

# A Social-Ecological Review of Cancer Disparities in Kentucky

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**Abstract:** Cancer continuously ranks among the top 10 leading causes of death in the United States. The burden of cancer is particularly elevated in the Commonwealth of Kentucky and its 54-county Appalachian region, where cancer is the leading cause of death. Kentucky's high rates of cancer have been attributed to a wide range of socioeconomic, behavioral, environmental, and policy influences, resulting in numerous disparities. The present review specifically evaluates the burden of lung, colorectal, cervical, and head and neck cancers in Kentucky, along with resultant cancer control research and community outreach efforts conducted by the state's only National Cancer Institute–designated cancer center using an adapted version of McLeroy's Social-Ecological Model. Here, we categorize disparities and identify relevant intervention approaches based on their level of influence (ie, individual, community, and policy).

**Key Words:** Appalachia, cancer, disparities, Kentucky, social-ecological model

Despite national, state, and local efforts focused on reducing cancer incidence and mortality in the United States, cancer continues to be the second leading cause of death.<sup>1,2</sup> The burden of cancer is elevated significantly in the Commonwealth of Kentucky, where cancer is the leading cause of death.<sup>3</sup> Nationally, Kentucky ranks first in all-site cancer incidence and mortality, part because of the high rates of cancer in its eastern 54-county Appalachian region as compared with the non-Appalachian counties in central and western Kentucky (Table 1).<sup>4,5</sup>

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Kentucky's high rates of cancer are attributed to myriad socioeconomic, behavioral, environmental, and policy influences, which can be described using an adapted version of McLeroy's Social-Ecological Model (SEM). The SEM examines the interactions between and among individuals; their family and peer networks; their community, and local, state, and national policies, and determines the impact those interactions have on a person's health status and resultant disparities.<sup>6,7</sup> For example, using the SEM, an interaction can be observed between the distressed economic status (ie, employment, income, and poverty indicators in the lowest 10% of all US counties) of 69% of counties in Appalachian Kentucky,<sup>8</sup> the significant number of health professional shortage areas throughout the region,<sup>9</sup> the lower rates of Pap testing among Appalachian adult women, and the elevated cervical cancer mortality in the region.<sup>10</sup>

The present report uses the overarching tiers of influence in the SEM to frame cancer disparities in Kentucky and identifies areas for cancer control research and community outreach as undertaken by the state's only National Cancer Institute (NCI)-designated cancer center, the University of Kentucky (UK) Markey Cancer Center (MCC; Fig.). The review focuses on lung, colorectal (CRC), cervical, and head and neck cancers (HNCs), which have been identified as cancers in Kentucky with high incidence and mortality (Table 1),<sup>4,5</sup> but those that also are responsive to evidence-based prevention and screening interventions and health policy recommendations that lead to improvements in population health.

## Key Points

- Cancer is the leading cause of death in Kentucky and incidence and mortality rates are higher than the national average.
- Kentucky's high rates of cancer are attributed to disparities in socioeconomic status, exposure to environmental factors, limited access to health care, geographic isolation, lower rates of health literacy, and at-risk health behaviors such as tobacco use.
- McLeroy's Social-Ecological Model can be applied to identify approaches that could reduce the incidence and mortality rates of some cancer types (eg, cervical, lung, colorectal, head and neck cancers) that are most responsive to prevention and screening interventions.

**Table 1. Age-adjusted cancer incidence and mortality data for select cancers in the United States and Kentucky, 2010–2014**

	National ranking	US	Kentucky	% Difference	Non-Appalachian Kentucky	Appalachian Kentucky	% Difference
Age-adjusted cancer incidence rates per 100,000 population							
All cancer sites	1	452.1	521.1***	15.26	514.5	538.5***	4.66
Lung	1	61.2	95.3***	55.72	89.9	108.9***	21.13
Colorectal	1	39.8	50.0***	25.63	48.0	55.1***	14.79
Larynx	1	3.5	5.7***	62.86	5.1	7.2***	41.18
Oral cavity	1	11.5	14.1***	22.61	13.9	14.5	4.32
Cervix	8	7.6	8.7***	14.47	8.1	10.2**	25.93
Age-adjusted cancer mortality rates per 100,000 population							
All cancer sites	1	165.6	201.5***	21.68	191.8	226.1***	17.88
Lung	1	44.4	69.6***	56.76	64.4	82.4***	27.95
Colorectal	5	14.7	17.2***	17.01	16.0	20.2***	26.25
Larynx	3	1.0	1.5***	50.00	1.3	1.9***	46.15
Oral cavity	6	2.5	3.0***	20.00	3.0	3.1	3.33
Cervix	10	2.3	2.8***	21.74	2.6	3.3*	26.92

