Proof of concept for health indicators

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2024-07-12

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# 1. Introduction

Outline an end-to-end process for creating public health indicators and generating public health profiles.

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| --- |
| Figure 1.1: Workflow |

# 2. Rapid EDA

A first step is to rapidly evaluate raw data.

In creating regional health indicators and profiles

Store data in a single directory

dir <- here("data")  
  
xl\_files <- fs::dir\_ls(dir, regexp = "xls")  
  
csv\_files <- fs::dir\_ls(dir, regexp = "csv")  
  
## read\_files   
  
xl <- map(xl\_files, read\_xlsx)  
csvs <- map(csv\_files, read\_csv)

map(xl, colnames)  
map(csvs, colnames)

Area name labels

| Dataset | Area field name |
| --- | --- |
| AMR | No area variable |
| Injury | Region |
| Flu | region\_en |
| Smoking | directorate\_name |
| Populations | Region |

To facilitate data linkage and creating indicator datasets, area variable names should be consistent between datasets.

Directorate is not equivalent to region.

There are 13 KSA regions and 20 health directorates

### 2.0.1 Area variable names

## rename area variables  
  
csvs$`/Users/julianflowers/poc/data/Flu Vaccine Coverage 2023 updated.csv` <- rename(csvs$`/Users/julianflowers/poc/data/Flu Vaccine Coverage 2023 updated.csv`, Region = region\_en)  
  
#csvs$`/Users/julianflowers/poc/data/Flu Vaccine Coverage 2023 updated.csv`

### 2.0.2 Area names

flu\_areas <- csvs$`/Users/julianflowers/poc/data/Flu Vaccine Coverage 2023 updated.csv` |>  
 select(Region) |> unique()  
  
smoking\_areas <- csvs$`/Users/julianflowers/poc/data/Smoking 2022.csv` |>  
 select(directorate\_name) |> unique()  
  
pop\_areas <- csvs$`/Users/julianflowers/poc/data/Translated\_Population\_Data\_with\_Governorates.csv` |>  
 select(Region) |> unique()  
  
injury\_areas <- xl$`/Users/julianflowers/poc/data/Nonfatal Hospitalizations for Injuries data 2023 (8-7-2024).xlsx` |> select(Region) |> unique()  
  
n\_areas <- data.frame(data = c("flu\_areas", "smoking\_areas", "pop\_areas", "injury\_areas"), no\_areas = map\_dbl(list(flu\_areas, smoking\_areas, pop\_areas, injury\_areas), nrow), area\_type = c("region", "directorate", "region", "region")) |>  
 knitr::kable()

The number of unique areas

| data | no\_areas | area\_type |
| --- | --- | --- |
| flu\_areas | 13 | region |
| smoking\_areas | 20 | directorate |
| pop\_areas | 13 | region |
| injury\_areas | 12 | region |

setdiff(flu\_areas, pop\_areas)

# A tibble: 9 × 1  
 Region   
 <chr>   
1 Riyadh   
2 Sharqiya   
3 Makkah Al Mukarramah  
4 Asir   
5 madina   
6 Al Qassim   
7 Hail   
8 Al Baha   
9 Northern Frontier

setdiff(pop\_areas, injury\_areas)

# A tibble: 10 × 1  
 Region   
 <chr>   
 1 Al Bahah   
 2 Al Hudud ash Shamaliyah   
 3 Ar Riyadh   
 4 Al Qasim   
 5 Al Madinah al Munawwarah   
 6 Al Mintaqah ash Sharqiyah  
 7 Tabuk   
 8 Ha'il   
 9 'Asir   
10 Makkah al Mukarramah

setdiff(injury\_areas, flu\_areas)

# A tibble: 2 × 1  
 Region   
 <chr>   
1 Makkah   
2 Madinah

# 3. Data preparation and cleaning

## 3.1 Data prep and clening

### 3.1.1 Creating a lookup table for KSA regions and health directorates

1. Population estimates by age, gender and region - downloaded from detailed census data 2022. source: <https://portal.saudicensus.sa/portal/public/1/15/101464?type=TABLE;> translated into English using ChatGPT4o.
2. This gives populations for 13 regions; smoking and injury date is based on health directorates - 20 units.
3. For these analyses aggregated directorates to regions to enable rate calculations
4. To map directorates to regions following steps were undertaken:
   * Shape file for KSA regional boundaries obtained from …
   * Directorate based locations of smoking cessation clinics were scraped from <https://www.moh.gov.sa/en/Ministry/Projects/TCP/Pages/default.aspx>
   * Locations were spatially joined to KSA regional boundaries to create a region <-> directorate lookup
5. Naming systems differed between datasets so renaming and recoding necessary

|  |
| --- |
| Figure 3.1: Comparative analysis |

### 3.1.2 Region names

devtools::install\_github("yutannihilation/ggsflabel")  
needs(tidyverse, data.table, readxl, myScrapers, sf, curl, ggsflabel)  
  
pops <- fread("/Users/julianflowers/Library/CloudStorage/GoogleDrive-julian.flowers12@gmail.com/My Drive/Saudi/data/pop\_ests.csv")  
  
region\_names <- pops$Region |> unique()  
  
region\_names |>  
 enframe()

# A tibble: 13 × 2  
 name value   
 <int> <chr>   
 1 1 Al Bahah   
 2 2 Al Jawf   
 3 3 Al Hudud ash Shamaliyah   
 4 4 Ar Riyadh   
 5 5 Al Qasim   
 6 6 Al Madinah al Munawwarah   
 7 7 Al Mintaqah ash Sharqiyah  
 8 8 Tabuk   
 9 9 Jazan   
10 10 Ha'il   
11 11 'Asir   
12 12 Makkah al Mukarramah   
13 13 Najran

## region names for injury data (NB only 12 names)  
df\_r <- read\_xlsx("/Users/julianflowers/spha/data/fwdatastrategypocpublichealthframeworkindicators/Nonfatal Hospitalizations for Injuries data 2023 (8-7-2024).xlsx") |> pluck("Region") |> unique()  
  
## directorate names for smoking data  
smok <- read\_csv("/Users/julianflowers/spha/data/fwdatastrategypocpublichealthframeworkindicators/Smoking 2022.csv")

### 3.1.3 Scrape smoking clinic locations

url <- "https://www.moh.gov.sa/en/Ministry/Projects/TCP/Pages/default.aspx"  
  
scc\_dir <- get\_page\_links(url) %>%  
 .[159:178]   
  
sc\_dir\_links <- paste0("https://www.moh.gov.sa", scc\_dir)  
  
sc\_dir\_names <- sc\_dir\_links |>  
 basename()  
  
## extract Google maps link of scc for each region and create data frame  
sc\_loc <- map(sc\_dir\_links, get\_page\_links) %>%  
 map(\(x) x[grepl("https://goo.gl", x)]) %>%  
 set\_names(., sc\_dir\_names) |>  
 enframe() |>  
 mutate(name = str\_remove(name, ".aspx"))

### 3.1.4 Function to extract coordinates from google map links

get\_coordinates\_from\_google\_maps <- function(url) {  
 # Follow the redirect to get the final URL  
 url <- url  
 response <- HEAD(url, config(followlocation = TRUE))  
 final\_url <- response$url  
   
 # Use a regular expression to find the coordinates in the final URL  
 match <- str\_match(final\_url, "@(-?\\d+\\.\\d+),(-?\\d+\\.\\d+)")  
 if (!is.na(match[1,2]) && !is.na(match[1,3])) {  
 latitude <- as.numeric(match[1,2])  
 longitude <- as.numeric(match[1,3])  
 return(list(latitude = latitude, longitude = longitude))  
 } else {  
 return(NULL)  
 }  
}

### 3.1.5 Extract smoking clinic coordinates

sc\_coords <- sc\_loc |>  
 unnest(value) |>  
 mutate(ll = map(value, get\_coordinates\_from\_google\_maps, .progress = TRUE))  
  
## create table of sc clinic locations   
sc\_ll <- sc\_coords |>  
 unnest\_wider(ll)  
  
## convert to sf file (need to remove missing coordinate values)  
  
sc\_ll\_sf <- sc\_ll |>  
 drop\_na() |>  
 st\_as\_sf(coords = c("longitude", "latitude"), crs = 4326)

### 3.1.6 Obtain KSA region boundary file

sa\_shp <- curl\_download("https://data.humdata.org/dataset/41ce9023-1d21-4549-a485-94316200aba0/resource/a0188b1b-2f40-4f27-8a43-25913a7378ca/download/sau\_adm\_gadm\_20210525\_shp.zip", destfile = tempfile())  
  
tmpd <- tempdir()  
  
sa\_shp\_1 <- curl\_download("https://data.humdata.org/dataset/41ce9023-1d21-4549-a485-94316200aba0/resource/99834c81-ad34-415e-91c5-af053d8e55b4/download/sau\_capp\_adm1\_1m\_ocha.zip", destfile = tempfile())  
  
#sa\_pop\_d <- curl\_download("https://data.humdata.org/dataset/14b288ca-1855-4025-9f01-41cba548e6f6/resource/44baa2f6-b6d8-4018-b9c6-fd81b493ec22/download/sau\_general\_2020\_geotiff.zip", destfile = tempfile())  
  
sa\_shp <- unzip(sa\_shp, exdir = tmpd)  
  
sa\_shp\_1 <- unzip(sa\_shp\_1, exdir = tmpd)  
  
#sa\_tif <- unzip(sa\_pop\_d, exdir = tmpd)  
  
shps <- fs::dir\_ls(tmpd, regexp = "shp$")  
  
## boundary polygon file  
sa\_bound <- read\_sf(shps[2])

### 3.1.7 Map smoking clinic locations against regional boundaries

sa\_bound |>  
 ggplot() +  
 geom\_sf(fill = "grey90") +  
 geom\_sf\_label\_repel(aes(label = ADM1\_EN)) +  
 geom\_sf(data = sc\_ll\_sf, aes(colour = name)) +  
 theme\_void() +  
 scale\_colour\_viridis\_d(option = "turbo", name = "Directorates")

|  |
| --- |
| Figure 3.2: SCC location map with regional boundaries |

### 3.1.8 Create a geographical lookup table

reg\_dir\_lu <- sa\_bound |>  
 st\_join(sc\_ll\_sf) |>  
 st\_drop\_geometry() |>  
 select(ADM1\_EN, name) |>  
 group\_by(ADM1\_EN, name) |>  
 summarise(n = n()) |>  
 ungroup() |>  
 group\_by(name) |>  
 arrange(name) |>  
 filter(n == max(n)) |>  
 select(name, everything())

Now we want to attach region names tpo the smoking data so we can join with population data in order to calculate attendance rates by age.

