leq 0.05$. Confidence intervals excluding 1.0 indicate statistically significant disparity (or difference in rates at $p \leq 0.05$). All analyses were completed with SAS 9.4 (SAS Institute Inc.). This study was approved as exempt by the University of Florida Institutional Review Board.

2.3. Results

Florida residents had 472,416 cancer diagnoses, and 214,869 cancer related deaths between 2014 and 2018. There were 4245 residential census tracts (2010) in Florida of which 2413 (56.8 %) were classified as high poverty. Thirty-two counties were classified as rural, and 35 counties classified as urban. Twenty-two cancer sites appeared in at least

1 of the top 20 cancer lists for incidence and/or mortality. Breast, prostate, lung, and colorectal cancers were the top 5 cancers for both incidence and mortality (Table 1). Thyroid and testis cancers appeared in the top 20 for overall incidence but not mortality, while larynx and esophagus cancers appeared in the top 20 cancers for mortality but not for incidence. Liver, pancreas, and ovarian cancer rank higher in terms of mortality than overall incidence, while uterine and melanoma cancers, ranked higher for incidence than for mortality.

2.4. Disparity: The risk Ratio

Table 2 shows the risk ratio scores representing the disparity and statistically derived confidence intervals between area level cancer incidence and mortality rates. Cancer sites organized by risk ratio are graphically displayed in Figs. 1 and 2.

Rurality. *Overall cancer incidence* was slightly lower in rural counties than urban (RR 0.98, 95 % CI 0.97–0.98) (Fig. 1a, all RRs are reported at a significance of $p \leq 0.05$ and exact lower and upper confidence intervals are provided in Table 2 and graphically in figures). Four tobacco-related cancers (larynx (RR 1.30), lung (RR 1.27), oropharyngeal (RR 1.19), and colorectal (RR 1.06), were the only cancers with statistically higher incidence in rural areas compared urban areas. Risk ratios for incidence were lower in rural areas for six cancer sites: thyroid (RR 0.77), prostate (RR 0.82), non-Hodgkin's lymphoma (RR 0.86), bladder (RR 0.90), breast (RR 0.90), and uterine cancer (RR 0.91), meaning that incidence was statistically *higher* in *urban* areas.

Rurality and Cancer Mortality. The *overall* mortality risk ratio in rural areas compared to urban areas was 1.21 (Fig. 2a). This disparity in rural areas was driven by only three cancers with statistically significant risk ratios for mortality, all of which are tobacco related— oral & pharynx (RR 1.52), lung (RR 1.43) and colorectal (RR 1.32). No cancer site had a statistically significant lower mortality RR in rural areas. The mortality risk ratio for larynx and cervical cancer were high but not statistically significant. The mortality risk ratio for cancer of the pancreas was 1, indicating that rurality was not related to a disparity in risk of cancer mortality for this cancer.

Poverty. *Incidence of cancer overall* was statistically higher in high poverty areas compared to low poverty areas (RR 1.01) (Fig. 1b). Ten cancer sites—cervical (RR 1.52), liver (RR 1.43), larynx (RR 1.41), stomach (RR 1.27), lung (RR 1.22), colorectal (RR 1.20), uterine (RR 1.20), oral & pharynx (RR 1.12), and pancreas (RR 1.08), —had statistically higher incidence RR in high poverty areas compared low poverty areas. Risk ratios for incidence were lower in high poverty areas for seven cancer sites—melanoma (RR 0.59), testis (RR 0.76), thyroid (RR 0.81), breast (RR 0.90), leukemia (RR 0.91), bladder (RR 0.91), and NH lymphoma (RR 0.92) The poverty related mortality risk ratios for esophagus, myeloma, and kidney cancers were higher than 1 but not statistically significant.