A rate ratio approach was used to test statistical difference between two age-adjusted rates. *P* values for Kentucky are calculated against US *P* values. *P* values for Appalachian Kentucky are calculated against *P* values for non-Appalachian Kentucky. Data sources are References 4 and 5.

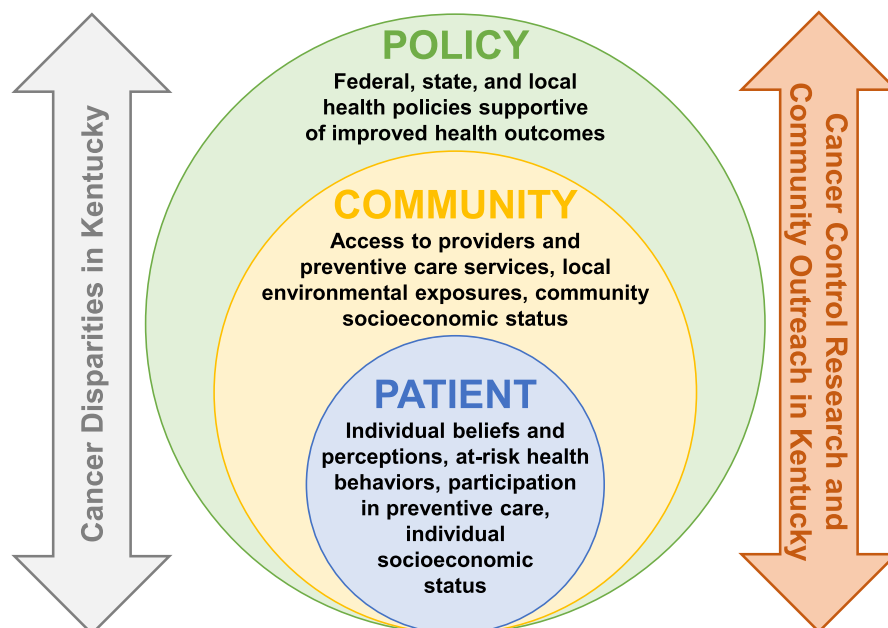
\**P* ≤ 0.05; \*\**P* ≤ 0.01; \*\*\**P* ≤ 0.001.

## Lung Cancer

Kentucky has the highest rates of lung cancer incidence and mortality nationwide. There is a 56% difference between lung cancer incidence in Kentucky and the United States and a 57% difference in mortality (Table 1).<sup>4,5</sup> As seen in Table 1, Appalachian residents have 5-year rates of lung cancer incidence and mortality that are higher than non-Appalachian residents.

## Patient- and Community-Level Influences

As reported by the NCI, the primary risk factors for lung cancer include exposure to tobacco smoke (firsthand or secondhand); a family history of lung cancer; human immunodeficiency virus (HIV) infection; environmental exposure to radon and radiation; air pollution; and workplace exposure to substances such as asbestos, arsenic, and chromium.<sup>11</sup> Approximately 80% to 90% of lung cancer cases are attributed to tobacco smoke.<sup>11</sup>



**Fig. McLeroy's Social-Ecological Model.**

As noted in Table 2, 26% of adults in Kentucky and 30% of adults living in Appalachian Kentucky are current smokers compared with 17% nationwide.<sup>12,13</sup> Contributing to the high rates of smoking is a historical and cultural context of tobacco farming in Kentucky. For instance, the 2012 Census of Agriculture data found that Kentucky has the highest number of tobacco farms and the second highest total tobacco acreage nationwide.<sup>14</sup>

Lung cancer screening rates are not reported on a state-by-state basis; however, in 2015, an estimated 6.8 million Americans were eligible for low-dose computed tomography screening based on their smoking status<sup>15</sup> (ie, any individual between the ages of 55 and 80 who currently smokes or has smoked  $\geq 30$  packs of cigarettes per year [or within the past 15 years]<sup>16</sup>). A mere 3.9% of those individuals received a low-dose computed tomography screening.<sup>15</sup> With national rates this low, it is unlikely that Kentucky lung cancer screening rates are near desirable levels among eligible candidates.

