

STATS/CSE 780

Assignment 1

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Introduction

Asbestos was a common construction material prior to the 1990s that was later found to be linked to diseases such as lung cancer and asbestosis (Government of Canada, 2023). Although it was banned in 2018, asbestos is still prevalent in old buildings and actively used in the military, nuclear, and chlor-alkali industries in Canada (Government of Canada, 2018). This report examines yearly asbestos waste trends and identifies key sectors that provinces can target to further reduce the toxin from the environment.

Methods

To begin the study, disposal data was downloaded from the Open Government Portal (Environment and Climate Change Canada, 2022) and filtered to asbestos waste only. While the original data had 17 variables, only the year, province, North American Industry Classification System (NAICS) code, and quantity of waste were important for this study.

Next, the data was enhanced using NAICS sector data and population estimates from Statistics Canada Statistics Canada (2022). NAICS sector names were scraped from the Statistics Canada website (2023) and mapped to the first two digits of the NAICS code in the data. This reduces the granularity of the original industry variables and allows for a high-level analysis later in the study. Population estimates (Statistics Canada, 2022) were joined to the data by province. This allows waste quantities to be adjusted by population size to account for differences caused by larger populations as seen in some provinces compared to others.

Finally, three line graphs were created to examine waste quantities at a country-level, province-level, and by industry. Quantities were converted to kilograms to standardize measurement methods and divided by population size before being plotted. All transformations and analyses were done using R and the last plot was created using Shiny (R Core Team, 2023a, 2023b).

Results

During the 1990s, asbestos waste was relatively stable in Canada at approximately 0.05 kg of waste per capita. From the early 2000s to the mid 2010s, waste quantities increased by 0.02 kg per capita

annually. Then from the mid 2010s to the latest available year 2021, there is a decrease of about 0.02 kg per capita per year. These trends are shown in Figure 1 below.

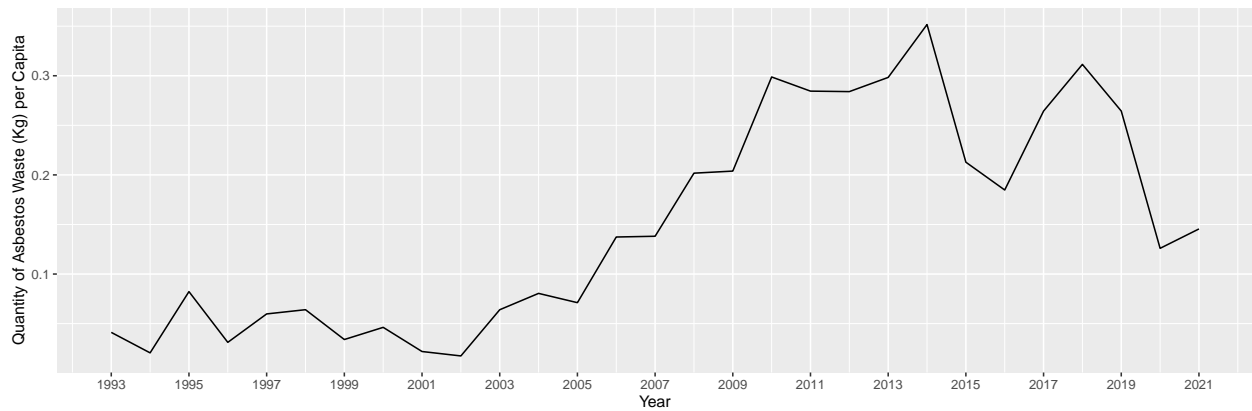


Figure 1: Asbestos waste across Canada by year

In Figure 2, we can see how these trend differ at the provincial level.