Poverty and Cancer Mortality. The overall mortality risk ratio was 22 % higher (RR 1.22) in high poverty areas compared to low poverty areas (Fig. 2b). Eight cancer sites have higher mortality risk ratios for high poverty areas—larynx (RR 1.83), cervical (RR 1.64), stomach (RR 1.45), liver (RR 1.44), oral & pharynx (RR 1.41), uterine (RR 1.37), colorectal (RR 1.34), lung (RR 1.24), prostate (RR 1.29), and breast cancer (RR 1.17), with esophagus, testis, and kidney trended higher in high poverty areas, but not reaching statistical significance (Fig. 2b). Although a few RRs trended lower in low poverty areas (melanoma and brain) none were statistically significant. There were no cancer sites with mortality risk ratios that were significantly *lower* in high poverty areas compared to low poverty areas.

3. Discussion

Overall cancer incidence was lower in rural and higher in urban communities. Lung cancer incidence was higher in rural areas; however, there was higher prostate and breast cancer incidence urban areas. Breast cancer was also higher in low poverty communities. This trend reflected breast cancer ascertainment bias. Consistent with effective early cancer screening for well-resourced individuals, breast cancer incidence is higher in wealthier neighborhoods where residents have greater access to early preventative cancer screening (Krieger 2002). Rates of advanced stage breast cancer have been reported to be higher in women living in communities of high poverty (Williams and Thompson 2017), which is indicative of the lower access to early preventive screening for low income populations.

Compared to rurality, poverty was related to higher levels of disparity. In this study, the highest recorded statistically significant RR disparities were for mortality from larynx and cervical cancer. The mortality from larynx and cervical cancer in high poverty areas was 83 % and 64 % higher than the rate in low poverty areas, respectively. Mortality for cervical, stomach, liver, uterine, prostate and breast cancer showed significantly high disparities related to high poverty, but does not indicate disparity related to rurality.

Liver cancer incidence is 43 % higher, and mortality is 42 % higher, in high poverty areas. Nationally, liver cancer incidence has plateaued and may be starting to decline, with a positive trend toward earlier diagnosis of cases. However, these advancements have been largely in wealthier populations. Low income patients are still being diagnosed at advanced stages and have a higher risk of mortality, likely reflecting poor access to care and treatment (Wong et al., 2021).

Counties designated as having persistent poverty (defined as having $\geq$ 20 % of residents in poverty since 1980) have been shown to have higher cancer mortality (Moss et al., 2020). These persistent poverty counties are generally rural counties, and the trend is driven by tobacco-related cancers. In rural counties poverty and tobacco use are long-standing challenges, and access to tobacco products in rural areas may be higher ("USDA ERS - Descriptions and Maps" n.d.; Hall et al., 2019). This is true for Florida, a state with a smoking rate equal to the national rate (~15 %), but where rural counties have much higher rates, including 22 rural counties with smoking rates over $\geq$ 25 % ("Explore Health Rankings | Rankings Data & Documentation" n.d.). Florida has a higher rate of uninsured (16 %) than the national average (13 %), and those uninsured span rural and urban counties ("Explore Health Rankings | Rankings Data & Documentation" n.d.). Although, poverty is widespread throughout Florida's sparsely populated rural counties, 61 % percent of those living in high poverty communities are in urban counties, often concentrated in near urban cores in more densely populated counties (US Census Bureau n.d.).

We recognize that limitations to our analyses include the following: 1) We were using data from the national cancer reporting system, linking to census tract variables, which did not capture other risk behavior such as individual smoking, environmental exposure, or access/adherence to recommend screening etc.; 2) Some populations may be less likely to be captured in public health datasets and highly mobile populations (students, agriculture workers) may be receiving diagnoses at locations other than where they reside at any one point in time; 3) Cancer incidence varies by gender and age, which could be investigated further in a future study;(Cook et al., 2009) 4) Analyses that use different measures and/or categorizations of rural or high poverty status may yield slightly different results; 5) In this study we consider only rurality and poverty. Racial disparities in cancer health outcomes are significant, but racial disparities have been acknowledged in previous research because demographic information on race/ethnicity is commonly collected and reported at the patient level (O'Keefe, Meltzer, and Bethea 2015; Singh and Jemal 2017). Poverty related information is rarely included in large health related datasets, leaving researchers to rely on spatial linkages to the census tract 'neighborhood' to acquire related socioeconomic indicators to infer patient level financial burden, but only when addresses are available. Determining the exact contribution of poverty to the cancer burden of rural and urban counties is a future area of research that can inform interventions into these communities.