### 3.1.9 Map directorates to regions

pops$Region |>  
 unique() |>  
 enframe()

# A tibble: 13 × 2  
 name value   
 <int> <chr>   
 1 1 Al Bahah   
 2 2 Al Jawf   
 3 3 Al Hudud ash Shamaliyah   
 4 4 Ar Riyadh   
 5 5 Al Qasim   
 6 6 Al Madinah al Munawwarah   
 7 7 Al Mintaqah ash Sharqiyah  
 8 8 Tabuk   
 9 9 Jazan   
10 10 Ha'il   
11 11 'Asir   
12 12 Makkah al Mukarramah   
13 13 Najran

smok\_1 <- smok |>  
 mutate(directorate\_name = recode(directorate\_name, "Qurayyat" = "Al-Qurayyat",   
 "Qunfotha" = "AL-Qunfudah",   
 "AlAhsa" = "Al-Ahsa",   
 "Baha" = "Al-Baha",  
 "Eastern" = "Eastern-Region",   
 "Hafer AlBatin" = "Hafr-Al-Batin",  
 "Northern Borders" = "Northern-Borders",  
 "Qassim" = "Al-Qassim",   
 "Jouf" = "Al-Jouf"  
 )) |>  
 left\_join(reg\_dir\_lu, by = c("directorate\_name" = "name"))   
 #left\_join(pops, by = c("ADM1\_EN" = "Region"))

### 3.1.10 Link smoking frequencies to population data

pops <- pops |>  
 mutate(age = parse\_number(`Single Age Group`))  
  
pops$Region |>  
 unique()

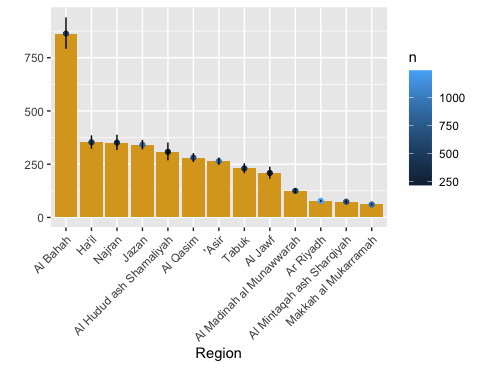
[1] "Al Bahah" "Al Jawf"   
 [3] "Al Hudud ash Shamaliyah" "Ar Riyadh"   
 [5] "Al Qasim" "Al Madinah al Munawwarah"   
 [7] "Al Mintaqah ash Sharqiyah" "Tabuk"   
 [9] "Jazan" "Ha'il"   
[11] "'Asir" "Makkah al Mukarramah"   
[13] "Najran"

smok\_pops\_region <- smok\_1 |>  
 mutate(Gender = str\_to\_title(patient\_gender)) |>  
 count(ADM1\_EN, age, Gender)   
  
  
## recode region names (ADM1\_EN)  
  
# smok\_pops\_region |>  
# mutate(Region = recode(ADM1\_EN,   
# "`Asir" = "'Asir",   
# "Ash Sharqiyah" = "Al Hudud ash Sharqiyah",   
# "Al Madinah" = ))  
  
smok\_pops\_region <- smok\_pops\_region |>  
 full\_join(pops, by = c("ADM1\_EN" = "Region", "age", "Gender"))   
  
  
  
## sense check  
smok\_pops\_region |>  
 count(Gender, ADM1\_EN, `18-44`) |>  
 print(n = 42)

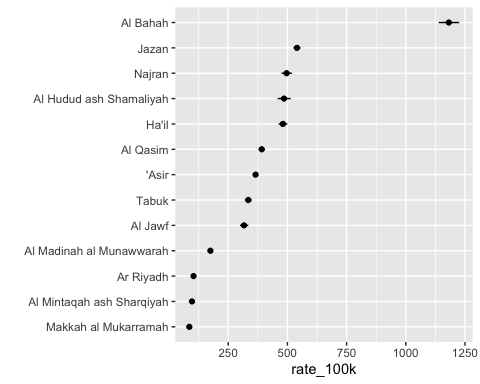
# A tibble: 69 × 4  
 Gender ADM1\_EN `18-44` n  
 <chr> <chr> <chr> <int>  
 1 Female 'Asir 18-44 967  
 2 Female 'Asir other 2206  
 3 Female Al Bahah 18-44 535  
 4 Female Al Bahah other 1178  
 5 Female Al Hudud ash Shamaliyah 18-44 216  
 6 Female Al Hudud ash Shamaliyah other 522  
 7 Female Al Jawf 18-44 216  
 8 Female Al Jawf other 522  
 9 Female Al Madinah <NA> 17  
10 Female Al Madinah al Munawwarah 18-44 484  
11 Female Al Madinah al Munawwarah other 1133  
12 Female Al Mintaqah ash Sharqiyah 18-44 648  
13 Female Al Mintaqah ash Sharqiyah other 1568  
14 Female Al Qasim 18-44 699  
15 Female Al Qasim other 1592  
16 Female Al Quassim <NA> 4  
17 Female Ar Riyad <NA> 21  
18 Female Ar Riyadh 18-44 1241  
19 Female Ar Riyadh other 2866  
20 Female Ash Sharqiyah <NA> 19  
21 Female Ha'il 18-44 482  
22 Female Ha'il other 1045  
23 Female Jazan 18-44 913  
24 Female Jazan other 2270  
25 Female Jizan <NA> 5  
26 Female Makkah <NA> 23  
27 Female Makkah al Mukarramah 18-44 917  
28 Female Makkah al Mukarramah other 2224  
29 Female Najran 18-44 372  
30 Female Najran other 821  
31 Female Tabuk 18-44 376  
32 Female Tabuk other 876  
33 Female `Asir <NA> 14  
34 Male 'Asir 18-44 967  
35 Male 'Asir other 2293  
36 Male Al Bahah 18-44 539  
37 Male Al Bahah other 1228  
38 Male Al Hudud ash Shamaliyah 18-44 216  
39 Male Al Hudud ash Shamaliyah other 520  
40 Male Al Jawf 18-44 216  
41 Male Al Jawf other 531  
42 Male Al Jawf <NA> 1  
# ℹ 27 more rows

### 3.1.11 Calculate regional smoking rates

## 18-44 F  
smok\_18\_44 <- smok\_pops\_region |>  
 filter(Gender == "Female", `18-44` == "18-44") |>  
 group\_by(ADM1\_EN) |>  
 reframe(n = n(),   
 sum\_pop = sum(Population),   
 rate\_100k = 100000 \* n / sum\_pop)  
  
 smok\_18\_44\_ci <- PHEindicatormethods::phe\_rate(smok\_18\_44, n, sum\_pop, multiplier = 100000)  
  
smok\_18\_44\_ci |>  
 ggplot() +  
 geom\_col(aes(reorder(ADM1\_EN, -rate\_100k), rate\_100k), fill = "goldenrod") +  
 geom\_point(aes(reorder(ADM1\_EN, -rate\_100k), rate\_100k, colour = n)) +  
 geom\_linerange(aes(x = ADM1\_EN, ymin = lowercl, ymax = uppercl)) +  
 labs(y = "",   
 x = "Region  
 ") +  
 theme(axis.text.x = element\_text(angle = 45, hjust = 1))



## 15+  
  
smok\_15\_ <- smok\_pops\_region |>  
 filter(`15+` == "15+") |>  
 group\_by(ADM1\_EN) |>  
 reframe(n = n(),   
 sum\_pop = sum(Population),   
 rate\_100k = 100000 \* n / sum\_pop)  
  
smok\_15\_ci <- PHEindicatormethods::phe\_rate(smok\_15\_, n, sum\_pop, multiplier = 100000)  
  
smok\_15\_ci |>  
 ggplot() +  
 geom\_point(aes(reorder(ADM1\_EN, rate\_100k), rate\_100k)) +  
 geom\_linerange(aes(x = ADM1\_EN, ymin = lowercl, ymax = uppercl)) +  
 coord\_flip() +  
 labs(x = "")



## AS specific  
  
smok\_pops\_region |>  
 #filter(`15+` == "15+") |>  
 group\_by(ADM1\_EN, `Five-Year Age Group`, Gender) |>  
 reframe(n = n(),   
 sum\_pop = sum(Population),   
 rate\_100k = 100 \* n / sum\_pop) |>  
 # select(-c(n, sum\_pop)) |>  
 pivot\_wider(-c(n, rate\_100k), names\_from = c("Gender", "Five-Year Age Group"), values\_from = "sum\_pop")

# A tibble: 20 × 38  
 ADM1\_EN `Female\_0-4` `Male\_0-4` `Female\_10-14` `Male\_10-14` `Female\_15-19`  
 <chr> <int> <int> <int> <int> <int>  
 1 'Asir 86076 89700 89842 92719 80089  
 2 Al Bahah 13905 14292 15738 16437 13866  
 3 Al Hudud … 20196 21493 17737 18266 14648  
 4 Al Jawf 35470 36359 29566 30401 23021  
 5 Al Madinah NA NA NA NA NA  
 6 Al Madina… 92536 95669 91346 94512 78252  
 7 Al Mintaq… 200425 208376 184743 191018 149977  
 8 Al Qasim 54714 56834 57093 58495 50842  
 9 Al Quassim NA NA NA NA NA  
10 Ar Riyad NA NA NA NA NA  
11 Ar Riyadh 307991 320698 298933 309250 254888  
12 Ash Sharq… NA NA NA NA NA  
13 Ha'il 32737 33782 32674 33511 27449  
14 Jazan 64626 67613 64993 68873 59475  
15 Jizan NA NA NA NA NA  
16 Makkah NA NA NA NA NA  
17 Makkah al… 281082 292376 299840 314392 270382  
18 Najran 31863 33038 27125 28865 22482  
19 Tabuk 42296 44012 39399 40646 34513  
20 `Asir NA NA NA NA NA  
# ℹ 32 more variables: `Male\_15-19` <int>, `Female\_20-24` <int>,  
# `Male\_20-24` <int>, `Female\_25-29` <int>, `Male\_25-29` <int>,  
# `Female\_30-34` <int>, `Male\_30-34` <int>, `Female\_35-39` <int>,  
# `Male\_35-39` <int>, `Female\_40-44` <int>, `Male\_40-44` <int>,  
# `Female\_45-49` <int>, `Male\_45-49` <int>, `Female\_5-9` <int>,  
# `Male\_5-9` <int>, `Female\_50-54` <int>, `Male\_50-54` <int>,  
# `Female\_55-59` <int>, `Male\_55-59` <int>, `Female\_60-64` <int>, …

# 4. AMR walkthrough

# 5. Introduction

This document outlines a stepwise approach to calculating AMR indicators from dummy data kindly supplied by PHA.

There are x steps

1. EDA (exploratory data analysis of raw data) - this involves cleaning, visualisation and creation of relevant variables.
2. Review of indicator definitions
   * Numerator
   * Denominator
3. Method for calculating numerator and denominator values from dataset. The outline uses R code for reproducibility and flexibility.
4. Calculating indicator values and uncertainty intervals
5. Suggested indicator visualisations (if appropriate).