In addition to behavioral health risk, Kentuckians are exposed to high to moderate levels of radon,<sup>17</sup> the second leading cause of lung cancer,<sup>18</sup> because of the state's unique limestone, shale, and dolomite geology and karst topography.<sup>19,20</sup> Radon exposure, which is substantial in central Kentucky, is especially concerning in combination with the high levels of tobacco smoke exposure. Notably, 30 Kentucky counties are ranked as high potential radon zones (ie, radon exposure  $>4$  pCi/L) and an additional 67 counties are ranked as moderate potential radon zones (ie, radon exposure between 2 and 4 pCi/L).<sup>17</sup> Other environmental concerns include two major coal beds in eastern and western Kentucky containing high concentrations of heavy metals. The presence of multiple carcinogens (eg, arsenic, cadmium, chromium) in air, soil, and water is both naturally occurring and linked to mountaintop and other coal mining practices that may place residents at risk of lung cancer, among other malignancies.<sup>21,22</sup> Additional research that is specific to lung cancer development and exposure to heavy metals via natural occurrence and industry practices in Kentucky is needed.

## Policy-Level Influences

Kentucky's low tobacco product tax, lack of a statewide smoking ban, lack of spending on tobacco prevention programs, and low minimum legal age to purchase cigarettes exacerbate its high rates of smoking. Nationally, the average excise tax on cigarettes is \$1.71 per pack.<sup>23</sup> Kentucky has the 43rd lowest excise tax nationwide, at \$0.60 per pack.<sup>23</sup> In fiscal year 2016, the state of Kentucky collected \$302 million from the tobacco master settlement agreement; the Centers for Disease Control and Prevention (CDC) recommended Kentucky spend \$56.4 million of the 2016 master settlement agreement revenue on tobacco prevention programs.<sup>24</sup> Despite the CDC's recommendation, Kentucky spent only \$2.5 million (4.4% of the CDC's recommendation) on tobacco prevention programs.<sup>24</sup>

Regarding smoke-free policies, as of October 1, 2017, only 26 communities in Kentucky have enacted comprehensive smoke-free policies (ie, smoking is banned in work/public places).<sup>25</sup> Four communities have instituted smoking bans in public places, and 15 communities have smoke-free policies with significant exceptions (ie, specific places and tobacco products are excluded).<sup>25</sup> With current legislation, only 32.7% of Kentucky's workforce is protected from cigarette smoke in the workplace.<sup>26</sup> States such as California and Hawaii have enacted legislation raising the minimum legal sale age (MLSA) for tobacco products to 21 years in an attempt to prevent youth from ever starting to smoke. In 2015, the Institute of Medicine released a report stating that raising the MLSA to 21 years reduces smoking rates by approximately 12% and reduces smoking-related deaths by approximately 10%.<sup>27</sup> At the time of publication, the MLSA in Kentucky is 18 years.

One area of progress relates to state policy supporting tobacco cessation. Notably, Kentucky has passed Senate Bill 89, which mandates insurance and Medicaid coverage for US Preventive Services Task Force–recommended tobacco cessation treatment interventions or programs.<sup>28</sup>

**Table 2. Select cancer risk factor prevalence data for the United States and Kentucky, 2014–2016**

	US		Kentucky		Appalachian Kentucky	
	Rate	95% CL	Rate	95% CL	Rate	95% CL
Females aged 13–17 y who are up to date with HPV vaccination <sup>a</sup>	49.5	47.6–51.4	39.7	30.9–49.3	—	—
Males aged 13–17 y who are up to date with HPV vaccination <sup>a</sup>	37.5	35.8–39.2	28.5	21.0–37.3	—	—
Women aged $\geq 18$ y who had a Pap test within the past 3 y <sup>b</sup>	74.9	74.5–75.4	74.5	72.4–77.0	69.6	65.9–73.2
Adults who are obese (BMI $\geq 30.0$ ) <sup>c</sup>	28.9	28.7–29.1	33.1	32.0–34.2	39.1	37.2–41.1
Adults who are currently smokers <sup>c</sup>	17.0	16.9–17.2	26.0	24.9–27.2	30.1	28.2–32.0
Adults aged $\geq 50$ y who have ever had a sigmoidoscopy or colonoscopy <sup>b</sup>	68.9	68.5–69.2	69.6	67.8–71.4	63.2	60.4–66.2
Adults aged $\geq 50$ y who had a blood stool test within past 2 y <sup>b</sup>	15.0	14.7–15.3	14.6	13.3–15.8	16.0	13.7–18.3
Adults who reported heavy drinking <sup>c</sup>	5.8	5.7–5.9	5.7	5.0–6.3	3.8	2.9–4.7

