07_immunization

Loading Libraries

```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(tidyr)
library(stringr)
library(readr)
library(here)
```

```
## here() starts at C:/Users/morul/School/3rd
Year/BIN381/BIN381_PROJECT/BIN381_PROJECT
```

```
library(ggplot2)
```

Load Dataset

```
imm_df <- read_csv(here("data", "raw", "immunization_national_zaf.csv"))
```

```
## Rows: 117 Columns: 29
## ── Column specification
────────────────────────────────────────────────────────
```

```
## Delimiter: ","
## chr (17): ISO3, DataId, Indicator, Value, Precision, DHS_CountryCode,
Countr...
## dbl  (8): IndicatorOrder, CharacteristicId, CharacteristicOrder, IsTotal,
Is...
## lgl  (4): RegionId, CILow, CIHigh, LevelRank
##
## ℹ Use `spec()` to retrieve the full column specification for this data.
## ℹ Specify the column types or set `show_col_types = FALSE` to quiet this
message.
```

Display Dataset content

```
# Make sure the file exists
```

```r
head(imm_df)
```

```
## # A tibble: 6 × 29
##   ISO3   DataId Indicator Value Precision DHS_CountryCode CountryName
SurveyYear
##   <chr>  <chr>  <chr>     <chr> <chr>     <chr>           <chr>
<chr>
## 1 #coun… #meta… #indicat… #ind… #indicat… <NA>            #country+n…
#date+year
## 2 ZAF    330965 BCG vacc… 96.8  1         ZA              South Afri… 1998
## 3 ZAF    139796 BCG vacc… 94.9  1         ZA              South Afri… 1998
## 4 ZAF    330966 DPT 1 va… 93.3  1         ZA              South Afri… 1998
## 5 ZAF    139797 DPT 1 va… 93.1  1         ZA              South Afri… 1998
## 6 ZAF    330967 DPT 2 va… 86.2  1         ZA              South Afri… 1998
## # ℹ 21 more variables: SurveyId <chr>, IndicatorId <chr>, IndicatorOrder
<dbl>,
## #   IndicatorType <chr>, CharacteristicId <dbl>, CharacteristicOrder
<dbl>,
## #   CharacteristicCategory <chr>, CharacteristicLabel <chr>,
## #   ByVariableId <chr>, ByVariableLabel <chr>, IsTotal <dbl>,
## #   IsPreferred <dbl>, SDRID <chr>, RegionId <lgl>, SurveyYearLabel <dbl>,
## #   SurveyType <chr>, DenominatorWeighted <dbl>, DenominatorUnweighted
<dbl>,
## #   CILow <lgl>, CIHigh <lgl>, LevelRank <lgl>
```

Remove the first row(meta data)

```r
imm_df <- imm_df[-1, ]
```

dimensions

```r
dim(imm_df)
```

```
## [1] 116  29
```

Inspect Duplicated rows

```r
dup_check <- imm_df %>%
  group_by(Indicator, SurveyYear, CharacteristicId, Value) %>%
  filter(n() > 1)

dup_check
```

```
## # A tibble: 0 × 29
## # Groups:   Indicator, SurveyYear, CharacteristicId, Value [0]
## # ℹ 29 variables: ISO3 <chr>, DataId <chr>, Indicator <chr>, Value <chr>,
## #   Precision <chr>, DHS_CountryCode <chr>, CountryName <chr>,
```

```
## #   SurveyYear <chr>, SurveyId <chr>, IndicatorId <chr>, IndicatorOrder
<dbl>,
## #   IndicatorType <chr>, CharacteristicId <dbl>, CharacteristicOrder
<dbl>,
## #   CharacteristicCategory <chr>, CharacteristicLabel <chr>,
## #   ByVariableId <chr>, ByVariableLabel <chr>, IsTotal <dbl>,
## #   IsPreferred <dbl>, SDRID <chr>, RegionId <lgl>, SurveyYearLabel <dbl>,
…
```

