

# THE PUTATIVE ROLE OF ENVIRONMENTAL CHEMICAL EXPOSURE IN THE DEVELOPMENT OF CERVICAL, PROSTATE AND COLORECTAL (CPC) CANCERS IN JAMAICA

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**Abstract – Objective:** Heavy metals in human tissues are thought to both develop and progress some types of cancers. Industrial mining in Jamaica has resulted in documented environmental and health issues. Mapping of soils in Jamaica shows major deposits of cadmium from bauxite mining in the central parts of Jamaica, which is significantly higher (100 to 1000 times) than worldwide critical limits. The present study was done to ascertain if there is a relationship between areas with high densities of cadmium and cervical-prostate and colorectal (CPC) cases.

**Patients and Methods:** This was a retrospective study; clinical records of CPC patients were abstracted from hospital files. Cases of CPC were categorized by parish and then compared with the distribution of cadmium in these parishes. The relationship between the numbers of CPC cases high cadmium density was explored using Pearson's Chi.

**Results:** Compared to the mean number of cases across Jamaica, parishes with high cadmium levels had a significantly higher proportion of CPC cases ( $p < 0.05$ ).

**Conclusions:** The higher number of CPC cases in parishes with reported cadmium levels cadmium suggests a plausible relationship. More work will be needed to establish if there is a definitive link between the levels of cadmium in CPC cases compared to healthy individuals.

**KEYWORDS:** Cadmium, Caribbean, Cervical cancer, Colorectal cancer, Environment, Heavy metals, Industrial mining, Jamaica, Prostate cancer.

## INTRODUCTION

The etiology of Cervical, Prostate, and Colorectal (CPC) cancers has been examined and researched extensively. Studies done by other researchers have aided in having a better understanding of each cancer which led to the development of screening programs, prophylactic treatments, and finally, the development of more targeted therapy.

This improved understanding of the disease has yielded better prognoses and fewer side effects <sup>1</sup>. Investigators have long since acknowledged that none of these three cancers have one main mechanism of carcinogenesis, instead, most research has shown that these cancers are often because of several risk factors working in tandem to create an environment for carcinogenesis <sup>2-6</sup>. Colorectal cancer can be found in both men and women. It



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remains one of the most common non-sex-specific malignancies globally <sup>7</sup>. In recent decades, studies have shown that about 5%-10% of colorectal cancer can be attributed to inherited mutations of well-established cancer-related genes and then about 25% of cases have a family history of colorectal cancer <sup>8,9</sup>. As a result of these studies, colorectal cancer has been the focus of targeted therapies such as monoclonal antibodies and in most recent years, immunotherapy. Immunotherapy has shown promising results in other cancers such as gastrointestinal malignancies and two drugs classified as immune checkpoint inhibitors have been approved in some countries for use in some cases of colorectal cancer <sup>10</sup>. Epidemiological research has found that about 75% of cases of colorectal cancer are found to be sporadic, meaning that it occurs in individuals who do not have a genetic predisposition or a family history of colorectal cancer <sup>9</sup>. This, therefore, suggests that only about 25% of colorectal cancer can be successfully treated with immunotherapy which limits the reach of this line of treatment. Therefore, even with these promising advances in treatment for colorectal cancer, immunotherapy will only work in individuals with specific immune markers that are being targeted by the specific drug, this means that there is still the issue of individuals whose colorectal cancer has not been linked to any genetic or inherited factors. Colorectal cancer is an environmental disease. When describing the word environmental as it relates to colorectal cancer, it is given a broad definition to include social, cultural, and lifestyle risk factors <sup>11</sup>. Many researchers do acknowledge that there is a wide range of risk factors for colorectal cancer such as inflammation, as well as lifestyle factors such as obesity, consumption of red meat, tobacco, and alcohol consumption <sup>8,12-14</sup>. Additional, risk factors such as environmental mutagens, the contribution of immune-mediated mechanisms have been theorized to often exacerbate or increase the likelihood of established genetic or hereditary factors resulting in carcinogenesis <sup>8</sup>. When listing environmental mutagens as risk factors of colorectal cancer carcinogenesis, the compounds that are normally implicated are carcinogenic compounds that cause gene mutations, these include polycyclic aromatic hydrocarbons (from burning of gas, wood, garbage, and tobacco), heterocyclic amines, nitrosamines, and aromatic amines <sup>15</sup>. Studies on the relationship between heavy metals and colorectal cancer are limited, however, there have been a few that compared the levels of heavy metals in the blood of colorectal cancer patients to a control group (healthy individuals). The result from one study found significant differences