<sup>a</sup>2016 data available from Reference 39.

<sup>b</sup>2014 data available from References 12 and 13.

<sup>c</sup>2014–2015 data References 12 and 13.

BMI, body mass index; CL, confidence limit; HPV, human papillomavirus.

## CRC

Despite notable increases in CRC screening and subsequent decreases in CRC incidence and mortality across the United States since the early 2000s, Kentucky continues to rank first nationwide for CRC incidence and fifth for CRC mortality (Table 1).<sup>4</sup>

### Patient- and Community-Level Influences

As reported by the NCI, individuals are at an increased risk of developing CRC if they are older than 50 years, have a personal history of CRC or high-risk adenomas, have a personal history of inflammatory bowel disease, have a family history of CRC, have an inherited risk (eg, Lynch syndrome), drink three or more alcoholic drinks per day, are obese, or smoke.<sup>29</sup> As noted earlier, Kentucky has significantly elevated smoking rates, and as presented in Table 2, one-third of Kentuckians are obese, with even higher rates in the Appalachian region of Kentucky (39%).<sup>12</sup> Primary screening tools for CRC include colonoscopy, sigmoidoscopy, and blood stool tests such as fecal immunochemical tests FITs.<sup>30</sup> Behavioral Risk Factor Surveillance System (BRFSS) data suggest that 70% of Kentuckians older than age 50 received a CRC screening endoscopy examination (vs 69% nationally) in 2014<sup>13</sup>; however, only 63% of Appalachian Kentuckians older than 50 reported receiving a CRC screening endoscopy in 2014 (Table 2).<sup>12</sup>

Barriers related to CRC screening are commonly cited by residents of Kentucky, including personal attitudes toward screening (eg, fear, discomfort, reticence), out-of-pocket costs, lack of provider recommendation and patient-centered communication, and lack of knowledge about screening examinations and where to obtain a colonoscopy.<sup>31–33</sup> In addition, patients have reported delays in treatment, which leads to them being less likely to seek treatment.<sup>34</sup>

### Policy-Level Influences

Kentucky policymakers and advocacy organizations have been active in implementing policies to help support CRC screening, including the passage of KRS 304.17A-257 (which provided coverage of “complete CRC screening based on ACS [American Cancer Society] guidelines” as a health insurance benefit without a copay or deductible) and KRS 214.540-544 (which helped establish the Kentucky Colon Cancer Screening Program [KCCSP]).<sup>35</sup> KCCSP receives CDC and state funding to provide free CRC screening tests to qualifying individuals. As a result of funding limitations, however, KCCSP cannot extend its program to the entire state; therefore, only 14 health departments provide free screenings, leaving more than half of the state’s counties without KCCSP services.

## Cervical Cancer

Kentucky ranks eighth nationwide for invasive cervical cancer incidence and tenth for related mortality.<sup>4</sup> As presented in Table 1, there is a 14% difference between Kentucky’s incidence rates

and those of the United States and a 22% difference in mortality.<sup>4</sup> In addition, 5-year invasive cervical cancer incidence and mortality rates in Appalachian Kentucky are higher than those in non-Appalachian Kentucky.<sup>5</sup>