Missing Values

```
# 1. Remove completely empty columns
imm_df <- imm_df %>% select(where(~!all(is.na(.))))

# 2. Impute numeric columns with median
num_cols <- imm_df %>% select(where(is.numeric)) %>% names()
imm_df <- imm_df %>%
  mutate(across(all_of(num_cols), ~ifelse(is.na(.), median(., na.rm = TRUE),
.)))

# 3. Impute categorical/character columns with mode
cat_cols <- imm_df %>% select(where(is.character)) %>% names()
get_mode <- function(x) {
  ux <- na.omit(x)
  if(length(ux) == 0) return(NA_character_)
  names(sort(table(ux), decreasing = TRUE))[1]
}
imm_df <- imm_df %>%
  mutate(across(all_of(cat_cols), ~ifelse(is.na(.), get_mode(.), .)))

# 4. Summary after handling missing values
missing_summary <- data.frame(
  Column = names(imm_df),
  Missing_Count = colSums(is.na(imm_df)),
  Missing_Percent = round(colMeans(is.na(imm_df)) * 100, 2)
)

cat("Total remaining NAs:", sum(is.na(imm_df)), "\n")
```

```
## Total remaining NAs: 0
```

```
cat("Missing value summary per column:\n")
```

```
## Missing value summary per column:
```

```
print(missing_summary)
```

```
##                                        Column Missing_Count
Missing_Percent
## ISO3                                     ISO3             0
```

```
0
## DataId                                DataId             0
0
## Indicator                           Indicator            0
0
## Value                                   Value            0
0
## Precision                           Precision            0
0
## DHS_CountryCode               DHS_CountryCode            0
0
## CountryName                       CountryName            0
0
## SurveyYear                         SurveyYear            0
0
## SurveyId                             SurveyId            0
0
## IndicatorId                       IndicatorId            0
0
## IndicatorOrder                 IndicatorOrder            0
0
## IndicatorType                   IndicatorType            0
0
## CharacteristicId             CharacteristicId            0
0
## CharacteristicOrder       CharacteristicOrder            0
0
## CharacteristicCategory CharacteristicCategory            0
0
## CharacteristicLabel       CharacteristicLabel            0
0
## ByVariableId                     ByVariableId            0
0
## ByVariableLabel               ByVariableLabel            0
0
## IsTotal                               IsTotal            0
0
## IsPreferred                       IsPreferred            0
0
## SDRID                                   SDRID            0
0
## SurveyYearLabel               SurveyYearLabel            0
0
## SurveyType                         SurveyType            0
0
## DenominatorWeighted       DenominatorWeighted            0
0
## DenominatorUnweighted   DenominatorUnweighted            0
0
```

Handling Missing Values

Strategies applied:

1. Remove empty columns – columns entirely missing were removed.
2. Numeric columns – missing values imputed with the median of available values.
3. Categorical/character columns – missing values imputed with the mode (most frequent value).
4. Denominators – missing values in DenominatorWeighted and DenominatorUnweighted were forward-filled using fill().

Outcome: All columns have complete values, making calculations and analyses reliable. - Missing denominators are filled using the previous non-missing value (fill()).

- Ensures numeric calculations work correctly.