Table 2
List of all cancers that appear in top 20 cancers in Florida for incidence and/or mortality, 2014–2018 data for overall incidence, and mortality from the Florida Department of Health. * indicates statistical significance of risk ratio at $p \leq 0.05$ for lower or higher disparity, lower and upper confident intervals are given (LCL, UCL). Blue and coral colors indicate lower or higher disparity, respectively. Example – uterine cancer incidence is statistically lower in rural areas than urban areas and statistically higher in high poverty areas compared to low poverty areas.

Incidence		Rurality			Poverty		
Site		Urban	Rural	RR (LCL, UCL)	Low	High	RR (LCL, UCL)
Overall	497.5	498.2	486.1	0.98 (0.97, 0.98)*	485.2	488.3	1.01 (1.00, 1.01)*
Breast	122.1	122.8	110.3	0.90 (0.88, 0.92)*	124.5	112.5	0.90 (0.89, 0.92)*
Prostate	105.3	106.5	87.7	0.82 (0.80, 0.85)*	102.4	104.1	1.02 (1.00, 1.04)*
Lung	58.8	57.9	73.3	1.27 (1.23, 1.31)*	53.6	65.2	1.22 (1.19, 1.25)*
Colorectal	38.5	38.3	40.7	1.06 (1.01, 1.11)*	35.3	42.4	1.20 (1.16, 1.25)*
Uterine	25.9	26.0	23.8	0.91 (0.84, 0.99)*	24.3	27.5	1.13 (1.07, 1.20)*
Melanoma	25.0	25.1	23.8	0.95 (0.89, 1.02)	27.6	16.4	0.59 (0.56, 0.63)*
NH-Lymphoma	23.4	23.6	20.2	0.86 (0.79, 0.93)*	23.4	21.4	0.92 (0.87, 0.97)*
Bladder	20.4	20.5	18.4	0.90 (0.82, 0.98)*	20.6	18.7	0.91 (0.86, 0.96)*
Leukemia	19.0	19.1	18.2	0.96 (0.88, 1.04)	19.0	17.2	0.91 (0.85, 0.97)*
Kidney	15.5	15.4	16.3	1.06 (0.96, 1.17)	14.9	15.7	1.05 (0.98, 1.13)
Oral & Pharynx	14.5	14.3	17.1	1.19 (1.09, 1.31)*	13.7	15.0	1.09 (1.01, 1.18)*
Pancreas	13.7	13.7	12.8	0.94 (0.84, 1.04)	13.0	14.1	1.08 (1.00, 1.17)*
Thyroid	12.9	13.1	10.1	0.77 (0.67, 0.88)*	13.9	11.2	0.81 (0.74, 0.89)*
Ovary	11.6	11.7	10.9	0.93 (0.80, 1.09)	11.7	11.0	0.94 (0.84, 1.05)
Cervical	9.3	9.3	10.6	1.15 (0.97, 1.36)	7.7	11.6	1.52 (1.33, 1.73)*
Myeloma	8.5	8.5	8.5	1.00 (0.85, 1.17)	8.0	8.6	1.08 (0.96, 1.21)
Liver	8.3	8.3	8.9	1.08 (0.93, 1.24)	7.1	10.2	1.43 (1.28, 1.59)*