# 6. AMR indicators

### 6.0.1 MRSA

Percentage of bloodstream infection due to methicillin-resistant Staphylococcus aureus (MRSA)

Numerator: No. of patients with growth of methicillin-resistant S. aureus in tested blood samples

Denominator: Total No. of patients with growth of S. aureus in tested blood samples

### 6.0.2 E. coli

Percentage of bloodstream infection due to 3rd-generation cephalosporin resistant E. coli

Numerator: No. of patients with growth of 3rd-generation cephalosporin resistant E. coli in tested blood samples

Denominator: Total No. of patients with growth of E. coli in tested blood samples

### 6.0.3 Import data

df <- amr

334 observations

## 6.1 Data preparation

### 6.1.1 calculate 5-year age bands

amr <- amr[, `:=` (five\_year = cut(age\_year, breaks = seq(0, 100, 5), right = FALSE))][]  
  
head(amr)

record\_number sample\_no patient\_mrn location  
 <num> <char> <char> <char>  
1: 1 ###### ##### Outpatient  
2: 17 ###### ##### Inpatient  
3: 20 ###### ##### Inpatient  
4: 25 ###### ##### Inpatient  
5: 43 ###### ##### Outpatient  
6: 63 ###### ##### Outpatient  
 patient\_hospitalized  
 <char>  
1: Patient had NOT been admitted for more than 2 days in the past 30 days  
2: Patient has been hospitalized for 2 days or less  
3: Patient has been hospitalized for more than 2 days  
4: Patient has been hospitalized for 2 days or less  
5: Patient had NOT been admitted for more than 2 days in the past 30 days  
6: Patient had NOT been admitted for more than 2 days in the past 30 days  
 specific\_location age\_year community\_origin site first\_name second\_name  
 <char> <num> <char> <char> <char> <char>  
1: Emergency Room 0 Community Origin Blood #### #####  
2: Intensive Care Unit 71 Community Origin Blood #### #####  
3: Intensive Care Unit 44 Hospital Origin Blood #### #####  
4: Intensive Care Unit 67 Community Origin Blood #### #####  
5: Emergency Room 67 Community Origin Blood #### #####  
6: Emergency Room 92 Community Origin Blood #### #####  
 family\_name national\_iqama\_id nationality pathogen\_name minocycline  
 <char> <char> <char> <char> <lgcl>  
1: #### ########## ##### Escherichia coli NA  
2: #### ########## ##### Escherichia coli NA  
3: #### ########## ##### Escherichia coli NA  
4: #### ########## ##### Escherichia coli NA  
5: #### ########## ##### Escherichia coli NA  
6: #### ########## ##### Escherichia coli NA  
 tigecycline ampicillin penicillin\_g oxacillin cefoxitin cefotaxime  
 <lgcl> <char> <lgcl> <char> <char> <char>  
1: NA R NA <NA> <NA> R  
2: NA R NA <NA> <NA> NA  
3: NA S NA <NA> <NA> S  
4: NA R NA <NA> <NA> R  
5: NA R NA <NA> <NA> NA  
6: NA R NA <NA> <NA> NA  
 ceftazidime ceftriaxone cefixime cefepime doripenem ertapenem imipenem  
 <char> <char> <lgcl> <char> <char> <char> <char>  
1: R R NA R NA S S  
2: S S NA S NA S S  
3: S S NA S NA S S  
4: R R NA R NA S S  
5: I S NA S NA S S  
6: R R NA R R S S  
 meropenem co\_trimoxazole azithromycin amikacin gentamicin ciprofloxacin  
 <char> <char> <lgcl> <lgcl> <lgcl> <char>  
1: S S NA NA NA S  
2: S S NA NA NA S  
3: S S NA NA NA S  
4: S R NA NA NA S  
5: S S NA NA NA S  
6: S R NA NA NA R  
 levofloxacin colistin spectinomycin five\_year  
 <char> <char> <lgcl> <fctr>  
1: S NA NA [0,5)  
2: S S NA [70,75)  
3: S NA NA [40,45)  
4: S NA NA [65,70)  
5: S S NA [65,70)  
6: R S NA [90,95)

### 6.1.2 remove non-relevant data

This step removes identifiers (names, record IDs)

amr <- amr |> select(-c(family\_name, first\_name, sample\_no, patient\_mrn, second\_name, national\_iqama\_id, nationality))

### 6.1.3 create per test file (long data)

* this create a *per test* dataset rather than a per patient sample dataset

amr\_long <- amr |>  
 pivot\_longer(names\_to = "antibiotic\_test", values\_to = "resistance", cols = minocycline:spectinomycin) |> setDT()

### 6.1.4 recode 3rd generation cephalosporins

* this step adds a new variable which labels 3rd generation cephalosporins

amr\_long <- amr\_long[, gen\_3 := case\_when(str\_detect(antibiotic\_test, "cef") ~ "3rd-gen", TRUE ~ "other")][]

## 6.2 Data summarisation and description (EDA)

* first generate a high level tabular summary

gtsummary::tbl\_summary(amr)

* represent this visually - we’ll use decompostion trees

amr\_freq <- amr\_long[pathogen\_name == "Escherichia coli", .N, by = .(five\_year, gen\_3, resistance, pathogen\_name)]  
  
collapsibleTreeSummary(amr\_freq,   
 c("gen\_3", "resistance"),   
 root = "E. coli",   
 nodeSize = "N",   
 attribute = "N",   
 fontSize = 16,   
 collapsed = FALSE)

## 6.3 Numerators and denominators

* to calculate indicators we need to calculate
* patients with blood stream infection
* samples with antibiotic resistance

amr\_long

record\_number location  
 <num> <char>  
 1: 1 Outpatient  
 2: 1 Outpatient  
 3: 1 Outpatient  
 4: 1 Outpatient  
 5: 1 Outpatient  
 ---   
7678: 1210 Inpatient  
7679: 1210 Inpatient  
7680: 1210 Inpatient  
7681: 1210 Inpatient  
7682: 1210 Inpatient  
 patient\_hospitalized  
 <char>  
 1: Patient had NOT been admitted for more than 2 days in the past 30 days  
 2: Patient had NOT been admitted for more than 2 days in the past 30 days  
 3: Patient had NOT been admitted for more than 2 days in the past 30 days  
 4: Patient had NOT been admitted for more than 2 days in the past 30 days  
 5: Patient had NOT been admitted for more than 2 days in the past 30 days  
 ---   
7678: Patient has been hospitalized for more than 2 days  
7679: Patient has been hospitalized for more than 2 days  
7680: Patient has been hospitalized for more than 2 days  
7681: Patient has been hospitalized for more than 2 days  
7682: Patient has been hospitalized for more than 2 days  
 specific\_location age\_year community\_origin site pathogen\_name  
 <char> <num> <char> <char> <char>  
 1: Emergency Room 0 Community Origin Blood Escherichia coli  
 2: Emergency Room 0 Community Origin Blood Escherichia coli  
 3: Emergency Room 0 Community Origin Blood Escherichia coli  
 4: Emergency Room 0 Community Origin Blood Escherichia coli  
 5: Emergency Room 0 Community Origin Blood Escherichia coli  
 ---   
7678: Non Intensive Unit 96 Hospital Origin Blood Staphylococcus aureus  
7679: Non Intensive Unit 96 Hospital Origin Blood Staphylococcus aureus  
7680: Non Intensive Unit 96 Hospital Origin Blood Staphylococcus aureus  
7681: Non Intensive Unit 96 Hospital Origin Blood Staphylococcus aureus  
7682: Non Intensive Unit 96 Hospital Origin Blood Staphylococcus aureus  
 five\_year antibiotic\_test resistance gen\_3  
 <fctr> <char> <char> <char>  
 1: [0,5) minocycline <NA> other  
 2: [0,5) tigecycline <NA> other  
 3: [0,5) ampicillin R other  
 4: [0,5) penicillin\_g <NA> other  
 5: [0,5) oxacillin <NA> other  
 ---   
7678: [95,100) gentamicin <NA> other  
7679: [95,100) ciprofloxacin R other  
7680: [95,100) levofloxacin R other  
7681: [95,100) colistin NA other  
7682: [95,100) spectinomycin <NA> other

## 6.4 Calculate resistance rates

* calculate proportion of tests resistant
* calculate confidence interval (using Wilsons score method for proportions via the PHEindicatormethods R package)

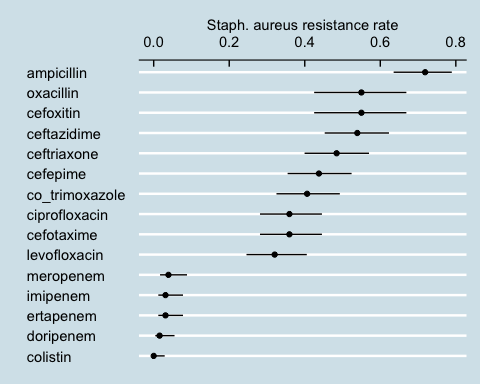
amr\_long[pathogen\_name == "Staphylococcus aureus" & !is.na(resistance), .N, by = .(resistance)] |>  
 pivot\_wider(names\_from = resistance, values\_from = N) |>  
 rowwise() |>  
 mutate(total\_tests = sum(c\_across(S:I), na.rm = TRUE),   
 resistance\_rate = R / total\_tests)

# A tibble: 1 × 6  
# Rowwise:   
 S `NA` R I total\_tests resistance\_rate  
 <int> <int> <int> <int> <int> <dbl>  
1 947 281 545 11 1784 0.305

by antibiotic

options(digits = 2)  
  
amr\_res\_ci\_sa <- amr\_long[pathogen\_name == "Staphylococcus aureus" & !is.na(resistance), .N, by = .(antibiotic\_test, resistance)] |>  
 pivot\_wider(names\_from = resistance, values\_from = N, values\_fill = 0) |>  
 rowwise() |>  
 mutate(total\_tests = sum(c\_across(S:I), na.rm = TRUE),   
 resistance\_rate = R / total\_tests)  
  
phe\_proportion(amr\_res\_ci\_sa, R, total\_tests) |>  
 bind\_cols(amr\_res\_ci\_sa) |>  
 ggplot() +  
 geom\_point(aes(reorder(antibiotic\_test, value), value)) +  
 geom\_linerange(aes(antibiotic\_test, ymin = lowercl, ymax = uppercl)) +  
 coord\_flip() +  
 labs(y = "Staph. aureus resistance rate", x = "") +   
 scale\_y\_continuous(position = "right")

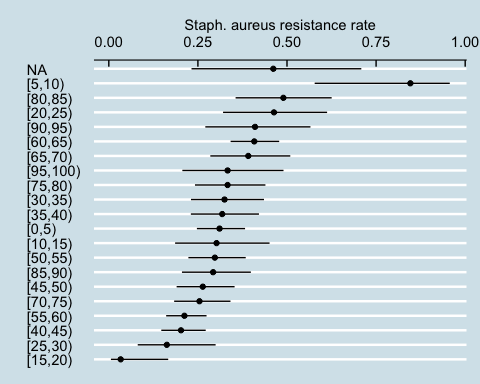
New names:  
• `R` -> `R...1`  
• `total\_tests` -> `total\_tests...2`  
• `R` -> `R...12`  
• `total\_tests` -> `total\_tests...14`



by age

amr\_res\_ci\_age <- amr\_long[pathogen\_name == "Staphylococcus aureus" & !is.na(resistance), .N, by = .(five\_year, resistance)] |>  
 pivot\_wider(names\_from = resistance, values\_from = N, values\_fill = 0) |>  
 rowwise() |>  
 mutate(total\_tests = sum(c\_across(S:I), na.rm = TRUE),   
 resistance\_rate = R / total\_tests)  
  
phe\_proportion(amr\_res\_ci\_age, R, total\_tests) |>  
 bind\_cols(amr\_res\_ci\_age) |>  
 ggplot() +  
 geom\_point(aes(reorder(five\_year, value), value)) +  
 geom\_linerange(aes(five\_year, ymin = lowercl, ymax = uppercl)) +  
 coord\_flip() +  
 labs(y = "Staph. aureus resistance rate", x = "") +   
 scale\_y\_continuous(position = "right")