in trace elements and heavy metals levels between healthy subjects and metastatic colon cancer patients <sup>16</sup>. Colorectal cancer is on the list of cancers with modifiable causes that can be readily identified including risk factors such as dietary, and lifestyle factors such as physical inactivity and obesity <sup>11,17,18</sup>. With easily identified modifiable causes, it is believed that a vast majority of colorectal cancer cases are preventable, yet colorectal cancer remains one of the most common cancers globally <sup>7,19</sup>.

## Prostate Cancer

Prostate cancer remains one of the most frequently diagnosed cancers in men worldwide despite advances in treatment and screening <sup>7</sup>. As a result of an increase in mortality rates, researchers around the world have focused on prostate cancer to try to understand the condition and to develop even better options for screening and treatment, especially in the advanced stages of the condition. Over the years, there have been studies that explore the risk factors of prostate cancer which, unlike colorectal and cervical cancer, the modifiable causes are poorly understood <sup>20</sup>. Scientists have theorized that factors such as smoking, prostatic infectious inflammatory factors, and environmental exposure to cadmium, herbicides, pesticides, polychlorinated biphenyls can be implicated in the etiopathology of prostate cancer <sup>20,21</sup>. Because prostate cancer has the highest incidence of all cancer types in Jamaica <sup>7</sup>, there is great focus on the disease and its risk factors among Jamaican men. As a result, there has been numerous studies done locally on potential risk factors and possible etiology of prostate cancer specific to Jamaican men or men of African descent. Various case control studies have suggested that factors such as phytoestrogens in the urine, dietary intake of fats, consumption of refined carbohydrates and proinflammatory foods such as red meat and sugar sweetened soft drinks may all be risk factors of prostate cancer in Jamaican men that require further examination <sup>22-25</sup>. The progression of prostate cancer is believed to be androgen-dependent and therefore in many clinical settings, the standard of care for prostate cancer is androgen deprivation therapy <sup>26</sup>. However, in recent years there has been an increase in cases of Castrate-Resistant Prostate Cancer (CRPC) <sup>27,28</sup>. CRPC has been found to develop on average between 12-18 months after the start of androgen deprivation therapy <sup>29,30</sup>. Until 2004 when docetaxel was approved for use, the treatment of men with CRPC was mainly palliative care <sup>26,31</sup>. In recent years, there has been an

increase in clinical trials to try to develop more drugs that can be used to treat CRPC<sup>32</sup>. Additionally, healthcare professionals are not only tasked with dealing with the high prevalence of prostate cancer, but also the increase in CRPC which has an impact on the treatment of the disease. The possible reason for the increase in cases of CRPC has yet to be clarified<sup>27,28</sup>. Scientists have started focusing on other therapies such as vaccine-based immunotherapy and treatment with radiopharmaceuticals such as Radium-223<sup>26,31</sup>. Despite the numerous advancements in the past few decades in treatment and prevention, the underlying etiology of this disease is still not clearly defined, and scientists have still not identified any clear modifiable risk factors<sup>26,31,32</sup>. However, research on this topic has been increasing with the hope that the discovery of these factors may further add to existing treatment and preventative measures<sup>32</sup>. Studies have hypothesized a possible relationship between heavy metals and the pathogenesis of prostate cancer; these studies have suggested that some heavy metals such as cadmium have estrogenic or androgenic abilities. Since prostate cancer progression has been surmised to be androgen-dependent, scientists have suggested that this may be a possible mechanism in which heavy metals are risk factors of prostate cancer<sup>33,34</sup>. Contrastingly, some studies have found no association between heavy metals and prostate cancer risk. A study done to explore the possible relationship between urinary arsenic and blood cadmium, lead and mercury levels and prostate specific antigen (PSA) did not find any association between these heavy metal levels in the body and PSA<sup>35</sup>. On the other hand, other studies found evidence that suggested a plausible relationship with metals such as zinc, cadmium, and arsenic levels in the body and the risk of prostate cancer<sup>34,36</sup>.