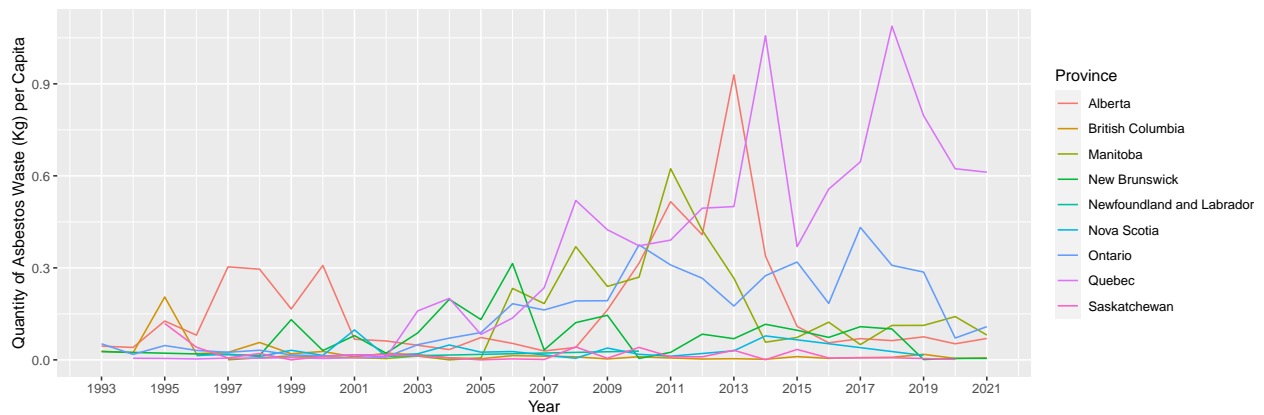


Figure 2: Asbestos waste by year and province

In the Shiny app (<https://1b5hyx-pao0zhu0vivian0-hsu.shinyapps.io/shiny/>), we narrow down provincial trends to the sector level to provide insight on which sectors provinces should consider investigating into.

Discussion

Based on the visuals, what do you recommend ppl to do?

Where were there limitations in the study? - Certain provinces/territories do not collect data on these substances. This could mean a couple of things - there is are no waste disposal places there,

they do not report on waste quantities, or they do not track that particular substance. - The data is measured and estimated differently by institution. While different methods could produce different amounts of variation from the true quantity, it is not a concern this is the best that can be provided. If in doubt, can look to standardize measurement techniques.

Results can be used to guide the development of stricter laws to reduce asbestos in the environment.

- As a whole, Canada's asbestos waste has been trending

High asbestos waste quantities per capita can be explained in a number of ways. For example, perhaps provinces with high quantities per capita may be replacing asbestos from old buildings, which isn't a negative thing if completed with proper precautions. Alternatively, the province could be

So having high waste quantities does not mean this is a bad thing.

Supplementary material

Report Code

```
# ----- LOAD PACKAGES AND DATA ----- #

library(tidyverse)
library(ggplot2)
library(stringi)

disposalDataRaw <- read_csv(file="NPRI-INRP_DisposalsEliminations_1993-present.csv",
                             locale=locale(encoding="latin1"))

naicsCodesRaw <- read_lines("https://www23.statcan.gc.ca/imdb/p3VD.pl?Function=getVD&TVD=136")
popDataRaw <- read_csv(file="17100009.csv")

# ----- DATA CLEANSING ----- #

# --- Step 1: Create 2-digit NAICS code lookup table --- #
# Pull 2-digit NAICS codes / code ranges and their descriptions from the source website.
naicsCodes <- data.frame(x=naicsCodesRaw) %>%
  filter(grepl("<th id=", x)) %>%
  mutate("Sector Code (2-digit NAICS Code)" = str_match(x, "CPV=\\s*(.*?)\\s*&")[,2],
         "Sector Name" = str_match(x, '"wb-inv">\\s*(.*?)\\s*</span>')[,2]) %>%
  select(`Sector Code (2-digit NAICS Code)`, `Sector Name`)
naicsCodes$`Sector Name` <- stri_replace_all_regex(naicsCodes$`Sector Name`,
                                                    pattern = c("&#40;", "&#41;", "&#44;"),
                                                    replacement = c("(", ")", ",",),
                                                    vectorize = F)

# Break code ranges down to their own rows
codeRangesOnly <- naicsCodes %>%
```

```

filter(str_length(`Sector Code (2-digit NAICS Code)`)>2) %>%
mutate(repStart = as.integer(str_match(`Sector Code (2-digit NAICS Code)`,
                                     "([0-9]{2})[-]([0-9]{2})")[,2]),
       repEnd = as.integer(str_match(`Sector Code (2-digit NAICS Code)`,
                                     "([0-9]{2})[-]([0-9]{2})")[,3])
) %>%
group_by(`Sector Name`) %>%
group_modify(~ tibble("Sector Code (2-digit NAICS Code)" =
                      seq(.$repStart, .$repEnd))) %>%
ungroup()

# Replace rows with code ranges with the broken down rows
naicsCodes <- rbind(naicsCodes, codeRangesOnly) %>%
  filter(str_length(`Sector Code (2-digit NAICS Code)`)==2)

# --- Step 2: Create mapping of province codes to names --- #
provMap <- tibble("Province Code" = c("AB", "BC", "MB", "NB", "NL", "NS", "NT", "NU", "ON", "PE",
                                     "QC", "SK", "YT"),
                 "Province Name" = c("Alberta", "British Columbia", "Manitoba",
                                     "New Brunswick", "Newfoundland and Labrador",
                                     "Nova Scotia", "Northwest Territories", "Nunavut",
                                     "Ontario", "Prince Edward Island", "Quebec",
                                     "Saskatchewan", "Yukon"))

# --- Step 3: Get population data for each province --- #
popData <- popDataRaw %>%
  mutate("Population Year" = as.numeric(substr(`REF_DATE`, 1, 4)),
         "Population Month" = substr(`REF_DATE`, 6, 7)) %>%
  filter(`Population Month` == "01",
         `GEO` != "Canada") %>%
  select(`Population Year`, `Population Month`, `GEO`, `VALUE`)