#Convert Data Types

```
# Define columns to convert, only if they exist
cols_to_numeric <- c("Value", "Precision", "DenominatorWeighted",
"DenominatorUnweighted")
cols_to_integer <- c("SurveyYear", "IndicatorOrder", "CharacteristicId")
cols_to_logical <- c("IsPreferred")

cols_to_numeric <- cols_to_numeric[cols_to_numeric %in% names(imm_df)]
cols_to_integer <- cols_to_integer[cols_to_integer %in% names(imm_df)]
cols_to_logical <- cols_to_logical[cols_to_logical %in% names(imm_df)]

# Convert
imm_df <- imm_df %>%
  mutate(
    across(all_of(cols_to_numeric), as.numeric),
    across(all_of(cols_to_integer), as.integer),
    across(all_of(cols_to_logical), ~as.logical(as.integer(.)))
  )

# Check structure
str(imm_df)

## tibble [116 × 25] (S3: tbl_df/tbl/data.frame)
##  $ ISO3                  : chr [1:116] "ZAF" "ZAF" "ZAF" "ZAF" ...
##  $ DataId                : chr [1:116] "330965" "139796" "330966" "139797"
...
##  $ Indicator             : chr [1:116] "BCG vaccination received" "BCG
vaccination received" "DPT 1 vaccination received" "DPT 1 vaccination
received" ...
##  $ Value                 : num [1:116] 96.8 94.9 93.3 93.1 86.2 82.4 76.4
```

```
73.8 91.2 87.7 ...
##  $ Precision             : num [1:116] 1 1 1 1 1 1 1 1 1 1 ...
##  $ DHS_CountryCode       : chr [1:116] "ZA" "ZA" "ZA" "ZA" ...
##  $ CountryName           : chr [1:116] "South Africa" "South Africa"
"South Africa" "South Africa" ...
##  $ SurveyYear            : int [1:116] 1998 1998 1998 1998 1998 1998 1998
1998 1998 1998 ...
##  $ SurveyId              : chr [1:116] "ZA1998DHS" "ZA1998DHS" "ZA1998DHS"
"ZA1998DHS" ...
##  $ IndicatorId           : chr [1:116] "CH_VACS_C_BCG" "CH_VACS_C_BCG"
"CH_VACS_C_DP1" "CH_VACS_C_DP1" ...
##  $ IndicatorOrder        : int [1:116] 93886010 93886010 93886020 93886020
93886030 93886030 93886040 93886040 93886050 93886050 ...
##  $ IndicatorType         : chr [1:116] "I" "I" "I" "I" ...
##  $ CharacteristicId      : int [1:116] 268002 268002 268002 268002 268002
268002 268002 268002 268002 268002 ...
##  $ CharacteristicOrder   : num [1:116] 268002 268002 268002 268002 268002
...
##  $ CharacteristicCategory: chr [1:116] "Source of vaccination information"
"Source of vaccination information" "Source of vaccination information"
"Source of vaccination information" ...
##  $ CharacteristicLabel   : chr [1:116] "Either source" "Either source"
"Either source" "Either source" ...
##  $ ByVariableId          : chr [1:116] "258001" "258002" "258001" "258002"
...
##  $ ByVariableLabel       : chr [1:116] "12-23" "24-35" "12-23" "24-35" ...
##  $ IsTotal               : num [1:116] 1 1 1 1 1 1 1 1 1 1 ...
##  $ IsPreferred           : logi [1:116] TRUE FALSE TRUE FALSE TRUE FALSE
...
##  $ SDRID                 : chr [1:116] "CHVACSCBCG" "CHVACSCBCG"
"CHVACSCDP1" "CHVACSCDP1" ...
##  $ SurveyYearLabel       : num [1:116] 1998 1998 1998 1998 1998 ...
##  $ SurveyType            : chr [1:116] "DHS" "DHS" "DHS" "DHS" ...
##  $ DenominatorWeighted   : num [1:116] 973 933 973 933 973 933 973 933 973
933 ...
##  $ DenominatorUnweighted : num [1:116] 971 951 971 951 971 951 971 951 971
951 ...
```

- Numeric: Value, Precision, DenominatorWeighted, DenominatorUnweighted
- Integer: SurveyYear, IndicatorOrder, CharacteristicId
- Logical: IsPreferred

#Drop the countries only onw unqiue value: reason, there is no useful information - county is also always za

```
# Columns to remove and rationale
cols_to_remove <- c(
  "ISO3",              # Only one value "ZAF" → provides no useful variation
```

```
  "DHS_CountryCode",     # Only one value "ZA" → redundant
  "CountryName",         # Always "South Africa" → redundant
  "SurveyId",            # Encodes survey metadata, not needed for analysis
  "ByVariableId",        # IDs for subgroup variables; not used in analysis
  "ByVariableLabel",     # Labels for subgroup variables; not needed
  "IsTotal",             # Logical flag that is either 0/1 for all → redundant
  "RegionId",            # Missing or NA → no information
  "SurveyYearLabel",     # Duplicate of SurveyYear → redundant
  "SurveyType",          # Always "DHS" → no variation
  "CharacteristicOrder" # IDs for order only; not analytically useful
)

# Remove only columns that exist to avoid errors
imm_df <- imm_df %>% select(-any_of(cols_to_remove))

# Documenting action
cat("Removed columns that were either redundant, constant, or not
analytically useful:\n")

## Removed columns that were either redundant, constant, or not analytically
useful:

cat(paste(cols_to_remove, collapse = ", "), "\n")

## ISO3, DHS_CountryCode, CountryName, SurveyId, ByVariableId,
ByVariableLabel, IsTotal, RegionId, SurveyYearLabel, SurveyType,
CharacteristicOrder
```