## Cervical Cancer

Research has shown that a large majority of cervical cancer cases are related to infection with the human papillomavirus (HPV)<sup>37-39</sup>. Even with the knowledge that HPV plays a major role in the development of cervical cancer, research today shows that it is not the sole contributing factor in the development of cervical cancer<sup>38</sup>. Research shows that even though the carcinogenic types of HPV (16 and 18) are found to be indicated in 70% of all cervical cancer cases, not all women with HPV eventually develop cervical cancer, other risk factors, such as smoking exist as well, the incidence of invasive cervical cancer was found to be 2-3 higher in women who reported that they

were current or former smokers<sup>2,40,41</sup>. A case control study done on Jamaican women showed that there was some risk associated with cervical dysplasia and women who used hormonal birth control<sup>42</sup>. Additionally, when looking at lifestyle factors and cervical cancer, a case-control study found risk factors such as alcohol consumption and number of sexual partners, which were significantly higher among cases of cervical cancer in Jamaican women<sup>43</sup>. Multiple case studies and research have established that cervical cancer could be easily managed if it is diagnosed earlier, due to the advances in screening, treatment, and prevention methods. However, even with screening methods such as pap-smear and HPV testing, cervical cancer continues to be one of the leading causes of cancer-related death in women<sup>44</sup>. Studies have shown a concerning trend in not only the change in recent years in the time to diagnosis but also an increase in cases of treatment resistance and recurrent cervical cancer<sup>45,46</sup>. The median age at which women are first diagnosed with cervical cancer is 49 years<sup>47</sup>. However, studies have shown that this may be changing. A study done in the UK showed that in the 9 years between 2000 and 2009, the incidence of cervical cancer in women between the ages of 20–29 years increased annually by 10.3%<sup>45,46</sup>. In China, when comparing the mean ages at the time of diagnosis of cervical cancer over 9 years, it was found that women were 5–10 years younger than mean ages that were reported 9 years earlier<sup>48</sup>. In addition to earlier ages of diagnosis, there has been an emergence of cases of treatment resistance cervical cancer which significantly decreases the prognosis for women with this type of cervical cancer<sup>48,49</sup>.

## Burden of CPC cancers in Jamaica

Data from Kingston and St. Andrew shows that from 2003 to 2007, a total of 4981 cancers were recorded by the Jamaica Cancer Registry which uses Kingston and St. Andrew as the population base of the registry<sup>50</sup>. It was found that males accounted for most of the cases with a total of 2536 cases, while females accounted for 2445. Based on data of the International Agency for Research on Cancer (IARC) estimates on the incidence and mortality rates in 185 Countries worldwide for 36 cancers, lung cancer was found to have the highest incidence and mortality rate<sup>19</sup>. In Jamaica, the cancers with the highest incidence were estimated to be prostate, breast, colorectal, lung, and cervical cancer<sup>51</sup>.

Seen in both men and women, colorectal cancer was found to be the fourth most common can-



cer globally and accounted for the second-highest number of deaths in both sexes <sup>7,19</sup>. The incidence of colorectal cancer in Jamaica was close to the incidence seen in the rest of the world, in that it was found to be the third most common cancer among both men and women <sup>51</sup>. Of the 7348 new cases of cancer estimated in Jamaica, 953 were colorectal cancer <sup>51</sup>.

When looking at the incidence and mortality of prostate cancer in Jamaica in 2018, it was found that Jamaica recorded 1309 of the 1,276,106 new cases and caused 928 of the 358,989 deaths worldwide <sup>51</sup>. Additionally, it was found that of the 7348 new cases of cancer seen in Jamaicans in 2018, prostate cancer had the highest incidence of all cancers with 1309 cases <sup>7</sup>. Based on new data published in 2021, the incidence of prostate cancer in Jamaican men is increasing as prostate cancer accounted for 1561 of the 7197 new cases reported in 2020 <sup>52</sup>.

Cervical cancer was found to be the fourth most common in women worldwide after breast, colorectal, and lung cancer <sup>53</sup>. In Jamaica, cervical cancer was found to be the third most common cancer in women. Research shows that of the 570,000 new cases of cervical cancer globally, Jamaica contributed 486 of that number in 2018 <sup>53</sup>. These numbers show that even with the global increase in screening programs and the introduction of prophylactic methods such as the HPV vaccine, prostate, colon, and cervical cancer continue to be a major issue in public health is not just Jamaica but, in the world <sup>7,53</sup>.