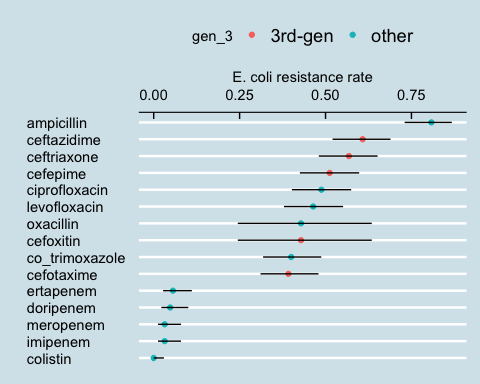
New names:  
• `R` -> `R...1`  
• `total\_tests` -> `total\_tests...2`  
• `R` -> `R...12`  
• `total\_tests` -> `total\_tests...14`



## 6.5 E. coli

amr\_res\_ci\_ec <- amr\_long[str\_detect(pathogen\_name, "coli") & !is.na(resistance), .N, by = .(antibiotic\_test, resistance, gen\_3)] |>  
 pivot\_wider(names\_from = resistance, values\_from = N, values\_fill = 0) |>  
 rowwise() |>  
 mutate(total\_tests = sum(c\_across(R:I), na.rm = TRUE),   
 resistance\_rate = R / total\_tests)  
  
phe\_proportion(amr\_res\_ci\_ec, R, total\_tests) |>  
 bind\_cols(amr\_res\_ci\_ec) |>  
 ggplot() +  
 geom\_point(aes(reorder(antibiotic\_test, value), value, colour = gen\_3)) +  
 geom\_linerange(aes(antibiotic\_test, ymin = lowercl, ymax = uppercl)) +  
 coord\_flip() +  
 labs(y = "E. coli resistance rate", x = "") + scale\_y\_continuous(position = "right")

New names:  
• `R` -> `R...1`  
• `total\_tests` -> `total\_tests...2`  
• `R` -> `R...11`  
• `total\_tests` -> `total\_tests...15`



#### 6.5.0.1 select methicillin tested samples

amr[, .SD, .SDcols = c("record\_number", "location", "patient\_hospitalized", "specific\_location", "community\_origin", "site", "pathogen\_name", "five\_year")]

record\_number location  
 <num> <char>  
 1: 1 Outpatient  
 2: 17 Inpatient  
 3: 20 Inpatient  
 4: 25 Inpatient  
 5: 43 Outpatient  
 ---   
330: 1218 Inpatient  
331: 1159 Outpatient  
332: 1183 Outpatient  
333: 1160 Outpatient  
334: 1210 Inpatient  
 patient\_hospitalized  
 <char>  
 1: Patient had NOT been admitted for more than 2 days in the past 30 days  
 2: Patient has been hospitalized for 2 days or less  
 3: Patient has been hospitalized for more than 2 days  
 4: Patient has been hospitalized for 2 days or less  
 5: Patient had NOT been admitted for more than 2 days in the past 30 days  
 ---   
330: Patient has been hospitalized for 2 days or less  
331: Patient had NOT been admitted for more than 2 days in the past 30 days  
332: Patient had NOT been admitted for more than 2 days in the past 30 days  
333: Patient had NOT been admitted for more than 2 days in the past 30 days  
334: Patient has been hospitalized for more than 2 days  
 specific\_location community\_origin site pathogen\_name  
 <char> <char> <char> <char>  
 1: Emergency Room Community Origin Blood Escherichia coli  
 2: Intensive Care Unit Community Origin Blood Escherichia coli  
 3: Intensive Care Unit Hospital Origin Blood Escherichia coli  
 4: Intensive Care Unit Community Origin Blood Escherichia coli  
 5: Emergency Room Community Origin Blood Escherichia coli  
 ---   
330: Non Intensive Unit Community Origin Blood Escherichia coli  
331: Emergency Room Community Origin Blood Staphylococcus aureus  
332: Out Patient Department Community Origin Blood Staphylococcus aureus  
333: Emergency Room Community Origin Blood Escherichia coli  
334: Non Intensive Unit Hospital Origin Blood Staphylococcus aureus  
 five\_year  
 <fctr>  
 1: [0,5)  
 2: [70,75)  
 3: [40,45)  
 4: [65,70)  
 5: [65,70)  
 ---   
330: [80,85)  
331: [85,90)  
332: [85,90)  
333: [90,95)  
334: [95,100)

# 7. smoking-poc

## 7.1

### 7.1.1 Data preparation

smoking <- smoking[, `:=` (five\_year = cut(age, breaks = seq(0, 100, 5), right = FALSE), `18-44` = between(age, 18, 44), `15+` = age >= 15)][]

### 7.1.2 Calculate numerator and denominator

smoking[patient\_gender == "female" & `18-44` == TRUE, .N, by = .(directorate\_name, year)]

directorate\_name year N  
 <char> <int> <int>  
 1: Asir 2022 9  
 2: Jazan 2022 145  
 3: Jouf 2022 23  
 4: Najran 2022 82  
 5: Qassim 2022 22  
 6: Eastern 2022 551  
 7: AlAhsa 2022 73  
 8: Tabuk 2022 291  
 9: Northern Borders 2022 4  
10: Madinah 2022 205  
11: Riyadh 2022 1830  
12: Jeddah 2022 1569  
13: Baha 2022 28  
14: Taif 2022 100  
15: Makkah 2022 578  
16: Qunfotha 2022 13  
17: Bisha 2022 6  
18: Hail 2022 22  
19: Hafer AlBatin 2022 60

## probably better - easier to calculate / matching age bands/ more statitsical power NB crude rates  
  
smoking[patient\_gender == "female" & `15+` == TRUE, .N, by = .(directorate\_name, year)]

directorate\_name year N  
 <char> <int> <int>  
 1: Asir 2022 84  
 2: Jazan 2022 158  
 3: Jouf 2022 28  
 4: Najran 2022 85  
 5: Qassim 2022 48  
 6: Eastern 2022 579  
 7: AlAhsa 2022 93  
 8: Tabuk 2022 436  
 9: Northern Borders 2022 7  
10: Madinah 2022 303  
11: Riyadh 2022 1862  
12: Jeddah 2022 1788  
13: Baha 2022 28  
14: Taif 2022 136  
15: Makkah 2022 636  
16: Qunfotha 2022 13  
17: Bisha 2022 6  
18: Hail 2022 22  
19: Hafer AlBatin 2022 60  
20: Qurayyat 2022 4  
 directorate\_name year N

## denominator

### 7.1.3 Choropleth map

sa\_shp <- curl\_download("https://data.humdata.org/dataset/41ce9023-1d21-4549-a485-94316200aba0/resource/a0188b1b-2f40-4f27-8a43-25913a7378ca/download/sau\_adm\_gadm\_20210525\_shp.zip", destfile = tempfile())  
  
tmpd <- tempdir()  
  
sa\_shp\_1 <- curl\_download("https://data.humdata.org/dataset/41ce9023-1d21-4549-a485-94316200aba0/resource/99834c81-ad34-415e-91c5-af053d8e55b4/download/sau\_capp\_adm1\_1m\_ocha.zip", destfile = tempfile())  
  
#sa\_pop\_d <- curl\_download("https://data.humdata.org/dataset/14b288ca-1855-4025-9f01-41cba548e6f6/resource/44baa2f6-b6d8-4018-b9c6-fd81b493ec22/download/sau\_general\_2020\_geotiff.zip", destfile = tempfile())  
  
sa\_shp <- unzip(sa\_shp\_l, exdir = tmpd)  
  
sa\_shp\_1 <- unzip(sa\_shp\_1, exdir = tmpd)  
  
sa\_tif <- unzip(sa\_pop\_d, exdir = tmpd)  
  
shps <- fs::dir\_ls(tmpd, regexp = "shp")  
  
sa\_bound <- read\_sf(shps[4])   
  
sa\_bound |>  
 ggplot() +  
 geom\_sf(aes(fill = ADM1\_EN)) +  
 geom\_sf(data = read\_sf(shps[12])) +  
 geom\_sf\_label(data = read\_sf(shps[12]), aes(label = NAME), colour = "blue", size = 3, nudge\_y = .5) +  
 theme\_void() +  
 scale\_fill\_viridis\_d(option = "rocket")  
  
smoking$directorate\_name |>  
 unique()  
  
sa\_bound$ADM1\_EN  
  
  
# source("/Users/julianflowers/Library/CloudStorage/GoogleDrive-julian.flowers12@gmail.com/My Drive/Saudi/pop-den.R")

# 8. flu

Injury

flu$region\_en |> unique()

[1] "Riyadh" "Sharqiya" "Makkah Al Mukarramah"  
 [4] "Asir" "madina" "Tabuk"   
 [7] "Jazan" "Najran" "Al Qassim"   
[10] "Hail" "Al Baha" "Northern Frontier"   
[13] "Al Jawf"

flu[, .N, by = .(Gender, AgeAtAdministration, region\_en)]

Gender AgeAtAdministration region\_en N  
 <char> <int> <char> <int>  
 1: M 23 Riyadh 18  
 2: F 23 Riyadh 36  
 3: F 33 Riyadh 93  
 4: M 33 Sharqiya 79  
 5: M 33 Riyadh 30  
 ---   
1019: M 6 Jazan 2  
1020: M 54 Al Qassim 5  
1021: F 54 Najran 2  
1022: M 54 Asir 5  
1023: F 54 Al Qassim 1

length(flu$region\_en |> unique())

[1] 13

length(flu$AgeAtAdministration |> unique())

[1] 89

max(flu$AgeAtAdministration)

[1] 118

flu\_reg\_names <- pluck(flu, "region\_en") |> unique()  
pops\_reg\_names <- pluck(pops, "Region") |> unique()  
  
intersect(flu\_reg\_names, pops\_reg\_names)

[1] "Tabuk" "Jazan" "Najran" "Al Jawf"

## only 4 names are identical between datasets  
## will need to recode region names in flu dataset to pop data names  
## also add new variable `region` to facilitate linkage between datasets  
  
flu <- flu[, region := recode(region\_en, "Riyadh" = "Ar Riyadh",   
 "Al Baha" = "Al Bahah",   
 "Sharqiya" = "Al Mintaqah ash Sharqiyah",  
 "Makkah Al Mukarramah" = "Makkah al Mukarramah",  
 "Al Qassim" = "Al Qasim",  
 "Hail" = "Ha'il",  
 "madina" = "Al Madinah al Munawwarah",  
 "Asir" = "'Asir",   
 "Northern Frontier" = "Al Hudud ash Shamaliyah")]  
  
  
## check names match  
intersect(unique(flu$region), pops\_reg\_names)

[1] "Ar Riyadh" "Al Mintaqah ash Sharqiyah"  
 [3] "Makkah al Mukarramah" "'Asir"   
 [5] "Al Madinah al Munawwarah" "Tabuk"   
 [7] "Jazan" "Najran"   
 [9] "Al Qasim" "Ha'il"   
[11] "Al Bahah" "Al Hudud ash Shamaliyah"   
[13] "Al Jawf"

labels <- unique(pops$`Five-Year Age Group`)  
  
#cut(flu$AgeAtAdministration, breaks = seq(0, max(flu$AgeAtAdministration), 5))  
## first create a terminal age band 80+ to match population data  
##   
flu <- flu[!is.na(AgeAtAdministration), age := ifelse(AgeAtAdministration >= 80, 85, AgeAtAdministration)]  
  
cut(flu$age, breaks = seq(0, 85, 5)) |> unique()