Columns removed because they were constant, redundant, or not analytically useful:

ISO3, DHS_CountryCode, CountryName, SurveyId, ByVariableId, ByVariableLabel, IsTotal, RegionId, SurveyYearLabel, SurveyType, CharacteristicOrder

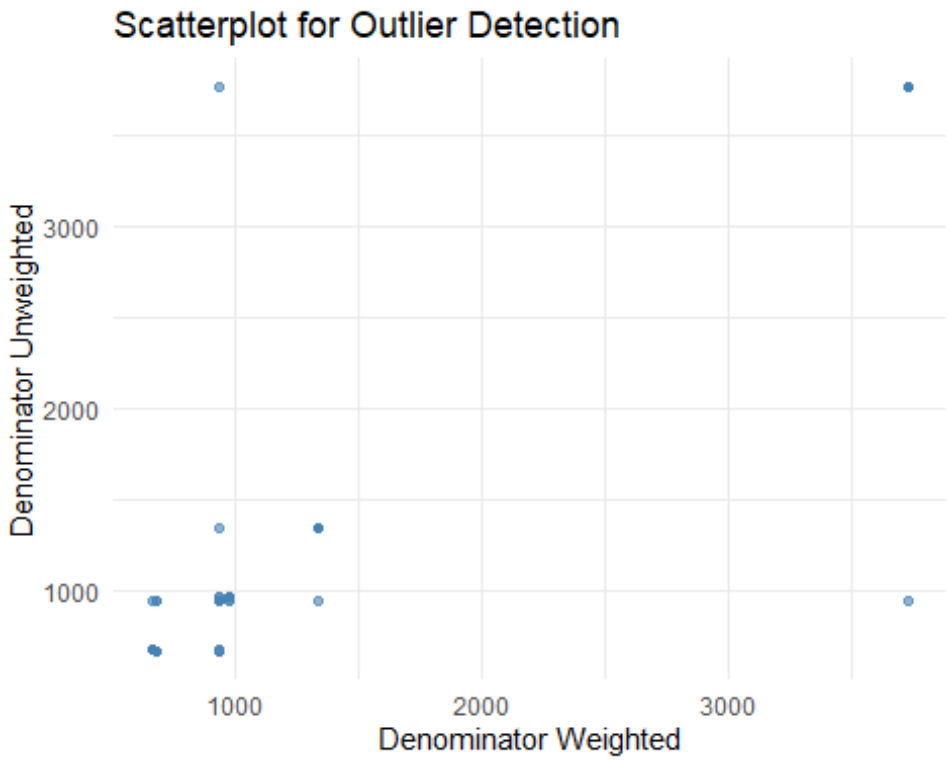
These columns either contained a single value or metadata that does not impact analysis.

#the missing values can be filled with the previous non missing value in the opposite attribute