### Patient- and Community-Level Influences

According to the NCI, cervical cancer risk factors include human papillomavirus (HPV) infection, diethylstilbestrol exposure, cigarette smoking, immunosuppression from HIV, long-term oral contraceptive use, and being sexually active at a young age or having had many sexual partners.<sup>36</sup> More important, almost all cervical cancer cases (>90%) are attributed to HPV, a sexually transmitted virus with an established preventive vaccine.<sup>37</sup> Updated CDC immunization recommendations state that individuals 15 to 26 years of age should receive all three doses of the HPV vaccine, and younger adolescents 9 to 14 years old should receive two doses.<sup>38</sup> As of 2016, only 40% of Kentucky adolescent girls are up to date with HPV vaccination requirements, compared with 50% nationally (Table 2).<sup>39</sup> Similarly, only 29% of adolescent boys in Kentucky are up to date with HPV vaccination requirements compared with 38% nationally.<sup>39</sup> Independent research studies have specifically identified low rates of HPV vaccination among adolescent girls 13 to 17 years old in Appalachia when compared with non-Appalachian adolescent girls.<sup>40</sup> Adolescent girls and young adult women in Appalachia have cited similar barriers to HPV vaccination, including lack of parental approval, misinformation about the vaccine, lack of provider recommendation, transportation barriers, fatalistic beliefs, and lack of knowledge related to the link between HPV and cervical cancer.<sup>41–44</sup>

Pap smears and HPV testing are used to screen for cervical cancer based on age, prior test results, and time intervals.<sup>36</sup> BRFSS data from 2014 suggest that Pap smear screening rates in Kentucky (75%) were similar to national screening rates (75%); however, Appalachian Kentucky screening rates are lower at 70% (Table 2).<sup>12,13</sup> Moreover, follow-up care for abnormal Pap smears has been noted as being lower in Appalachian Kentucky.<sup>45</sup> Fears related to what physicians may find upon further examination, privacy concerns, fear that the test will be painful, and transportation issues have been cited as barriers to receiving follow-up care.<sup>45</sup>

### Policy-Level Influences

To increase vaccination rates among adolescents, Rhode Island, Virginia, and Washington, DC have enacted HPV vaccination mandates for school entry.<sup>46</sup> As a result, these states and the District have seen an increase in vaccination rates either at or above the national average for males and females.<sup>47</sup> Kentucky does not have a school-mandated HPV vaccination requirement, nor is HPV vaccination required to be reported in the state’s immunization registry. Related to screening, with Medicaid expansion, rates of cervical cancer screening in Kentucky increased by 88% among Medicaid enrollees from 2013 to 2014, however.<sup>48</sup>

## HNCs

For the purposes of this review, HNCs are defined as cancer of the larynx and oral cavity. Kentucky ranks first for 5-year incidence rates for cancer of the larynx and oral cavity, respectively.<sup>4</sup> In addition, Kentucky ranks third nationally for larynx cancer and sixth for oral cavity cancer mortality (Table 1).<sup>4</sup>

## Patient- and Community-Level Influences

According to the NCI, tobacco and/or alcohol use, HPV infection, betel quid or gutka chewing, and a personal history of HNC have been linked to an increased risk of HNCs.<sup>49</sup> As discussed earlier, Kentucky has high rates of smoking and low rates of HPV vaccination. BRFSS data from 2016 indicate that 13.6% of men in Kentucky currently use smokeless tobacco.<sup>50</sup> Rates of heavy drinking in Kentucky and Appalachian Kentucky are lower than the national average (Table 2).<sup>12,13</sup>

## Policy-Level Influences

Because of the overlapping risk factors between lung and cervical cancers and HNCs, there are shared policy-level interventions that can be implemented to reduce the burden of HNCs in Kentucky. As previously discussed, rates of smoking and limited HPV prevention in Kentucky are influenced by the lack of HPV school vaccination requirements, lower tobacco excise taxes, lower minimum legal age to purchase tobacco, and limited comprehensive smoking bans.

## Discussion

Research has been published related to cancer disparities in Kentucky and Appalachia. A unique contribution of the present review, however, is the application of the tiers of influence found in the SEM to multiple cancers prevalent in Kentucky that are amenable to evidence-based prevention and screening strategies and health policy recommendations that have implications for improvements in population health. The review identified overarching themes and barriers to healthful living, including individual and communal beliefs and perceptions about cancer prevention and screening, increased at-risk health behaviors such as tobacco use and higher rates of obesity, lack of provider recommendation for guideline-recommended cancer screening and immunization, barriers to access to care, environmental exposures to carcinogens, and limited state health policies supporting positive health outcomes.