[1] (20,25] (30,35] (35,40] (0,5] <NA> (40,45] (25,30] (60,65] (55,60]  
[10] (50,55] (65,70] (5,10] (15,20] (45,50] (10,15] (75,80] (70,75] (80,85]  
17 Levels: (0,5] (5,10] (10,15] (15,20] (20,25] (25,30] (30,35] ... (80,85]

length(pops$`Five-Year Age Group` |> unique())

[1] 17

flu <- flu[, age\_band := cut(age, breaks = seq(0, 85, 5), labels = labels, right = TRUE)][]  
  
## count vaccinations by age, gender and region  
flu\_freq <- flu[, .N, by = .(Gender, region, age\_band)][order(region, age\_band, Gender)][, age\_band := as.character(age\_band)]  
  
flu\_freq[]

Gender region age\_band N  
 <char> <char> <char> <int>  
 1: F 'Asir 0-4 25  
 2: M 'Asir 0-4 1  
 3: F 'Asir 5-9 7  
 4: M 'Asir 5-9 1  
 5: F 'Asir 10-14 4  
 ---   
319: M Tabuk 65-69 1  
320: F Tabuk 75-79 1  
321: M Tabuk 80+ 1  
322: F Tabuk <NA> 15  
323: M Tabuk <NA> 34

## first remove NAs  
  
flu\_freq <- flu\_freq[!(is.na(age\_band)),]  
flu\_freq <- flu\_freq[, Gender := recode(Gender, "M" = "Male", "F" = "Female")][]  
  
## check age bands match  
  
identical(flu\_freq$age\_band |> unique(), pops$`Five-Year Age Group` |> unique())

[1] TRUE

## join population and aggregated flu data  
  
## first exclude nationality and single age columns from the pop data  
  
pops[, `:=` (`Single Age Group` = NULL, Nationality = NULL)][]

Region Five-Year Age Group Gender Population age\_numeric 15+ 18-44  
 <char> <char> <char> <int> <int> <char> <char>  
 1: Al Bahah 0-4 Female 577 0 other other  
 2: Al Bahah 0-4 Female 58 0 other other  
 3: Al Bahah 0-4 Female 115 0 other other  
 4: Al Bahah 0-4 Female 1 0 other other  
 5: Al Bahah 0-4 Female 364 0 other other  
 ---   
54409: Najran 80+ Male 1 100 15+ other  
54410: Najran 80+ Male 15 100 15+ other  
54411: Najran 80+ Male 42 100 15+ other  
54412: Najran 80+ Male 8 100 15+ other  
54413: Najran 80+ Male 1 100 15+ other

## then calculate 5-year pops by age band, gender and region  
  
pops\_agg <- pops[, sum\_pop := sum(Population), by = .(Region, `Five-Year Age Group`, Gender)] |>  
 select(Region, Gender, `Five-Year Age Group`, sum\_pop)   
  
pops\_agg$`Five-Year Age Group` |> unique()

[1] "0-4" "5-9" "10-14" "15-19" "20-24" "25-29" "30-34" "35-39" "40-44"  
[10] "45-49" "50-54" "55-59" "60-64" "65-69" "70-74" "75-79" "80+"

## Now join aggregate population data to aggregated flu data and replace structural zeros (missing region-age-gender combinations) by 0  
  
flu\_agg <- complete(flu\_freq, Gender, region, age\_band) |>  
 inner\_join(pops\_agg, by = c("Gender", "region" = "Region", "age\_band" = "Five-Year Age Group")) |>  
 distinct() |>  
 mutate(N = ifelse(is.na(N), 0, N)) |>  
 setDT()

## 8.1 Check

which(is.na(flu\_agg[, .(N, sum\_pop), by = .(age\_band, Gender, region)])) ## no NAs

integer(0)

summary(flu\_agg)

Gender region age\_band N   
 Length:442 Length:442 Length:442 Min. : 0.00   
 Class :character Class :character Class :character 1st Qu.: 0.00   
 Mode :character Mode :character Mode :character Median : 3.00   
 Mean : 19.09   
 3rd Qu.: 18.00   
 Max. :253.00   
 sum\_pop   
 Min. : 696   
 1st Qu.: 9340   
 Median : 27800   
 Mean : 72795   
 3rd Qu.: 73094   
 Max. :776167

## 8.2 Calculate rates

flu\_agg[, rate := 100000 \* N/sum\_pop][]

Gender region age\_band N sum\_pop rate  
 <char> <char> <char> <num> <int> <num>  
 1: Female 'Asir 0-4 25 86076 29.044101  
 2: Female 'Asir 10-14 4 89842 4.452261  
 3: Female 'Asir 15-19 19 80089 23.723607  
 4: Female 'Asir 20-24 87 70589 123.248665  
 5: Female 'Asir 25-29 75 72715 103.142405  
 ---   
438: Male Tabuk 60-64 14 8327 168.127777  
439: Male Tabuk 65-69 1 4546 21.997360  
440: Male Tabuk 70-74 0 2469 0.000000  
441: Male Tabuk 75-79 0 1467 0.000000  
442: Male Tabuk 80+ 1 1767 56.593096

## works!

## 8.3 Compare regions

Using KSA population as standard rate

To do this will use the phe\_dsr function from the PHEindicatormethods package from CRAN (see DSR vignette)

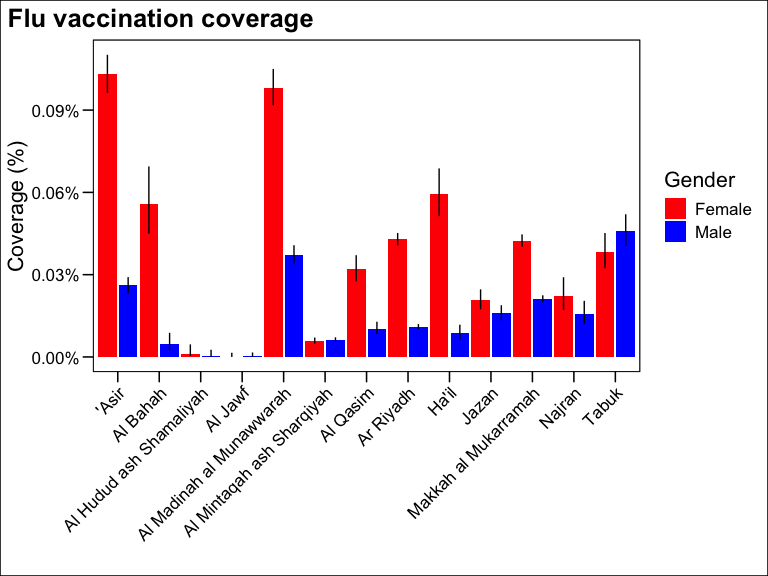
## first load PHEindicatormethods and epitools  
  
needs(PHEindicatormethods, epitools)  
  
## calculate gender, age-specific populations for KSA  
##   
  
ksa\_pop <- pops[, ref\_pop := sum(Population), by = .(Gender, `Five-Year Age Group`)][, .(`Five-Year Age Group`, Gender, ref\_pop)] |>  
 distinct() |>  
 rename(age\_band = `Five-Year Age Group`)  
  
ksa\_pop\_f <- filter(ksa\_pop, Gender == "Female") |> select(-Gender)  
  
##

## 8.4 Calculate coverage

flu\_rate <- setDT(flu\_agg)[, `:=` (tot\_obs = sum(N, na.rm = TRUE), tot\_pop = sum(sum\_pop, na.rm = TRUE)), by = .(region, Gender)][,.(region, Gender, tot\_obs, tot\_pop)] |>  
 distinct()  
  
flu\_coverage <- phe\_proportion(flu\_rate, x = tot\_obs, n = tot\_pop)

## 8.5 Visualise

flu\_coverage |>  
 ggplot() +  
 geom\_col(aes(region, value, fill = Gender), position = position\_dodge(width = 1)) +  
 geom\_linerange(aes(region, ymin = lowercl, ymax = uppercl, group = Gender), position = position\_dodge(width = 1)) +  
 labs(title = "Flu vaccination coverage",   
 y = "Coverage (%)",   
 x = "") +  
 ggthemes::theme\_base() +  
 theme(plot.title.position = "plot",   
 axis.text.x = element\_text(angle = 45, hjust = 1, )) +  
 scale\_y\_continuous(label = scales::percent) +  
 scale\_fill\_discrete(type = c("red", "blue"))



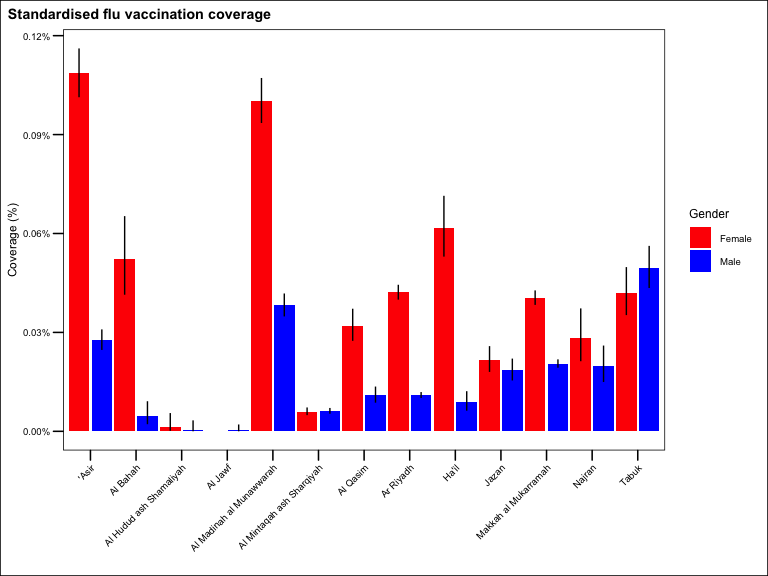
## 8.6 Age-standarised coverage

Note

flu\_agg\_std <- flu\_agg |>  
 left\_join(ksa\_pop, by = c("age\_band", "Gender"))  
  
## which region - gender combinations have data for 17 age bands?  
##   
##   
  
ksa\_pop\_f

age\_band ref\_pop  
 <char> <int>  
 1: 0-4 1263917  
 2: 5-9 1354766  
 3: 10-14 1249029  
 4: 15-19 1079884  
 5: 20-24 1050547  
 6: 25-29 1242388  
 7: 30-34 1250860  
 8: 35-39 1113283  
 9: 40-44 839031  
10: 45-49 592256  
11: 50-54 463843  
12: 55-59 351281  
13: 60-64 253046  
14: 65-69 156115  
15: 70-74 94864  
16: 75-79 64100  
17: 80+ 77419

gp <- flu\_agg\_std |>  
 mutate(age\_band = fct\_relevel(as.factor(age\_band), "5-9", after = 1)) |>  
 arrange(age\_band)  
  
gp\_nest <- gp |>  
 nest\_by(region, Gender)  
   
flu\_dsrs <- gp\_nest |>  
 mutate(ds\_rates = list(epitools::ageadjust.direct(count = data$N, pop = data$sum\_pop, stdpop = data$ref\_pop))) |>  
 unnest\_wider(ds\_rates) |>  
 select(-data)   
  
  
flu\_dsrs |>  
 ggplot() +  
 geom\_col(aes(region, adj.rate, fill = Gender), position = position\_dodge(width = 1)) +  
 geom\_linerange(aes(region, ymin = lci, ymax = uci, group = Gender), position = position\_dodge(width = 1)) +  
 labs(title = "Standardised flu vaccination coverage",   
 y = "Coverage (%)",   
 x = "") +  
 theme(plot.title.position = "plot",   
 axis.text.x = element\_text(angle = 45, hjust = 1),   
 panel.background = element\_blank()) +  
 scale\_fill\_discrete(type = c("red", "blue")) +  
 scale\_y\_continuous(label = scales::percent)