## Cadmium in Jamaica

Jamaica has been involved in the bauxite industry since the mid-1900s. There is a paucity of scientific evidence on whether exposure to the environment surrounding the bauxite industry has any effect or whether it may lead to the development of cancers in persons from the immediate area. Lands that have undergone bauxite mining have been utilized for farming purposes, and other post-mining activities. However, farming on bauxite land is also a concern as products may contain heavy metals, most notably, cadmium that is left behind from the ores <sup>54</sup>. The major deposits of bauxite were found in St. Elizabeth, which is the most important agricultural parish in Jamaica <sup>54</sup>. An island-wide survey of Jamaican soils indicates that there are areas such as Manchester where the concentration of cadmium in the soil is comparable to soils that have been classified as highly polluted with maximum concentrations of 900 mg/kg-1 <sup>54</sup>. The concentration

of cadmium in Jamaican soil was found to range from 0.2 to 401 mg/kg-1 <sup>55</sup>. This concentration found in central Jamaica is significantly higher (100 to 1000 times) than the critical limits that have been established by some countries in the world <sup>56</sup>. Mapping of soils in Jamaica showed that major deposits of heavy metals such as cadmium from bauxite mining are found in St. Elizabeth <sup>57</sup>. Analysis of the bioavailability of cadmium in paired yam samples from the northern section of Manchester and the south-western section of St. Ann showed that the combined extractable cadmium fraction, which accounts for about 55% of the total cadmium found in the soil, is bioavailable and is a good predictor of the concentration of cadmium in the plant <sup>54,56</sup>.

A study conducted in Jamaica, analyzing the cadmium concentrations in kidney and liver tissue of deceased Jamaicans during autopsies showed that levels of cadmium in these tissues were almost twice as high as levels seen in other countries such as the UK and Sweden <sup>58</sup>. When compared to the cadmium distribution in areas of the country, St. Elizabeth was found to have values that were above the 95<sup>th</sup> percentile (Figure 1) <sup>54,56</sup>.