Brain	6.2	6.2	6.2	0.99 (0.80, 1.22)	6.4	5.7	0.90 (0.77, 1.04)
Stomach	6.1	6.1	6.0	0.99 (0.80, 1.21)	5.5	7.0	1.27 (1.11, 1.45)*
Testis	4.9	5.0	4.0	0.81 (0.59, 1.13)	5.4	4.1	0.76 (0.60, 0.96)*
Esophagus	4.9	4.8	5.4	1.11 (0.90, 1.37)	4.6	5.1	1.12 (0.94, 1.32)
Larynx	4.0	4.0	5.2	1.30 (1.02, 1.66)*	3.4	4.9	1.41 (1.17, 1.71)*
Mortality		**Rurality**			**Poverty**		
Site		Urban	Rural	RR (LCL, UCL)	Low	High	RR (LCL, UCL)
Overall	151.4	149.5	180.4	1.21 (1.19, 1.23)*	140.2	171.6	1.22 (1.21, 1.24)*
Lung	38.7	37.7	53.9	1.43 (1.38, 1.49)*	34.9	45.6	1.31 (1.26, 1.35)*
Breast	19.3	19.2	20.3	1.06 (0.96, 1.16)	18.2	21.2	1.17 (1.09, 1.25)*
Prostate	17.3	17.2	18.9	1.10 (0.99, 1.21)	15.8	20.4	1.29 (1.19, 1.39)*
Colorectal	13.3	13.1	16.3	1.24 (1.13, 1.37)*	11.9	15.9	1.34 (1.24, 1.45)*
Pancreas	10.7	10.7	10.8	1.00 (0.89, 1.13)	10.5	11.2	1.07 (0.98, 1.18)
Liver	6.5	6.4	7.1	1.11 (0.93, 1.31)	5.6	8.0	1.42 (1.24, 1.61)*
Ovary	6.4	6.4	6.2	0.96 (0.77, 1.20)	6.5	6.2	0.95 (0.81, 1.12)
Leukemia	6.3	6.3	6.7	1.07 (0.89, 1.28)	6.2	6.4	1.03 (0.89, 1.18)
NH-Lymphoma	5.1	5.1	4.9	0.95 (0.76, 1.19)	4.9	5.4	1.09 (0.93, 1.28)
Uterine	4.6	4.6	4.7	1.01 (0.77, 1.33)	4.1	5.6	1.37 (1.13, 1.67)*
Bladder	4.4	4.4	5.4	1.23 (0.99, 1.52)	4.3	4.8	1.12 (0.94, 1.34)
Brain	4.2	4.1	4.4	1.07 (0.83, 1.37)	4.3	3.9	0.90 (0.74, 1.10)
Esophagus	3.7	3.7	4.3	1.16 (0.90, 1.50)	3.5	4.1	1.18 (0.96, 1.44)
Kidney	3.4	3.3	4.0	1.19 (0.91, 1.56)	3.2	3.7	1.16 (0.93, 1.44)
Myeloma	3.0	3.0	3.1	1.04 (0.76, 1.43)	2.8	3.2	1.15 (0.90, 1.46)
Oral & Pharynx	2.8	2.7	4.1	1.52 (1.15, 2.01)*	2.4	3.4	1.41 (1.10, 1.81)*
Stomach	2.7	2.7	3.1	1.18 (0.85, 1.63)	2.3	3.4	1.45 (1.12, 1.87)*
Cervical	2.6	2.6	3.5	1.34 (0.91, 1.99)	2.1	3.5	1.64 (1.18, 2.28)*
Melanoma	2.4	2.4	3.1	1.32 (0.95, 1.85)	2.6	2.2	0.85 (0.63, 1.14)
Larynx	1.2	1.1	1.8	1.56 (0.93, 2.63)	0.9	1.6	1.83 (1.13, 2.97)*
Thyroid	0.5	0.5	0.5	1.14 (0.34, 3.83)	0.4	0.5	1.12 (0.43, 2.92)
Testis	0.3	0.3	0.3	1.05 (0.1, 11.09)	0.2	0.3	1.44 (0.24, 8.68)