# 9. Injury

## 9.1 Injury

options(digits = 2)  
summary(injury)

DateOfBirth code diagnosis   
 Min. :1939-08-16 00:00:00.000 Length:10380 Length:10380   
 1st Qu.:1970-10-10 00:00:00.000 Class :character Class :character   
 Median :1985-11-10 00:00:00.000 Mode :character Mode :character   
 Mean :1984-01-01 12:27:30.296   
 3rd Qu.:1996-07-05 00:00:00.000   
 Max. :2022-01-30 00:00:00.000   
 NA's :773   
 Gender Region   
 Length:10380 Length:10380   
 Class :character Class :character   
 Mode :character Mode :character

obs <- nrow(injury)  
na\_dob <- injury[is.na(DateOfBirth), ]  
na\_dob\_n <- nrow(na\_dob)

Overall there are 10380 records, of which 773 (7.45% ) have missing dates of of birth.

injury[, .N, by = .(diagnosis, code, Gender, Region )]

diagnosis  
 <char>  
 1: Crushing injury of ankle and foot  
 2: Fracture of femur  
 3: Superficial injury of forearm  
 4: Dislocation, sprain and strain of joints and ligaments at ankle and foot level  
 5: Intracranial injury  
 6: Fracture of forearm  
 7: Fracture of forearm  
 8: Certain early complications of trauma, not elsewhere classified  
 9: Injury of unspecified body region  
10: Fracture of neck  
11: Fracture of skull and facial bones  
12: Open wound of thorax  
13: Open wound of shoulder and upper arm  
14: Fracture of femur  
15: Fracture of forearm  
16: Fracture of femur  
17: Certain early complications of trauma, not elsewhere classified  
18: Fracture of rib(s), sternum and thoracic spine  
19: Fracture of femur  
20: Burn body region unspecified  
21: Fracture of lower leg, including ankle  
22: Fracture of foot, except ankle  
23: Toxic effect of contact with venomous animals  
24: Other and unspecified injuries of neck  
25: Fracture of lower leg, including ankle  
26: Dislocation, sprain and strain of joints and ligaments at neck level  
27: Burns classified according to extent of body surface involved  
28: Other specified complications of trauma  
29: Fracture of lower leg, including ankle  
30: Burn of shoulder and upper limb, except wrist and hand  
31: Fracture of skull and facial bones  
32: Burn of shoulder and upper limb, except wrist and hand  
33: Open wound of head  
34: Poisoning by diuretics and other and unspecified drugs, medicaments and biological substances  
35: Fracture of lower leg, including ankle  
36: Sequelae of injuries of head  
37: Poisoning by diuretics and other and unspecified drugs, medicaments and biological substances  
38: Burn of wrist and hand  
39: Fracture of shoulder and upper arm  
40: Burns classified according to extent of body surface involved  
41: Fracture of skull and facial bones  
42: Superficial injury of wrist and hand  
43: Fracture of shoulder and upper arm  
44: Burn body region unspecified  
45: Injury of muscle and tendon at wrist and hand level  
46: Intracranial injury  
47: Foreign body in alimentary tract  
48: Other specified complications of trauma  
49: Fracture of lower leg, including ankle  
50: Complications of procedures, not elsewhere classified  
51: Fracture of shoulder and upper arm  
52: Intracranial injury  
53: Crushing injury of ankle and foot  
54: Fracture of femur  
55: Fracture of spine, level unspecified  
56: Dislocation, sprain and strain of joints and ligaments at ankle and foot level  
57: Fracture of lumbar spine and pelvis  
58: Dislocation, sprain and strain of joints and ligaments at wrist and hand level  
59: Injury of other and unspecified intrathoracic organs  
60: Burn body region unspecified  
61: Superficial injury of hip and thigh  
62: Crushing injuries involving multiple body regions  
63: Burns classified according to extent of body surface involved  
64: Open wound of head  
65: Other injuries involving multiple body regions, not elsewhere classified  
66: Fracture of forearm  
67: Intracranial injury  
68: Burn of head and neck  
69: Crushing injury of wrist and hand  
70: Toxic effect of contact with venomous animals  
71: Other and unspecified injuries of neck  
72: Other specified complications of trauma  
73: Open wound of head  
74: Poisoning by diuretics and other and unspecified drugs, medicaments and biological substances  
75: Burn of wrist and hand  
76: Fracture of skull and facial bones  
77: Fracture of lower leg, including ankle  
78: Fracture of spine, level unspecified  
79: Fracture of rib(s), sternum and thoracic spine  
80: Fracture of skull and facial bones  
81: Intracranial injury  
82: Fracture of lumbar spine and pelvis  
83: Certain early complications of trauma, not elsewhere classified  
 diagnosis  
 code Gender Region N  
 <char> <char> <char> <int>  
 1: S97 Male Makkah 140  
 2: S72 Female Makkah 240  
 3: S50 Male Makkah 300  
 4: S93 Male Riyadh 160  
 5: S06 Male Makkah 400  
 6: S52 Male Madinah 258  
 7: S52 Female Makkah 360  
 8: T79 Male Makkah 160  
 9: T14 Male Madinah 160  
10: S12 Male Riyadh 160  
11: S02 Male Riyadh 160  
12: S21 Male Riyadh 160  
13: S41 Male Riyadh 160  
14: S72 Male Madinah 225  
15: S52 Male Makkah 180  
16: S72 Male Makkah 180  
17: T79 Male Madinah 59  
18: S22 Male Madinah 66  
19: S72 Female Riyadh 600  
20: T30 Male Madinah 500  
21: S82 Male Madinah 167  
22: S92 Male Makkah 160  
23: T63 Male Madinah 58  
24: S19 Male Madinah 58  
25: S82 Male Makkah 160  
26: S13 Male Riyadh 280  
27: T31 Male Riyadh 280  
28: T89 Male Riyadh 100  
29: S82 Female Riyadh 280  
30: T22 Male Riyadh 280  
31: S02 Male Makkah 187  
32: T22 Male Makkah 160  
33: S01 Male Northern Frontier 58  
34: T50 Male Northern Frontier 57  
35: S82 Male Sharqiya 160  
36: T90 Female Makkah 160  
37: T50 Female Madinah 160  
38: T23 Male Madinah 58  
39: S42 Male Najran 160  
40: T31 Male Makkah 160  
41: S02 Male Al Baha 58  
42: S60 Female Al Jawf 160  
43: S42 Female Al Qassim 160  
44: T30 Female Asir 160  
45: S66 Male Hail 160  
46: S06 Male Jazan 140  
47: T18 Male Madinah 20  
48: T89 Male Makkah 20  
49: S82 Female Makkah 60  
50: T81 Male Madinah 20  
51: S42 Female Makkah 20  
52: S06 Female Makkah 20  
53: S97 Male Madinah 20  
54: S72 Female Madinah 135  
55: T08 Male Madinah 7  
56: S93 Male Makkah 20  
57: S32 Male Makkah 27  
58: S63 Female Makkah 20  
59: S27 Male Makkah 20  
60: T30 Male Makkah 20  
61: S70 Male Makkah 20  
62: T04 Male Makkah 20  
63: T31 Male Madinah 20  
64: S01 Male Makkah 20  
65: T06 Male Makkah 20  
66: S52 Female Madinah 122  
67: S06 Male Madinah 7  
68: T20 Male Makkah 20  
69: S67 Male Makkah 20  
70: T63 Female Madinah 102  
71: S19 Female Madinah 102  
72: T89 Female Riyadh 180  
73: S01 Female Northern Frontier 102  
74: T50 Female Northern Frontier 103  
75: T23 Female Madinah 102  
76: S02 Female Al Baha 102  
77: S82 Female Madinah 13  
78: T08 Female Madinah 13  
79: S22 Female Madinah 114  
80: S02 Female Makkah 13  
81: S06 Female Madinah 13  
82: S32 Female Makkah 13  
83: T79 Female Madinah 101  
 code Gender Region N

unique(injury$Region)

[1] "Makkah" "Riyadh" "Madinah"   
 [4] "Northern Frontier" "Sharqiya" "Najran"   
 [7] "Al Baha" "Al Jawf" "Al Qassim"   
[10] "Asir" "Hail" "Jazan"

The data contains values for 12 of the 13 regions.

## exclude missing DoB  
injury\_dob <- injury[!is.na(DateOfBirth),]  
  
injury\_dob <- injury\_dob[!is.na(DateOfBirth), age := .(as.POSIXct(ymd("2023-06-01")) - DateOfBirth)][, age\_year := floor(as.numeric(age) / 365)][, age\_band := cut(age\_year, seq(0, 120, 5))][]

## 9.2 Aggregate injury data

injury\_dob[, .N, by = .(Region, diagnosis, code, age\_band, Gender)][order(Region)] |>  
 pivot\_wider(names\_from = Region, values\_from = N) |>  
 arrange(age\_band, code, Gender) |>  
 flextable::flextable()