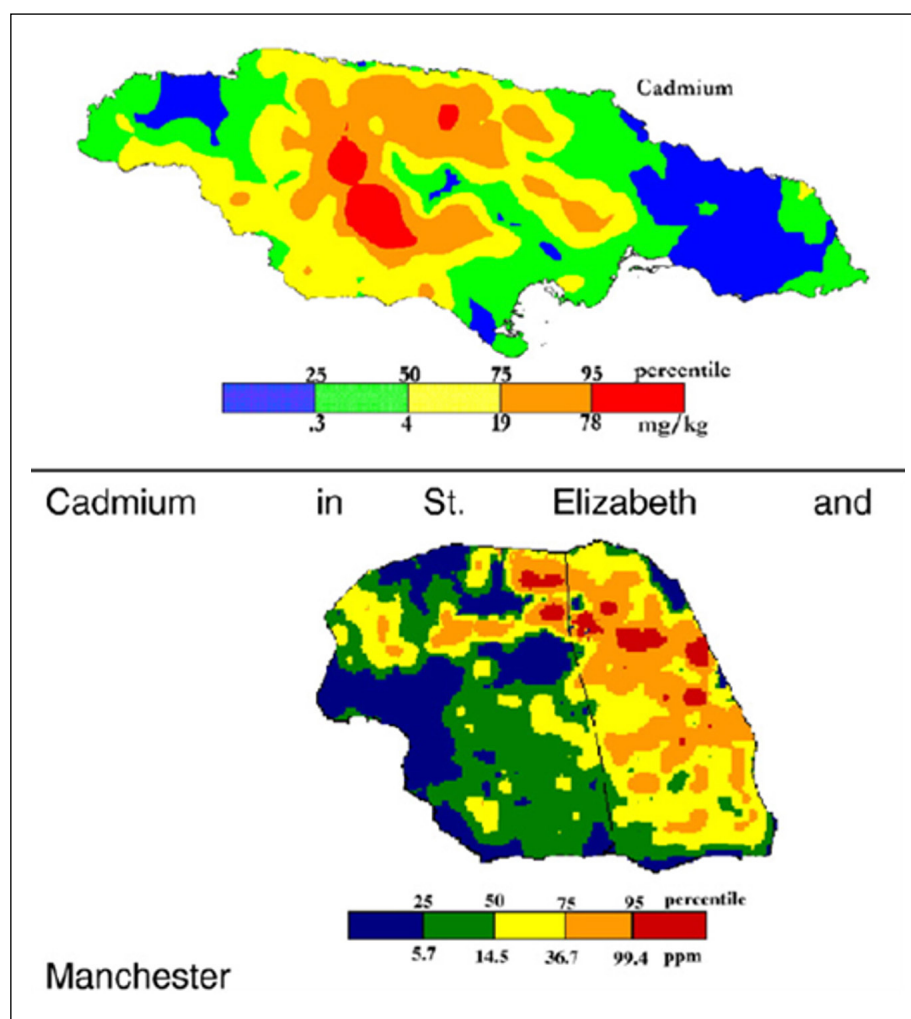
## PATIENTS AND METHODS

This was a retrospective study where patients' medical records were reviewed based on diagnosis CPC. Socio-demographic information and clinical records of CPC patients were abstracted from the hospital files at the Mandeville Regional Hospital and the University Hospital of the West Indies. Medical records were also reviewed for patients who were currently being tested for CPC based on observation of the physician.

When a patient is diagnosed with cancer at a rural parish in Jamaica, they are normally referred to a Parish with a major hospital that is better equipped to treat them. Therefore, many patients in Parishes such as Clarendon, St. Elizabeth, St. Ann will be referred to the Mandeville Regional Hospital in Manchester. Since some of the major cancer treatment centers in Jamaica are in the Parishes of Kingston and St. Andrew, a large majority of the cancer patients regardless of Parish of residence are referred to these parishes upon diagnosis or sometimes when cancer is suspected. Therefore, many studies that look at cancer prevalence, incidence, or mortality in Jamaica state a study population specifically from Kingston and St. Andrew since they offer a good representation of the Jamaican population <sup>50,59,60</sup>. The Mandeville Regional Hospital



**Fig. 1.** Distribution of cadmium in Jamaican soils<sup>55,56</sup>.



is a major hospital in the southern region of Jamaica. This hospital is under the regulation of the Southern Regional Health Authority which is responsible for all public health institutions in Manchester, St. Elizabeth and Clarendon. The Mandeville Regional Hospital is the only Type B hospital in this region, therefore many major cases in the region are referred to this hospital. The University Hospital of the West Indies (UHWI) being a type A hospital is also a Centre where major cases are referred from all over Jamaica<sup>61</sup>. Therefore, by collecting data from these two institutions, it was possible to get CPC patients from 11 of 14 parishes.

### Socio-demographic variables

Socio-demographic data such as age, gender, and parish of residence were abstracted from the patient's medical records and used as variables in data analysis as applicable.

### Clinical variables

Clinical data such as the type of cancer, type of treatment, family history of cancer, and date of diagnosis were abstracted from the patient's medical records and used as variables in data analysis as applicable.

### Review of Patient Medical Records

A total of two hundred (200) potential patient records were reviewed at the Mandeville Regional Hospital in Manchester Jamaica after permission was obtained from the hospital administration. The Mandeville Regional Hospital is a public hospital located in central Jamaica which services patients mainly from other mainly inland parishes such as St Elizabeth and Clarendon. The records were obtained from patients attending female surgery, gynecology, oncology, urology, and colorectal clinic. The Mandeville Regional Hospital is a Type B



hospital which specializes in secondary care; because of this, the University Hospital of the West Indies was engaged as this hospital provides tertiary care. Therefore, after the initial chart review at the Mandeville Regional Hospital, another review was conducted at the Diagnostic Unit which conducts daily clinics for women with gynecological malignancies within the University Hospital of the West Indies. Because the diagnostic unit specializes in gynecological cases, this caused a surplus of female cases. To combat this, permission was obtained from a private physician to go through cases at the Mona Institute of Medical Sciences (MIMS) which is a private facility. From these facilities, an additional review of 46 patients was conducted. With the help of the hospital staff, these records were flagged based on a diagnosis of cervical, colorectal, or prostate abnormality. Records were also flagged based on the procedure ordered by the physician for confirmation of a diagnosis; these patients' records were then followed up by the researcher after subsequent visits by the patients to the clinics to confirm the diagnosis of one of the three cancers that were being reviewed. With this follow up 36 of 246 patients were ruled out and found to be not eligible; some of these patients were found to have had other cancers or conditions such as, endometrial cancer, stomach cancer, benign prostatic hyperplasia and prostatomegaly. A third review of the patient records excluded an additional 70 patients due to diagnosis not being confirmed, initial abnormality ruled non-malignant as well as due to the lack of sufficient data included in the chart because patients did not return to the clinic after initial diagnosis.