```

```

# --- Step 4: Filter disposal data for asbestos and join extra data --- #
disposalData <- disposalDataRaw %>%
  filter(grepl("asbestos",
    `Substance Name (English) / Nom de substance (Anglais)`,
    ignore.case = TRUE)) %>%
  mutate("Quantity (Kg)" = if_else(`Units / Unités` == "tonnes",
    `Quantity / Quantité`*1000,
    `Quantity / Quantité`),
    "Sector Code (2-digit NAICS Code)" = substr(`NAICS / Code_SCIAN`, 1, 2)) %>%
  left_join(naicsCodes,
    by = c("Sector Code (2-digit NAICS Code)" =
      "Sector Code (2-digit NAICS Code)")) %>%
  left_join(provMap,
    by = c("PROVINCE" = "Province Code")) %>%
  left_join(popData,
    by = c("Province Name" = "GEO",
      "Reporting_Year / Année" = "Population Year")) %>%
  group_by(`Reporting_Year / Année`,
    `Province Name`,
    `Sector Code (2-digit NAICS Code)`,
    `Sector Name`,
    `VALUE`) %>%
  summarize("Quantity (Kg)" = sum(`Quantity (Kg)`) %>%
  ungroup() %>%
  rename("Year" = `Reporting_Year / Année`,
    "Province" = `Province Name`,
    "Population" = `VALUE`)

# ----- SAVE DATA FOR SHINY ----- #

```

```

save(disposalData, file="shiny/disposalData.RData")

# ----- DATA AGGREGATION FOR GRAPHS ----- #

# --- Step 1: Data for country-level line graph --- #
# Aggregate data
disposalData_countryFig <- disposalData %>%
  group_by(`Year`) %>%
  summarize("Quantity of Asbestos Waste (Kg) per Capita" =
    sum(`Quantity (Kg)`)/sum(`Population`))

# Stats for in-text description
mean_1990s <- disposalData_countryFig %>%
  filter(`Year` <= 2000) %>%
  select(`Quantity of Asbestos Waste (Kg) per Capita`) %>%
  sapply(mean)

slope_early2000sToMid2010s <- lm(`Quantity of Asbestos Waste (Kg) per Capita` ~ `Year`,
  data=disposalData_countryFig %>% filter(`Year` >= 2000,
    `Year` <= 2014))$coeff[[2]]

slope_mid2010sToPresent <- lm(`Quantity of Asbestos Waste (Kg) per Capita` ~ `Year`,
  data=disposalData_countryFig %>% filter(`Year` >= 2014))$coeff

# --- Step 2: Data for province-level line graph --- #
# Aggregate data
disposalData_provinceFig <- disposalData %>%
  group_by(`Year`,`Province`) %>%
  summarize("Quantity of Asbestos Waste (Kg) per Capita" =
    sum(`Quantity (Kg)`)/sum(`Population`))