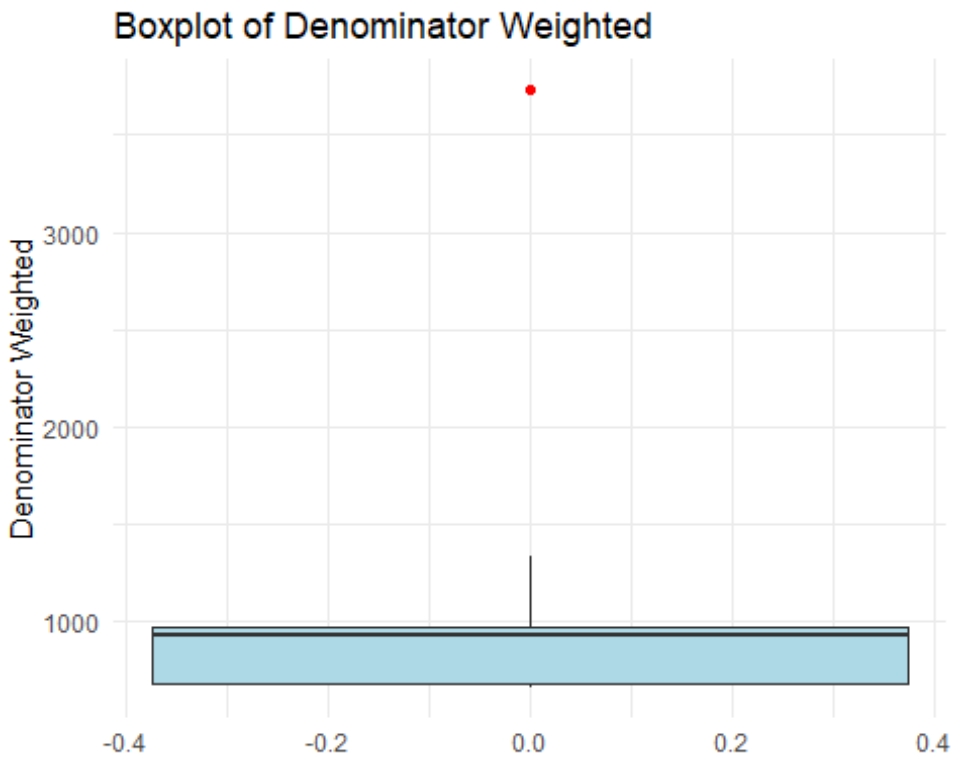
```
imm_df <- imm_df %>%
  fill(DenominatorWeighted, DenominatorUnweighted, .direction = "down")

imm_df[
       c("DenominatorWeighted", "DenominatorUnweighted")]

## # A tibble: 116 × 2
##    DenominatorWeighted DenominatorUnweighted
##                  <dbl>                 <dbl>
##  1                 973                   971
##  2                 933                   951
##  3                 973                   971
##  4                 933                   951
```

```
##  5                  973                    971
##  6                  933                    951
##  7                  973                    971
##  8                  933                    951
##  9                  973                    971
## 10                  933                    951
## # ℹ 106 more rows
```

```
ggplot(imm_df, aes(x = DenominatorWeighted, y = DenominatorUnweighted)) +
  geom_point(alpha = 0.6, color = "steelblue") +
  labs(title = "Scatterplot for Outlier Detection",
       x = "Denominator Weighted",
       y = "Denominator Unweighted") +
  theme_minimal()
```




```
ggplot(imm_df, aes(y = DenominatorWeighted)) +
  geom_boxplot(fill = "lightblue", outlier.color = "red", outlier.shape = 16)
+
  labs(title = "Boxplot of Denominator Weighted",
       y = "Denominator Weighted") +
  theme_minimal()
```