At the end of the chart review, there were 140 patients with the parish of residence in 11 of Jamaica's 14 Parishes ([Appendix A](#): Flow chart of sample selection and inclusion).

## Data Entry

Data were abstracted from patient paper-based medical records and entered onto paper-based data abstraction forms ([Appendix B](#): Data Abstraction Form). All patient data were then anonymized, assigned a unique identifier number, and the data entered in an excel spreadsheet.

## Statistical Analysis

Statistical analysis of the data was done using Microsoft Excel data analysis tool pack. In cases of missing variables, these were marked as not recorded. A descriptive analysis (frequencies and

percentages of categorical variables) was conducted on the raw data collected to describe the type of cancer and the number of cases of cancer in each Parish. To determine the possible association between the number of cases of CPC cancers and parish of residence, the Chi-square test for association was used to analyze if there was a significant difference between the mean number of CPC cases in each parish and the actual number of cases. Statistical significance was set at  $p$ -value ( $p < 0.05$ ).

## RESULTS

The number of persons with prostate cancer increased with age. The highest number of cases of prostate cancer was found to be in the 70-79 age group. The number of persons with colon cancer was consistent across all age bands, from age 30 years upwards (2.9%). Most of the cases found were cervical cancer (80.7%) with the highest numbers being in the 30-39-year age band (Table 1). The mean age of all patients was 45.20 years and the standard deviation was 17.76. More than half of the sample were females (82.1%). Majority of females in the sample were younger than forty years old (Table 1).

**TABLE 1.** Socio-demographics of the study population.

Variable	Number of CPC Patients (%)
<b>Gender</b>	
Male	17.9 (25)
Female	82.1 (115)
<b>Age in Decades</b>	
17-19	2.9 (4)
20-29	17.9 (25)
30-39	26.4 (37)
40-49	17.1 (24)
50-59	8.6 (12)
60-69	12.9 (18)
70-79	10.0 (14)
80-89	3.6 (5)
<b>Parish of Residence</b>	
Clarendon	2.14 (3)
Kingston	12.9 (18)
Manchester	20.0 (28)
Portland	2.14 (3)
St Andrew	9.3 (13)
St Ann	8.57 (12)
St Catherine	15.0 (21)
St Elizabeth	17.1 (24)
St James	3.6 (5)
St Thomas	2.1 (3)
Trelawny	7.1 (10)
<b>Total</b>	<b>140</b>

**TABLE 2.** Cancer history and status of the patient population.

<b>Characteristic</b>	<b>Number of CPC Patients (%)</b>
<b>Type of Cancer *</b>	
Cervical	80.7 (113)
Prostate	16.4 (23)
Colorectal	2.9 (4)
<b>Family History of Cancer *</b>	
Yes	3.4 (5)
No	2.8 (4)
Not Recorded	93.6 (131)
<b>Total</b>	140

Most of the docket had missing data on occupation so although the data was collected from 5 of 140 docket, no meaningful analyses could be conducted and thus it was not included. Data on family history of cancer was also very limited (Table 2).

Manchester (28) and St Elizabeth (24) had twice the number of cases above the mean number of cases of 13 (Figure 2). Statistical analysis (Chi-square test) showed a significant difference between the mean number of cases in each parish and the actual number of cases ( $p < 0.05$ ) (Table 3).