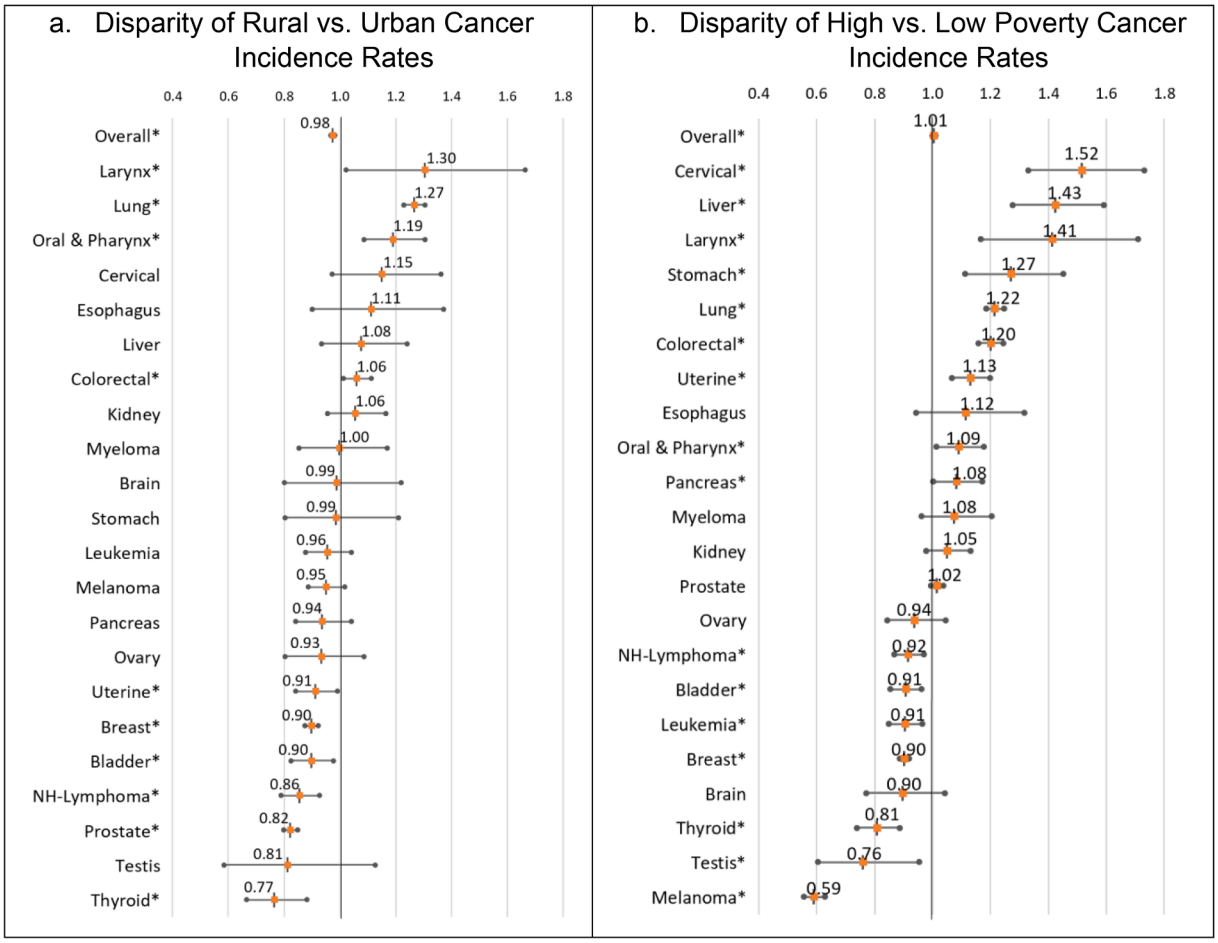

Fig. 1. Disparity *risk ratio* and *95% confidence interval estimations* for age-adjusted cancer incidence rates in Florida 2014–2018. Example – Larynx cancer incidence risk is 30% higher in rural residents than in urban residents (a.). Thyroid cancer incidence risk is 23% lower in rural residents than in urban residents. Cervical cancer incidence shows the largest disparity and is 52% higher in residents of high poverty areas than residents low poverty residents (b.). Although, cancer of the esophagus has a higher RR than cancer of the oral & pharynx or pancreas cancer, however it is not statistically significant.