Another contribution of this review is the identification of areas of intervention through both cancer control research and community outreach as led by the state's only NCI-designated cancer center, the UK MCC.<sup>51</sup> The MCC specifically supports a clinical and research network, cancer control research studies, collaborative community programming, and policy initiatives addressing specific barriers and levels of influence addressed by the present review that may serve as a model for other cancer centers' work in their respective communities.

For example, at the individual and community levels, the MCC Network collaborates with 26 community hospitals in Kentucky to deliver cutting-edge clinical trials, advanced cancer care and screening, community education, and training for healthcare professionals.<sup>52</sup> The MCC Network supports the concept that high-quality cancer care should be delivered "close to home," which helps to address issues related to distance and travel for rural residents and increases the capacity of local healthcare facilities and their providers. MCC researchers also have engaged with hundreds of individuals in Appalachian Kentucky through faith-placed cervical cancer screening and smoking cessation interventions delivered by lay health advisors.<sup>53,54</sup> Multilevel interventions are delivered by the Kentucky LEADS (Lung Cancer. Education. Awareness. Detection. Survivorship.) Collaborative and the Terminate Lung Cancer study teams, both of which aim to increase healthcare providers' implementation of high-quality lung cancer screening and tobacco cessation treatment, and raise community awareness of lung cancer screening services.<sup>55-57</sup> Similarly, BREATHE (Bridging Research Efforts and Advocacy Toward Healthy Environments), a coalition of research programs including the Tobacco Policy Research Program, the Kentucky Center for Smoke-free Policy, and the Radon Policy Research Program, helps support smoke-free communities and worksites, radon control and mitigation, and smoking cessation activities in Kentucky.<sup>58-61</sup>

Related to CRC, the MCC has a long history of working with 15 local cancer coalitions across the state to implement multi-component strategies such as academic detailing with primary care providers, engaging the faith community to promote CRC screening, using small and mass media to increase community demand for screening services, and supporting KCCSP. As a result, Kentucky has moved from 49th (34.7% in 2001) to 23rd (69.6% in 2014) among all states for guideline-adherent CRC endoscopy screening; the state CRC incidence rate has fallen by 24% and the mortality rate has decreased 30%. In complementary efforts to increase CRC endoscopy screening, MCC-based outreach staff are evaluating the impact of community-based distribution of FIT kits in Appalachian Kentucky and navigation of individuals to follow-up testing and treatment as appropriate, and MCC investigators are testing the impact of tailored health communication messages to promote annual adherence to FIT testing. As noted in Table 2, in 2014 Appalachian adults reported slightly higher blood stool testing rates compared with national and state estimates. Similar community-based efforts have been conducted with HPV vaccination, including partnerships with schools and health departments, with a focus on adherence to the full series<sup>41,62,63</sup> and recruitment of women via free health clinics, community events, and health departments to self-collect a cervicovaginal swab, followed by HPV testing and navigation to Pap testing if needed.<sup>64,65</sup>

As a final example of MCC's work in the community, given the presence of environmental carcinogens in Kentucky, the UK Center for Appalachian Research in Environmental Sciences has established a regionally focused research and community

engagement infrastructure to foster innovative studies of environmental factors in chronic diseases such as cancer and community health disparities.<sup>66</sup>

Although this review is, to the best of our knowledge, novel in its purpose to identify and address specific cancer burdens in Kentucky as aligned with the primary levels of influence found in the SEM, there are noted limitations. The review is not exhaustive in its identification of disease risk factors, influences, and related interventions. Indeed, other causative factors such as the significant socioeconomic disparities present in Kentucky, residents' genetic makeup, historical residential and occupational exposures, unique geology, and the extreme prevalence of tobacco use and obesity may explain any observed differences within Kentucky and between other areas of the United States. In addition, we did not explicitly address familial and peer influences or national health policies that may affect individuals' health behaviors and outcomes. Last, we recognize that the MCC is just one entity among a host of dedicated organizations and stakeholders committed to reducing the incidence, morbidity, and mortality of cancer in Kentucky.

## Conclusions

Kentucky's high rates of cancer and continuous ranking in the top 10 for multiple cancer sites signify that there are tangible health concerns in the state. Addressing the disparities outlined in this review requires mounting a collaborative, multilevel effort that is centered on reducing individual and community-level health disparities, empowering the public and providers with cancer information and education, and improving health policy—all with the goal of reducing Kentucky's significant cancer burden and improving quality of life among its constituents.

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