```



```
# ----- PLOT COUNTRY-LEVEL LINE GRAPH ----- #

disposalData_countryFig %>%
  ggplot(aes(x=`Year`, y=`Quantity of Asbestos Waste (Kg) per Capita`)) +
  geom_line() +
  scale_x_continuous(breaks = round(seq(min(disposalData_countryFig$`Year`),
                                         max(disposalData_countryFig$`Year`), by = 2),1))

# ----- PLOT PROVINCE-LEVEL LINE GRAPH ----- #

disposalData_provinceFig %>%
  ggplot(aes(x=`Year`, y=`Quantity of Asbestos Waste (Kg) per Capita`, color=`Province`)) +
  geom_line() +
  scale_x_continuous(breaks = round(seq(min(disposalData_provinceFig$`Year`),
                                         max(disposalData_provinceFig$`Year`), by = 2),1))
```

Shiny App Code

```
library(shiny)
library(tidyverse)
library(ggplot2)
library(stringi)

# ----- DATA PRE-PROCESSING ----- #

# Load disposal data
load("disposalData.RData")

# Drop down options
provinceOptions <- disposalData %>%
```

```

select(`Province`) %>%
distinct(`Province`) %>%
pull()

# ----- APP UI ----- #
ui <- fluidPage(

  # Application title
  titlePanel("Yearly Asbestos Waste by Province and Sector"),

  # Sidebar with a slider input for number of bins
  sidebarLayout(
    sidebarPanel(
      selectInput(inputId = "province",
                  label = "Province",
                  choices = provinceOptions
                )
    ),

    # Show a plot of the generated distribution
    mainPanel(
      plotOutput("lineGraph")
    )
  )
)

# ----- SERVER LOGIC ----- #
server <- function(input, output) {

```

```

output$lineGraph <- renderPlot({

  # Filter waste data by user's province selection
  disposalData_line <- disposalData %>%
    filter(`Province` == input$province) %>%
    group_by(`Year`, `Sector Name`) %>%
    summarize("Quantity of Asbestos Waste (Kg) per Capita" =
      sum(`Quantity (Kg)`)/sum(`Population`))

  # Plot line graph that show waste by year and sector for the selected province
  disposalData_line %>%
    ggplot(aes(x=`Year`,
               y=`Quantity of Asbestos Waste (Kg) per Capita`,
               color=`Sector Name`)) +
    geom_line() +
    scale_x_continuous(breaks = round(seq(min(disposalData_line$`Year`),
                                           max(disposalData_line$`Year`), by = 4),1))

  })

}

# ----- RUN APP ----- #
shinyApp(ui = ui, server = server)

```

References

- Environment and Climate Change Canada. (2022). *Bulk data files for all years – releases, disposals, transfers and facility locations*. Government of Canada. <https://doi.org/10.18164/774eeb0c-a069-4674-a9f7-82f4adf54369>
- Government of Canada. (2018). *Prohibition of asbestos and products containing asbestos regulations*. <https://laws-lois.justice.gc.ca/eng/regulations/SOR-2018-196/page-1.html#docCont>
- Government of Canada. (2023). *Asbestos and your health*. <https://www.canada.ca/en/health-canada/services/air-quality/indoor-air-contaminants/health-risks-asbestos.html>
- R Core Team. (2023a). *Easy web apps for data science without the compromises*. R Foundation for Statistical Computing. <https://shiny.posit.co/>
- R Core Team. (2023b). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. <https://www.R-project.org/>
- Statistics Canada. (2022). *Population estimates, quarterly*. Government of Canada. <https://open.canada.ca/data/en/dataset/ec690886-687d-4d59-9b1b-51311435d344>
- Statistics Canada. (2023). *North american industry classification system (NAICS) canada 2022 version 1.0*. <https://www23.statcan.gc.ca/imdb/p3VD.pl?Function=getVD&TVD=1369825>