4. Conclusion

Overall cancer incidence and cancer mortality were higher in high poverty communities. A lack of adequate health insurance coverage, which is a challenge in communities of poverty, is associated with less access to care, less timely and effective cancer prevention, diagnosis, and treatment, and poorer survival outcomes compared to cancer patients with health insurance coverage (Ward et al., 2008; Smith et al., 2019). Addressing insurance and cost-related barriers to care is a critical component of efforts to ensure access to high-quality cancer prevention, early detection, and treatment services.

In addition to poverty, other social determinants of health such as social isolation deserve attention (Georges E. Khalil, Jones, and Fujimoto 2021). Cancer initiating behaviors like tobacco use, obesity, and lack of physical activity may contribute to poorer cancer outcomes in low income and rural areas (Loomans-Kropp and Umar 2019). Those with exposure to others who engage in risky behaviors may be at higher risk of also adopting such behaviors (Georges E. Khalil, Jones, and Fujimoto 2021). Future research should investigate this dynamic by assessing rural and urban cancer inducing risky behaviors to elucidate the contributing factors to higher cancer incidence and cancer-related mortality in each population. Through such investigations, it becomes possible to tailor precision cancer prevention interventions. This line of research is supported by NCI's recent efforts to fund rural cancer control through the Division of Cancer Control and Population Sciences (Kennedy et al., 2018). Community outreach and patient engagement are also essential to the success of cancer control and prevention (Cheng et al., 2022). By engaging members of rural communities in local efforts in cancer control, their participation in behavioral health programs (e.g., screening, tobacco cessation and physical activity) and clinical trials also improves (Khalil et al., 2019).

Low income communities, rural or urban, will require focused efforts to address challenges specific to each population. However, it has been well documented that community socioeconomic stressors can relate to behaviors that increase cancer risk, such as tobacco use initiation, and poor diet (Kollman 2018), while also being associated with lower rates of cancer screening (Davis et al., 2017; Fedewa et al., 2017). Successful interventions, such as patient navigation and providing cancer education, can help to address the disparity between high and low poverty communities (Falk, Cubbin, and Jones 2020). Sustained policy and community-based efforts are required to address challenges suffered by all communities of poverty, both rural and urban. Collaborations with rural programs such as Cooperative Extension aim to improve education about screening, address social factors influencing health behaviors, and promote access to follow up care (Gutter et al., 2020). Tailored and targeted precision public health interventions are required to successfully address the challenges of the urban poor.

CRediT authorship contribution statement

Jaclyn M. Hall: Conceptualization, Data curation, Investigation, Visualization, Methodology, Writing – original draft, Writing – review &