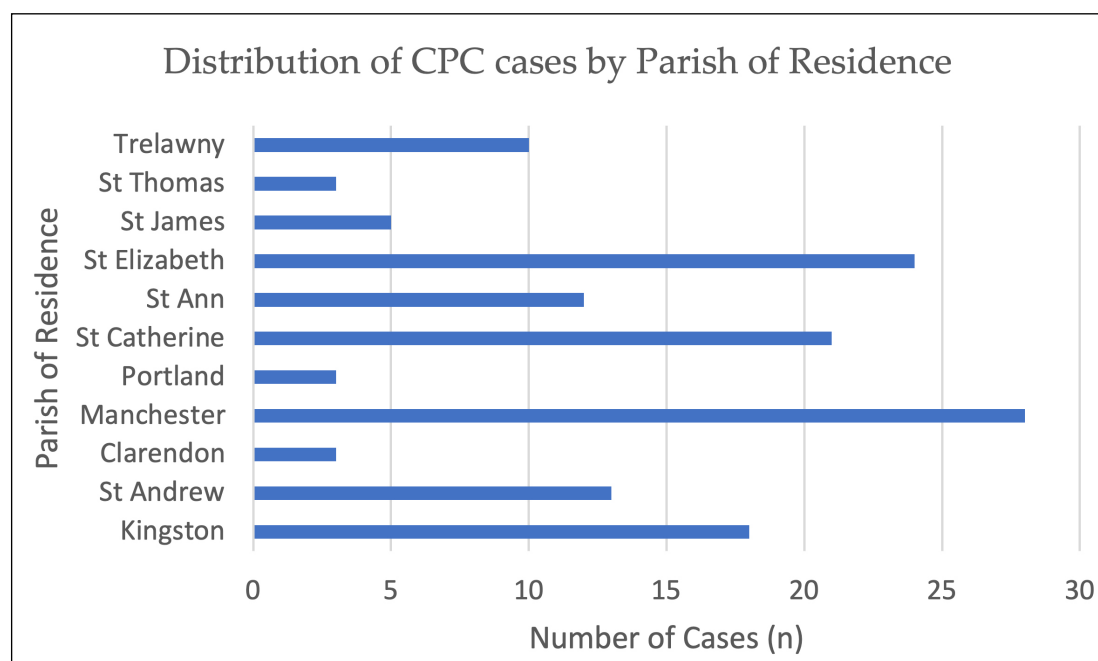
## DISCUSSION

The major finding of this retrospective study showed that when compared to the mean number of cases across Jamaica, St. Elizabeth and Manchester had a significantly higher number of CPC

**TABLE 3.** Summary Statistics of Mean CPC cases.

<b>Statistic</b>	<b>Value</b>
Mean	12.7
Standard Error	2.7
Median	12
Mode	3
Standard Deviation	8.9
Sample Variance	80.8
Kurtosis	-1.2
Skewness	0.4
Range	25
Minimum	3
Maximum	28
Sum	140
Count	11

cases compared to the other parishes in Jamaica ( $n=28$  and  $n=24$  respectively) ( $p < 0.05$ ). St. Catherine and Kingston also showed high numbers of CPC cases ( $n=21$  and  $n=18$ , respectively). When considering the established concentrations/distributions of heavy metals in soils across the country, the number of CPC cases in these parishes are of great interest. There seems to be a potential relationship between the number of CPC cases in specific parishes and the concentration/distribution of heavy metals in the soil in each of those parishes. In geochemical mapping Manchester and St. Elizabeth continue to have the highest concentration of cadmium and arsenic. St. Elizabeth is seen to have the highest distribution of arsenic in the country with a concentration of 400

**Fig. 2.** Distribution (n) of CPC cases by parish of residence.



mg/kg<sup>-1</sup> <sup>55,62,63</sup>. When compared to world concentrations, the levels of cadmium have been found to be 100–1,000 times higher in Jamaica <sup>56,64</sup>. The cadmium level in soil sampled in Manchester was found to be the highest in the country with a concentration of 931 mg/kg<sup>-1</sup> <sup>56</sup>. The entire parish of Manchester has been described by scientists as a cadmium anomaly because of the high levels of cadmium found in soil sampled from the parish. High levels of cadmium (478 mg/kg<sup>-1</sup>) were also found in a St. Andrew community that was the site of an old mine <sup>65</sup>. This high level of cadmium in St. Andrew while not as high as central parishes may possibly be related to the relatively high number of CPC cases seen that parish (9.29%). It is believed that these high levels of heavy metals in St. Elizabeth and Manchester are because of bauxite mining <sup>64</sup>.