| diagnosis | code | age\_band | Gender | Al Baha | Al Jawf | Al Qassim | Asir | Hail | Jazan | Madinah | Makkah | Najran | Northern Frontier | Riyadh | Sharqiya |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Crushing injury of wrist and hand | S67 | (0,5] | Male |  |  |  |  |  |  |  | 20 |  |  |  |  |
| Burn body region unspecified | T30 | (0,5] | Female |  |  |  | 160 |  |  |  |  |  |  |  |  |
| Burn body region unspecified | T30 | (0,5] | Male |  |  |  |  |  |  | 320 | 20 |  |  |  |  |
| Fracture of skull and facial bones | S02 | (10,15] | Male |  |  |  |  |  |  |  | 20 |  |  | 160 |  |
| Fracture of forearm | S52 | (10,15] | Male |  |  |  |  |  |  | 199 |  |  |  |  |  |
| Superficial injury of wrist and hand | S60 | (10,15] | Female |  | 160 |  |  |  |  |  |  |  |  |  |  |
| Fracture of femur | S72 | (10,15] | Female |  |  |  |  |  |  | 9 |  |  |  |  |  |
| Fracture of lower leg, including ankle | S82 | (10,15] | Male |  |  |  |  |  |  |  | 160 |  |  |  |  |
| Crushing injury of ankle and foot | S97 | (10,15] | Male |  |  |  |  |  |  | 20 |  |  |  |  |  |
| Fracture of spine, level unspecified | T08 | (10,15] | Female |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Burn of wrist and hand | T23 | (10,15] | Female |  |  |  |  |  |  | 8 |  |  |  |  |  |
| Burn body region unspecified | T30 | (10,15] | Male |  |  |  |  |  |  | 160 |  |  |  |  |  |
| Other specified complications of trauma | T89 | (10,15] | Female |  |  |  |  |  |  |  |  |  |  | 8 |  |
| Fracture of rib(s), sternum and thoracic spine | S22 | (15,20] | Female |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Crushing injuries involving multiple body regions | T04 | (15,20] | Male |  |  |  |  |  |  |  | 19 |  |  |  |  |
| Open wound of head | S01 | (20,25] | Female |  |  |  |  |  |  |  |  |  | 17 |  |  |
| Fracture of skull and facial bones | S02 | (20,25] | Female | 19 |  |  |  |  |  |  | 1 |  |  |  |  |
| Intracranial injury | S06 | (20,25] | Female |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Other and unspecified injuries of neck | S19 | (20,25] | Female |  |  |  |  |  |  | 18 |  |  |  |  |  |
| Fracture of rib(s), sternum and thoracic spine | S22 | (20,25] | Female |  |  |  |  |  |  | 19 |  |  |  |  |  |
| Fracture of lumbar spine and pelvis | S32 | (20,25] | Female |  |  |  |  |  |  |  | 1 |  |  |  |  |
| Fracture of forearm | S52 | (20,25] | Female |  |  |  |  |  |  | 38 |  |  |  |  |  |
| Fracture of forearm | S52 | (20,25] | Male |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Fracture of femur | S72 | (20,25] | Female |  |  |  |  |  |  | 19 |  |  |  |  |  |
| Fracture of lower leg, including ankle | S82 | (20,25] | Female |  |  |  |  |  |  | 2 | 20 |  |  |  |  |
| Crushing injuries involving multiple body regions | T04 | (20,25] | Male |  |  |  |  |  |  |  | 1 |  |  |  |  |
| Fracture of spine, level unspecified | T08 | (20,25] | Female |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Injury of unspecified body region | T14 | (20,25] | Male |  |  |  |  |  |  | 160 |  |  |  |  |  |
| Foreign body in alimentary tract | T18 | (20,25] | Male |  |  |  |  |  |  | 20 |  |  |  |  |  |
| Burn of wrist and hand | T23 | (20,25] | Female |  |  |  |  |  |  | 19 |  |  |  |  |  |
| Burns classified according to extent of body surface involved | T31 | (20,25] | Male |  |  |  |  |  |  |  |  |  |  | 280 |  |
| Poisoning by diuretics and other and unspecified drugs, medicaments and biological substances | T50 | (20,25] | Female |  |  |  |  |  |  | 160 |  |  | 18 |  |  |
| Toxic effect of contact with venomous animals | T63 | (20,25] | Female |  |  |  |  |  |  | 19 |  |  |  |  |  |
| Certain early complications of trauma, not elsewhere classified | T79 | (20,25] | Female |  |  |  |  |  |  | 18 |  |  |  |  |  |
| Other specified complications of trauma | T89 | (20,25] | Female |  |  |  |  |  |  |  |  |  |  | 32 |  |
| Other specified complications of trauma | T89 | (20,25] | Male |  |  |  |  |  |  |  | 20 |  |  |  |  |
| Open wound of head | S01 | (25,30] | Female |  |  |  |  |  |  |  |  |  | 13 |  |  |
| Open wound of head | S01 | (25,30] | Male |  |  |  |  |  |  |  | 20 |  |  |  |  |
| Fracture of skull and facial bones | S02 | (25,30] | Female | 12 |  |  |  |  |  |  | 2 |  |  |  |  |
| Intracranial injury | S06 | (25,30] | Female |  |  |  |  |  |  | 2 |  |  |  |  |  |
| Intracranial injury | S06 | (25,30] | Male |  |  |  |  |  |  |  | 160 |  |  |  |  |
| Fracture of neck | S12 | (25,30] | Male |  |  |  |  |  |  |  |  |  |  | 160 |  |
| Other and unspecified injuries of neck | S19 | (25,30] | Female |  |  |  |  |  |  | 12 |  |  |  |  |  |
| Open wound of thorax | S21 | (25,30] | Male |  |  |  |  |  |  |  |  |  |  | 160 |  |
| Fracture of rib(s), sternum and thoracic spine | S22 | (25,30] | Female |  |  |  |  |  |  | 14 |  |  |  |  |  |
| Fracture of lumbar spine and pelvis | S32 | (25,30] | Female |  |  |  |  |  |  |  | 2 |  |  |  |  |
| Fracture of shoulder and upper arm | S42 | (25,30] | Male |  |  |  |  |  |  |  |  | 160 |  |  |  |
| Superficial injury of forearm | S50 | (25,30] | Male |  |  |  |  |  |  |  | 160 |  |  |  |  |
| Fracture of forearm | S52 | (25,30] | Female |  |  |  |  |  |  | 12 |  |  |  |  |  |
| Fracture of femur | S72 | (25,30] | Female |  |  |  |  |  |  | 6 |  |  |  |  |  |
| Fracture of lower leg, including ankle | S82 | (25,30] | Female |  |  |  |  |  |  | 2 |  |  |  |  |  |
| Fracture of lower leg, including ankle | S82 | (25,30] | Male |  |  |  |  |  |  | 160 |  |  |  |  |  |
| Fracture of spine, level unspecified | T08 | (25,30] | Female |  |  |  |  |  |  | 2 |  |  |  |  |  |
| Burn of head and neck | T20 | (25,30] | Male |  |  |  |  |  |  |  | 20 |  |  |  |  |
| Burn of wrist and hand | T23 | (25,30] | Female |  |  |  |  |  |  | 4 |  |  |  |  |  |
| Poisoning by diuretics and other and unspecified drugs, medicaments and biological substances | T50 | (25,30] | Female |  |  |  |  |  |  |  |  |  | 12 |  |  |
| Toxic effect of contact with venomous animals | T63 | (25,30] | Female |  |  |  |  |  |  | 12 |  |  |  |  |  |
| Certain early complications of trauma, not elsewhere classified | T79 | (25,30] | Female |  |  |  |  |  |  | 12 |  |  |  |  |  |
| Other specified complications of trauma | T89 | (25,30] | Female |  |  |  |  |  |  |  |  |  |  | 14 |  |
| Open wound of head | S01 | (30,35] | Female |  |  |  |  |  |  |  |  |  | 11 |  |  |
| Open wound of head | S01 | (30,35] | Male |  |  |  |  |  |  |  |  |  | 8 |  |  |
| Fracture of skull and facial bones | S02 | (30,35] | Female | 18 |  |  |  |  |  |  | 1 |  |  |  |  |
| Fracture of skull and facial bones | S02 | (30,35] | Male | 10 |  |  |  |  |  |  | 1 |  |  |  |  |
| Intracranial injury | S06 | (30,35] | Female |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Intracranial injury | S06 | (30,35] | Male |  |  |  |  |  |  | 1 | 17 |  |  |  |  |
| Other and unspecified injuries of neck | S19 | (30,35] | Female |  |  |  |  |  |  | 11 |  |  |  |  |  |
| Other and unspecified injuries of neck | S19 | (30,35] | Male |  |  |  |  |  |  | 8 |  |  |  |  |  |
| Fracture of rib(s), sternum and thoracic spine | S22 | (30,35] | Female |  |  |  |  |  |  | 13 |  |  |  |  |  |
| Fracture of rib(s), sternum and thoracic spine | S22 | (30,35] | Male |  |  |  |  |  |  | 9 |  |  |  |  |  |
| Fracture of lumbar spine and pelvis | S32 | (30,35] | Female |  |  |  |  |  |  |  | 1 |  |  |  |  |
| Fracture of lumbar spine and pelvis | S32 | (30,35] | Male |  |  |  |  |  |  |  | 1 |  |  |  |  |
| Open wound of shoulder and upper arm | S41 | (30,35] | Male |  |  |  |  |  |  |  |  |  |  | 160 |  |
| Superficial injury of forearm | S50 | (30,35] | Male |  |  |  |  |  |  |  | 140 |  |  |  |  |
| Fracture of forearm | S52 | (30,35] | Female |  |  |  |  |  |  | 11 |  |  |  |  |  |
| Fracture of forearm | S52 | (30,35] | Male |  |  |  |  |  |  | 8 |  |  |  |  |  |
| Fracture of femur | S72 | (30,35] | Female |  |  |  |  |  |  | 12 |  |  |  |  |  |
| Fracture of femur | S72 | (30,35] | Male |  |  |  |  |  |  | 9 |  |  |  |  |  |
| Fracture of lower leg, including ankle | S82 | (30,35] | Female |  |  |  |  |  |  | 2 |  |  |  |  |  |
| Fracture of lower leg, including ankle | S82 | (30,35] | Male |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Fracture of foot, except ankle | S92 | (30,35] | Male |  |  |  |  |  |  |  | 2 |  |  |  |  |
| Fracture of spine, level unspecified | T08 | (30,35] | Female |  |  |  |  |  |  | 2 |  |  |  |  |  |
| Fracture of spine, level unspecified | T08 | (30,35] | Male |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Burn of shoulder and upper limb, except wrist and hand | T22 | (30,35] | Male |  |  |  |  |  |  |  |  |  |  | 280 |  |
| Burn of wrist and hand | T23 | (30,35] | Female |  |  |  |  |  |  | 10 |  |  |  |  |  |
| Burn of wrist and hand | T23 | (30,35] | Male |  |  |  |  |  |  | 9 |  |  |  |  |  |
| Burns classified according to extent of body surface involved | T31 | (30,35] | Male |  |  |  |  |  |  | 2 | 160 |  |  |  |  |
| Poisoning by diuretics and other and unspecified drugs, medicaments and biological substances | T50 | (30,35] | Female |  |  |  |  |  |  |  |  |  | 11 |  |  |
| Poisoning by diuretics and other and unspecified drugs, medicaments and biological substances | T50 | (30,35] | Male |  |  |  |  |  |  |  |  |  | 8 |  |  |
| Toxic effect of contact with venomous animals | T63 | (30,35] | Female |  |  |  |  |  |  | 11 |  |  |  |  |  |
| Toxic effect of contact with venomous animals | T63 | (30,35] | Male |  |  |  |  |  |  | 8 |  |  |  |  |  |
| Certain early complications of trauma, not elsewhere classified | T79 | (30,35] | Female |  |  |  |  |  |  | 11 |  |  |  |  |  |
| Certain early complications of trauma, not elsewhere classified | T79 | (30,35] | Male |  |  |  |  |  |  | 8 |  |  |  |  |  |
| Other specified complications of trauma | T89 | (30,35] | Female |  |  |  |  |  |  |  |  |  |  | 26 |  |
| Other specified complications of trauma | T89 | (30,35] | Male |  |  |  |  |  |  |  |  |  |  | 14 |  |
| Intracranial injury | S06 | (35,40] | Male |  |  |  |  |  | 140 |  |  |  |  |  |  |
| Dislocation, sprain and strain of joints and ligaments at neck level | S13 | (35,40] | Male |  |  |  |  |  |  |  |  |  |  | 280 |  |