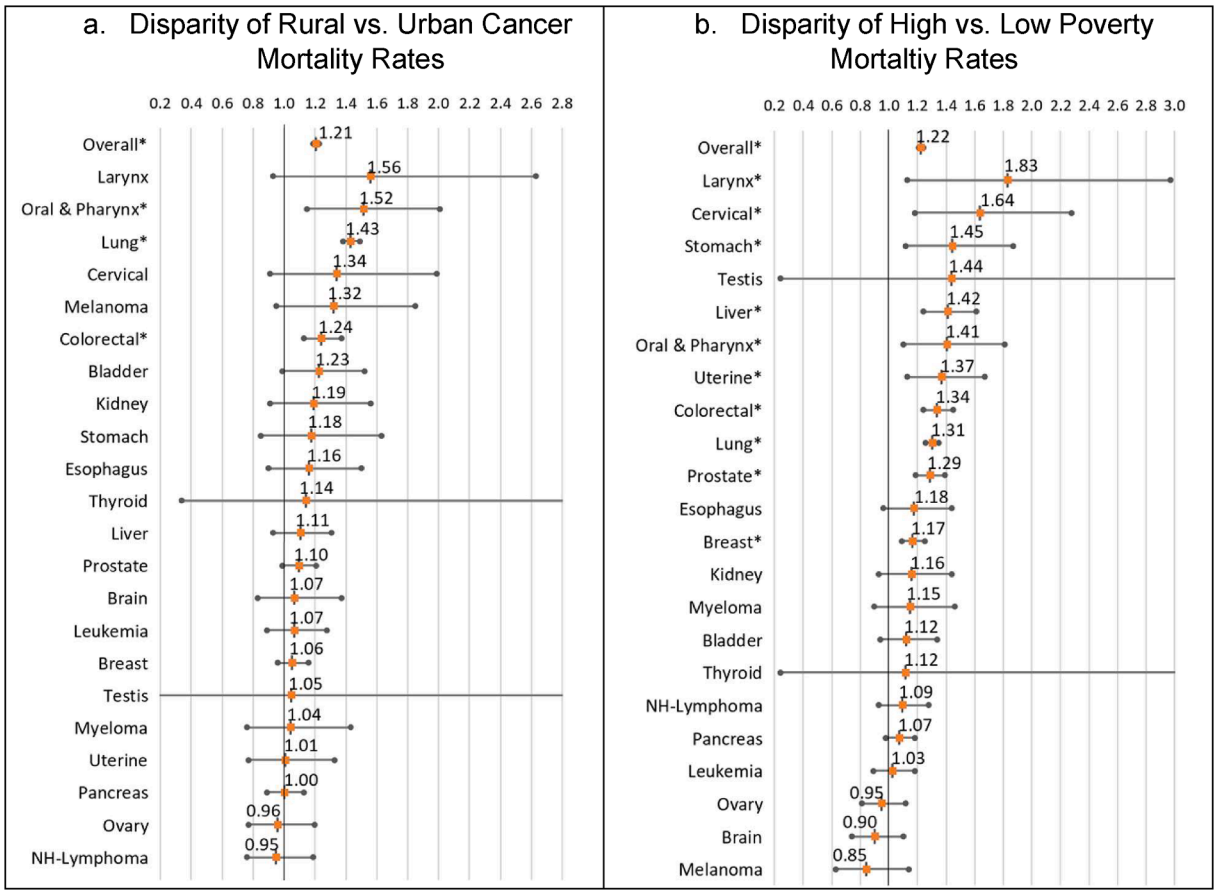

Fig. 2. Disparity *risk ratio* and *95% confidence interval estimations* for age-adjusted cancer mortality rates in Florida 2014–2018. Example – Mortality from oral & pharynx and lung cancer show the largest statistically significant RR, with oral & pharynx cancer mortality being 52 % higher in rural areas compared to urban (2a.). Larynx cancer mortality shows the largest disparity in both graphs, but its RR is only statistically significance related to poverty (2b.), with larynx cancer being 83% higher in high poverty communities compared to low poverty. Mortality of cervical cancer RR is not significantly related to rurality but is significantly related to high poverty area. Cancer mortality RR is not statically lower in rural areas or high poverty areas for any cancer. The mortality RR related to high poverty is similar for breast, kidney and myeloma, but only breast cancer mortality disparity is statistically significant. The disparity for larynx incidence and testis mortality is large, but being 22nd and 20th in the incidence list of 22 cancers means that they suffer from small numbers in the RR statistic.

editing. **Sarah M. Szurek:** Project administration, Investigation, Methodology, Writing – review & editing. **Heedeok Cho:** Data curation, Investigation, Validation, Visualization. **Yi Guo:** Supervision, Methodology, Resources, Software, Formal analysis, Writing – review & editing. **Michael S. Gutter:** Investigation, Visualization, Writing – review & editing. **Georges E. Khalil:** Writing – review & editing. **Jonathan D. Licht:** Writing – review & editing. **Elizabeth A. Shenkman:** Conceptualization, Project administration, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The authors acknowledge that this work was not supported by external funding.

Data availability

The data that has been used is confidential.

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