There has been evidence of uptake of heavy metals in plants based on studies done on the bioavailability of heavy metals in the soil as well as the analysis of heavy metal content in certain foods <sup>54</sup>. St. Elizabeth is considered one of the most important agricultural parishes in Jamaica. According to the agricultural census done by the Statistical Institute of Jamaica (STATIN), in 2007, St. Elizabeth had the 5<sup>th</sup> largest proportion of the total land for farming in Jamaica with 30,022 hectares of the total 325,810 hectares of farmland in the entire Island. The parishes with higher proportions were Clarendon, St. Catherine, St. Ann, and Westmoreland <sup>66</sup>. In 2018, it was noted that St. Elizabeth had the largest number of registered farmers in all parishes across Jamaica and contributed approximately 102, 657 tons of domestic food crops <sup>67</sup>. With this great contribution to the agricultural industry in Jamaica, the high levels of heavy metals found in St. Elizabeth are of great interest and concern since it has been established that heavy metals found in soil enter the roots of plants either by passive diffusion or active transport <sup>68</sup>. The major cause for concern would be the possibility of most of the population being exposed to the extremely high levels of heavy metals found in the parish and not just citizens living specifically in St. Elizabeth.

Local scientific studies done on the effects of consuming foods contaminated by heavy metals in the environment have produced results that show that food grown in Jamaica have higher content of heavy metals than other countries. One study done by scientists at the Northern Caribbean University assessing the content of heavy metals in Jamaican grown crops sampled from farming communities in St. Elizabeth and Manchester found evidence to suggest that the heavy metals were available in soluble forms in the soil for absorption by food

crops. Crops such as the yellow yam and sweet potato which are popular staples in the Jamaican diet showed high concentrations of cadmium, arsenic, and lead <sup>69</sup>. Cadmium concentrations were found to be significantly high in the yellow yam (0.21 mg/kg) while lead concentrations were found to be high in the sweet potato (1.39 mg/kg). These concentrations exceeded the Food and Agriculture Organization of the United Nations/World Health Organization (FAO/WHO) recommended maximum value of cadmium and lead concentrations which is 0.1 mg/kg in root and tuber vegetables <sup>70</sup>. Another study done by scientists at the University of the West Indies suggested that cadmium in the food chain should be of concern, where results found that cadmium levels in legumes, leafy vegetables, and root vegetables sampled from farms in central Jamaica to be significantly higher than the same crops grown in other countries such as Denmark, the UK, and the USA <sup>71</sup>.

## CONCLUSIONS

The results show that there were higher number of CPC cases in parishes with historically reported high soil levels/distribution of heavy metals such as lead, cadmium, and arsenic. There is, therefore, a plausible relationship between the number of cases in the parish of residence and the reported levels/distribution of heavy metals in the soil. More work is needed to establish if there is a definitive link between the levels of heavy metals in patients with CPC in these areas compared to healthy individuals.

## AUTHOR CONTRIBUTIONS:

Conceptualization, Julian Bailey, and Patience Bazuaye-Alonge; Methodology, Julian Bailey, Patience Bazuaye-Alonge, and Shelly McFarlane.; writing—original draft preparation, Julian Bailey.; writing — review and editing, Julian Bailey, and Shelly McFarlane.; Supervision, Patience Bazuaye-Alonge and Shelly McFarlane. All authors have read and agreed to the published version of the manuscript.

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## INSTITUTIONAL REVIEW BOARD STATEMENT:

The study was conducted in accordance with the Declaration of Helsinki and approved by the Advisory Panel on Ethics and Medico-Legal Affairs, Ministry of Health, and Wellness.

## ETHICS COMMITTEE:

Local ethical approval was granted by the Southern Regional Health Authority which has oversight for the Mandeville Regional Hospital. (Protocol code 2016/11, approval date, June 13, 2016).



**INFORMED CONSENT STATEMENT:**

Consent was given via the regional authorities for review of patient information. Data was obtained retrospectively via review of patient dockets that were anonymized before review. All patients included in the study were given unique identifier numbers/codes.

**DATA AVAILABILITY STATEMENT:**

The data obtained via retrospective patient chart review and presented in this study are available on request from the corresponding author. The data are not publicly available due to maintain patient privacy. No new data relating to cadmium levels were created or analyzed in this study. Thus, data sharing regarding this is not applicable to this article.

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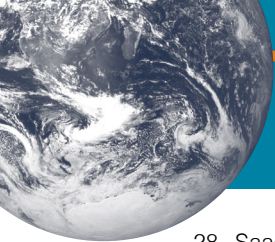
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**CONFLICTS OF INTEREST:**

The authors declare no conflict of interest.

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