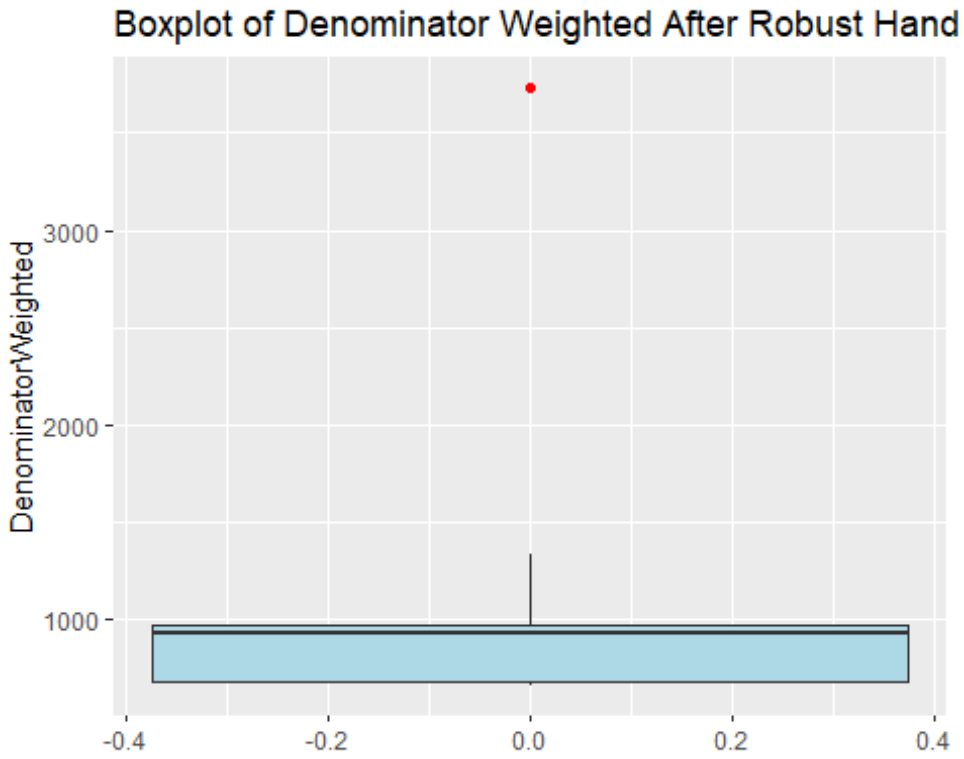



```
dim(imm_df)
```

```
## [1] 116  15
```

#Outlier Handling

```
# Winsorize at 1st and 99th percentiles
lower_w <- quantile(imm_df$DenominatorWeighted, 0.01, na.rm = TRUE)
upper_w <- quantile(imm_df$DenominatorWeighted, 0.99, na.rm = TRUE)

lower_uw <- quantile(imm_df$DenominatorUnweighted, 0.01, na.rm = TRUE)
upper_uw <- quantile(imm_df$DenominatorUnweighted, 0.99, na.rm = TRUE)

imm_df <- imm_df %>%
  mutate(
    DenominatorWeighted = pmax(pmin(DenominatorWeighted, upper_w), lower_w),
    DenominatorUnweighted = pmax(pmin(DenominatorUnweighted, upper_uw),
lower_uw)
  )

ggplot(imm_df, aes(y = DenominatorWeighted)) +
  geom_boxplot(fill = "lightblue", outlier.color = "red") +
  labs(title = "Boxplot of Denominator Weighted After Robust Handling")
```




```
summary(imm_df$DenominatorWeighted)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     660     677     933    1185     973    3734

summary(imm_df$DenominatorUnweighted)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     670     670     951    1192     971    3761
```

Robust Outlier Handling via Winsorization

Purpose:
The dataset contains extreme values in `DenominatorWeighted` and `DenominatorUnweighted` that skew the distribution. Instead of removing rows, we Winsorize the data to limit extreme values while keeping all observations intact.

Steps:

1. **Calculate bounds:**
    - 1st percentile (`0.01`) → lower bound
    - 99th percentile (`0.99`) → upper bound
      This ensures the extreme 1% of values on either side are capped.
2. **Apply Winsorization:**

- Values below the lower bound are set to the lower bound.
- Values above the upper bound are set to the upper bound.

3. **Visual Check:**
   - A boxplot is created to verify the effect of Winsorization on `DenominatorWeighted`.
4. **Summary Statistics:**
   - `summary()` is used to compare min, max, mean, and quartiles after capping, confirming that extreme outliers have been mitigated.

Code Explanation:

- `quantile(..., 0.01, na.rm = TRUE)` → computes the 1st percentile ignoring missing values.
- `pmin()` and `pmax()` → ensure values stay within the specified bounds.
- `geom_boxplot(outlier.color = "red")` → visualizes remaining extreme points (if any).

Outcome:
The extreme skew in denominator columns is reduced, improving stability for subsequent analyses, while retaining all rows in the dataset.

Final check and Save Dataset

#save cleaned data

```
write_csv(imm_df, here("data","processed", "immunization_cleaned.csv"))
```