| Fracture of lumbar spine and pelvis | S32 | (35,40] | Female |  |  |  |  |  |  |  | 4 |  |  |  |  |
| Fracture of lumbar spine and pelvis | S32 | (35,40] | Male |  |  |  |  |  |  |  | 21 |  |  |  |  |
| Fracture of forearm | S52 | (35,40] | Male |  |  |  |  |  |  |  | 180 |  |  |  |  |
| Injury of muscle and tendon at wrist and hand level | S66 | (35,40] | Male |  |  |  |  | 160 |  |  |  |  |  |  |  |
| Fracture of femur | S72 | (35,40] | Male |  |  |  |  |  |  |  | 19 |  |  |  |  |
| Fracture of lower leg, including ankle | S82 | (35,40] | Female |  |  |  |  |  |  |  | 20 |  |  |  |  |
| Burn of shoulder and upper limb, except wrist and hand | T22 | (35,40] | Male |  |  |  |  |  |  |  | 160 |  |  |  |  |
| Open wound of head | S01 | (40,45] | Female |  |  |  |  |  |  |  |  |  | 8 |  |  |
| Open wound of head | S01 | (40,45] | Male |  |  |  |  |  |  |  |  |  | 2 |  |  |
| Fracture of skull and facial bones | S02 | (40,45] | Female | 1 |  |  |  |  |  |  | 5 |  |  |  |  |
| Fracture of skull and facial bones | S02 | (40,45] | Male | 2 |  |  |  |  |  |  | 1 |  |  |  |  |
| Intracranial injury | S06 | (40,45] | Female |  |  |  |  |  |  | 5 |  |  |  |  |  |
| Intracranial injury | S06 | (40,45] | Male |  |  |  |  |  |  | 1 | 142 |  |  |  |  |
| Other and unspecified injuries of neck | S19 | (40,45] | Female |  |  |  |  |  |  | 8 |  |  |  |  |  |
| Other and unspecified injuries of neck | S19 | (40,45] | Male |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Fracture of rib(s), sternum and thoracic spine | S22 | (40,45] | Female |  |  |  |  |  |  | 41 |  |  |  |  |  |
| Fracture of rib(s), sternum and thoracic spine | S22 | (40,45] | Male |  |  |  |  |  |  | 11 |  |  |  |  |  |
| Fracture of lumbar spine and pelvis | S32 | (40,45] | Female |  |  |  |  |  |  |  | 1 |  |  |  |  |
| Fracture of forearm | S52 | (40,45] | Female |  |  |  |  |  |  | 39 |  |  |  |  |  |
| Fracture of forearm | S52 | (40,45] | Male |  |  |  |  |  |  | 9 |  |  |  |  |  |
| Dislocation, sprain and strain of joints and ligaments at wrist and hand level | S63 | (40,45] | Female |  |  |  |  |  |  |  | 19 |  |  |  |  |
| Superficial injury of hip and thigh | S70 | (40,45] | Male |  |  |  |  |  |  |  | 19 |  |  |  |  |
| Fracture of femur | S72 | (40,45] | Female |  |  |  |  |  |  | 11 |  |  |  |  |  |
| Fracture of femur | S72 | (40,45] | Male |  |  |  |  |  |  | 4 |  |  |  |  |  |
| Fracture of lower leg, including ankle | S82 | (40,45] | Male |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Crushing injury of ankle and foot | S97 | (40,45] | Male |  |  |  |  |  |  |  | 139 |  |  |  |  |
| Fracture of spine, level unspecified | T08 | (40,45] | Female |  |  |  |  |  |  | 3 |  |  |  |  |  |
| Fracture of spine, level unspecified | T08 | (40,45] | Male |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Burn of wrist and hand | T23 | (40,45] | Female |  |  |  |  |  |  | 8 |  |  |  |  |  |
| Burn of wrist and hand | T23 | (40,45] | Male |  |  |  |  |  |  | 3 |  |  |  |  |  |
| Burn body region unspecified | T30 | (40,45] | Male |  |  |  |  |  |  | 19 |  |  |  |  |  |
| Burns classified according to extent of body surface involved | T31 | (40,45] | Male |  |  |  |  |  |  | 17 |  |  |  |  |  |
| Poisoning by diuretics and other and unspecified drugs, medicaments and biological substances | T50 | (40,45] | Female |  |  |  |  |  |  |  |  |  | 8 |  |  |
| Poisoning by diuretics and other and unspecified drugs, medicaments and biological substances | T50 | (40,45] | Male |  |  |  |  |  |  |  |  |  | 3 |  |  |
| Toxic effect of contact with venomous animals | T63 | (40,45] | Female |  |  |  |  |  |  | 7 |  |  |  |  |  |
| Toxic effect of contact with venomous animals | T63 | (40,45] | Male |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Certain early complications of trauma, not elsewhere classified | T79 | (40,45] | Female |  |  |  |  |  |  | 38 |  |  |  |  |  |
| Certain early complications of trauma, not elsewhere classified | T79 | (40,45] | Male |  |  |  |  |  |  | 10 |  |  |  |  |  |
| Other specified complications of trauma | T89 | (40,45] | Female |  |  |  |  |  |  |  |  |  |  | 8 |  |
| Other specified complications of trauma | T89 | (40,45] | Male |  |  |  |  |  |  |  |  |  |  | 1 |  |
| Open wound of head | S01 | (45,50] | Female |  |  |  |  |  |  |  |  |  | 33 |  |  |
| Open wound of head | S01 | (45,50] | Male |  |  |  |  |  |  |  |  |  | 7 |  |  |
| Fracture of skull and facial bones | S02 | (45,50] | Female | 33 |  |  |  |  |  |  | 1 |  |  |  |  |
| Fracture of skull and facial bones | S02 | (45,50] | Male | 6 |  |  |  |  |  |  |  |  |  |  |  |
| Intracranial injury | S06 | (45,50] | Female |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Intracranial injury | S06 | (45,50] | Male |  |  |  |  |  |  |  | 41 |  |  |  |  |
| Other and unspecified injuries of neck | S19 | (45,50] | Female |  |  |  |  |  |  | 33 |  |  |  |  |  |
| Other and unspecified injuries of neck | S19 | (45,50] | Male |  |  |  |  |  |  | 8 |  |  |  |  |  |
| Fracture of rib(s), sternum and thoracic spine | S22 | (45,50] | Female |  |  |  |  |  |  | 2 |  |  |  |  |  |
| Fracture of lumbar spine and pelvis | S32 | (45,50] | Female |  |  |  |  |  |  |  | 1 |  |  |  |  |
| Fracture of shoulder and upper arm | S42 | (45,50] | Female |  |  | 160 |  |  |  |  |  |  |  |  |  |
| Fracture of forearm | S52 | (45,50] | Female |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Dislocation, sprain and strain of joints and ligaments at wrist and hand level | S63 | (45,50] | Female |  |  |  |  |  |  |  | 1 |  |  |  |  |
| Superficial injury of hip and thigh | S70 | (45,50] | Male |  |  |  |  |  |  |  | 1 |  |  |  |  |
| Fracture of femur | S72 | (45,50] | Female |  |  |  |  |  |  | 34 |  |  |  |  |  |
| Fracture of femur | S72 | (45,50] | Male |  |  |  |  |  |  | 6 | 1 |  |  |  |  |
| Fracture of lower leg, including ankle | S82 | (45,50] | Female |  |  |  |  |  |  | 4 |  |  |  |  |  |
| Fracture of lower leg, including ankle | S82 | (45,50] | Male |  |  |  |  |  |  |  |  |  |  |  | 160 |
| Fracture of foot, except ankle | S92 | (45,50] | Male |  |  |  |  |  |  |  | 158 |  |  |  |  |
| Dislocation, sprain and strain of joints and ligaments at ankle and foot level | S93 | (45,50] | Male |  |  |  |  |  |  |  | 20 |  |  |  |  |
| Crushing injury of ankle and foot | S97 | (45,50] | Male |  |  |  |  |  |  |  | 1 |  |  |  |  |
| Fracture of spine, level unspecified | T08 | (45,50] | Female |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Burn of wrist and hand | T23 | (45,50] | Female |  |  |  |  |  |  | 33 |  |  |  |  |  |
| Burn of wrist and hand | T23 | (45,50] | Male |  |  |  |  |  |  | 6 |  |  |  |  |  |
| Burn body region unspecified | T30 | (45,50] | Male |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Burns classified according to extent of body surface involved | T31 | (45,50] | Male |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Poisoning by diuretics and other and unspecified drugs, medicaments and biological substances | T50 | (45,50] | Female |  |  |  |  |  |  |  |  |  | 33 |  |  |
| Poisoning by diuretics and other and unspecified drugs, medicaments and biological substances | T50 | (45,50] | Male |  |  |  |  |  |  |  |  |  | 6 |  |  |
| Toxic effect of contact with venomous animals | T63 | (45,50] | Female |  |  |  |  |  |  | 33 |  |  |  |  |  |
| Toxic effect of contact with venomous animals | T63 | (45,50] | Male |  |  |  |  |  |  | 8 |  |  |  |  |  |
| Certain early complications of trauma, not elsewhere classified | T79 | (45,50] | Female |  |  |  |  |  |  | 1 |  |  |  |  |  |
| Other specified complications of trauma | T89 | (45,50] | Female |  |  |  |  |  |  |  |  |  |  | 57 |  |
| Other specified complications of trauma | T89 | (45,50] | Male |  |  |  |  |  |  |  |  |  |  | 14 |  |
| Fracture of forearm | S52 | (50,55] | Female |  |  |  |  |  |  |  | 20 |  |  |  |  |
| Fracture of femur | S72 | (50,55] | Female |  |  |  |  |  |  |  | 40 |  |  | 320 |  |
| Fracture of lower leg, including ankle | S82 | (50,55] | Female |  |  |  |  |  |  |  |  |  |  | 280 |  |
| Other injuries involving multiple body regions, not elsewhere classified | T06 | (50,55] | Male |  |  |  |  |  |  |  | 20 |  |  |  |  |
| Complications of procedures, not elsewhere classified | T81 | (50,55] | Male |  |  |  |  |  |  | 20 |  |  |  |  |  |
| Sequelae of injuries of head | T90 | (50,55] | Female |  |  |  |  |  |  |  | 160 |  |  |  |  |
| Certain early complications of trauma, not elsewhere classified | T79 | (55,60] | Male |  |  |  |  |  |  |  | 160 |  |  |  |  |
| Intracranial injury | S06 | (60,65] | Female |  |  |  |  |  |  |  | 20 |  |  |  |  |
| Intracranial injury | S06 | (60,65] | Male |  |  |  |  |  |  |  | 40 |  |  |  |  |
| Fracture of forearm | S52 | (60,65] | Female |  |  |  |  |  |  |  | 20 |  |  |  |  |
| Fracture of femur | S72 | (60,65] | Female |  |  |  |  |  |  | 20 |  |  |  | 280 |  |
| Fracture of femur | S72 | (60,65] | Male |  |  |  |  |  |  |  | 160 |  |  |  |  |
| Fracture of lower leg, including ankle | S82 | (60,65] | Female |  |  |  |  |  |  |  | 20 |  |  |  |  |
| Dislocation, sprain and strain of joints and ligaments at ankle and foot level | S93 | (60,65] | Male |  |  |  |  |  |  |  |  |  |  | 160 |  |
| Fracture of skull and facial bones | S02 | (65,70] | Male |  |  |  |  |  |  |  | 160 |  |  |  |  |
| Fracture of femur | S72 | (65,70] | Female |  |  |  |  |  |  |  | 20 |  |  |  |  |
| Injury of other and unspecified intrathoracic organs | S27 | (70,75] | Male |  |  |  |  |  |  |  | 20 |  |  |  |  |
| Fracture of femur | S72 | (70,75] | Female |  |  |  |  |  |  |  | 160 |  |  |  |  |
| Fracture of shoulder and upper arm | S42 | (75,80] | Female |  |  |  |  |  |  |  | 20 |  |  |  |  |
| Fracture of femur | S72 | (75,80] | Female |  |  |  |  |  |  |  | 20 |  |  |  |  |
| Fracture of femur | S72 | (75,80] | Male |  |  |  |  |  |  | 160 |  |  |  |  |  |
| Fracture of forearm | S52 | (80,85] | Female |  |  |  |  |  |  |  | 320 |  |  |  |  |

# 10. Summary

In summary, this book has no content whatsoever.

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# References