SubnationalCRVS R Package: Demo

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Contents

1 Setup

Since the `SubnationalCRVS` package is still under active development, it is hosted on my GitHub page (`www.github.com/jroth-unfpa/SubnationalCRVS`) rather than on CRAN. As a result, `SubnationalCRVS` cannot be installed with the usual `install.packages()` function; instead, we install `SubnationalCRVS` with the `install.github()` function from the `devtools` package. The dependency `DemoTools` is also not hosted on CRAN and must be installed with `install.github()`.

```
library(devtools)
install_github("timriffe/DemoTools") # installing the DemoTools dependency (not on CRAN)
install_github("jroth-unfpa/SubnationalCRVS") # installing the SubnationalCRVS package itself
```

Now we can load `SubnationalCRVS`, specify the name of the local folder in which we will save the plots, and create that local folder if it does not already exist.

```
library(SubnationalCRVS)
my_plots_dir <- "Plots/" # local folder where the plots should be saved
dir.create(my_plots_dir) # create the folder if it does not already exist
```

We will also load the `dplyr` package to customize the display of some of the tables returned by `SunbationalCRVS`.

```r
library(dplyr)
```

2 View the Example Datasets Included with the Subnational-CRVS Package

The `SubnationalCRVS` package comes with two tabulations – disaggregated by age, sex, and province – created from publicly available datasets from Ecuador (LINKS), based on the country's 2001 Census, 2010 Census, and annual counts of registered deaths from 2001 through 2010.

```r
head(ecuador_single_year_ages)
```

```
##   province_name province_name_short sex age pop1 pop2      date1      date2
## 1         Azuay                 Azu   m   0 6086 6750 2001-11-25 2010-11-28
## 2         Azuay                 Azu   m   1 6555 6984 2001-11-25 2010-11-28
## 3         Azuay                 Azu   m   2 7232 7090 2001-11-25 2010-11-28
## 4         Azuay                 Azu   m   3 7101 7095 2001-11-25 2010-11-28
## 5         Azuay                 Azu   m   4 7083 6961 2001-11-25 2010-11-28
## 6         Azuay                 Azu   m   5 6583 6895 2001-11-25 2010-11-28
```

The `ecuador_single_year_ages` dataset reports the estimated populations in Ecuador by single-year ages (0, 1, 2, … in the `age` column) from both the 2001 Census (`pop1` column) and the 2010 Census (`pop2` column), separately for males and females (`m` and `f` in the `sex` column) and province (full name in the `province` column and abbreviated name in the `province_name_short` column).

```r
head(ecuador_five_year_ages)
```

```
##   province_name province_name_short sex age  pop1  pop2 deaths      date1
## 1         Azuay                 Azu   m   0 34101 34886    772 2001-11-25
## 2         Azuay                 Azu   m  10 34946 38125    223 2001-11-25
## 3         Azuay                 Azu   m  15 32387 37611    416 2001-11-25
## 4         Azuay                 Azu   m  20 25634 33665    480 2001-11-25
## 5         Azuay                 Azu   m  25 18606 28376    475 2001-11-25
## 6         Azuay                 Azu   m  30 16193 22026    456 2001-11-25
##        date2
## 1 2010-11-28
## 2 2010-11-28
## 3 2010-11-28
## 4 2010-11-28
## 5 2010-11-28
## 6 2010-11-28
```

The `ecuador_five_year_ages` dataset has the same variables as `ecuador_single_year_ages` with two exceptions: (1) the `age` variable now represents five-year age groups (in the `age` column, with 0-4 coded as 0, 5-9 coded as 5, 10-14 coded as 10, etc.) instead of single-year ages; and (2) there is an additional column called `deaths` that reports the registered deaths collected between 2001 and 2010.

3 Conduct Demographic Data Quality Assessment (DDQA)

3.1 Sex ratio: PlotSexRatios()

One step in the demographic data quality assessment (DDQA) process is to use the `PlotSexRatios()` function in the `SubnationalCRVS` package to compute and plot sex ratios within each combination of province, sex, and single-year age for the 2001 and 2010 data stored in `ecuador_single_year_ages`.

We must provide our tabulated data frame in the `data` argument of `PlotSexRatios()` and, additionally, we need to provide a few additional arguments to `PlotSexRations()` to describe the variable names and values in the dataset:

- `name.disaggregations` is the name of variable representing the subnational disaggregation (apart from sex) in `data`. Here we specify `name.disaggregations="province_name"`.
- `name.sex` is the name of variable representing sex. Here we specify `name.sex="sex"`
- `name.age` is the name of variable representing age. Here we specify `name.age="age"`
- `name.date1` is the name of variable that provides the data of the earlier of the two time periods. Here we specify `name.date1="date1"` (the value of this variable, `"2001-11-15"` is the date of Ecuador's 2001 Census)
- `name.date2` is the name of variable that provides the data of the earlier of the two time periods. Here we specify `name.date1="date1"` (the value of this variable, `"2010-11-28"` is the date of Ecuador's 2010 Census)
- `name.population.year1` is the name of variable representing the population in the earlier of the two time periods represented in the dataset. Here we specify `name.population.year2="pop1"`
- `name.population.year2` is the name of variable representing the population in the earlier of the two time periods represented in the dataset. Here we specify `name.population.year2="pop2"`
- `name.male` is the name of value of the `name.sex` variable that represents males
- `name.female` is the name of value of the `name.sex` variable that represents females

In addition, we specify the option argument `plots.dir=my_plots_dir` so that the plots will save in a local folder `Plots`; the default behavior would be to save the plots in the working directory of the R script.

```
c_s <- ComputeSexRatios(data=ecuador_single_year_ages_combined,
                  name.disaggregations="province_name",
                  name.males="m",
                  name.females="f",
                  name.age="age",
                  name.sex="sex",
                  name.date1="date1",
                  name.date2="date2",
                  name.population.year1="pop1",
                  name.population.year2="pop2")

s <- PlotSexRatios(data=ecuador_single_year_ages_combined,
                  name.disaggregations="province_name",
                  name.males="m",
                  name.females="f",
                  name.age="age",
                  name.sex="sex",
                  name.date1="date1",
                  name.date2="date2",
                  name.population.year1="pop1",
                  name.population.year2="pop2",
                  name.national="National",
                  label.subnational.level="Province",
                  plots.dir=my_plots_dir)
```

The plots of sex ratios are saved in the `Plots/` sub-folder we specified with the argument `plots.dir=my_plots_dir`; `plots.dir` is an optional argument and, if we do not specify a value for it, the plots will be saved the working directory. We also specified `label.subnational.level="Province"` so that the disaggregations are labeled `Province` instead of the less clear `province_name`.

3.1.1 View sex ratios in combined plot

The sex ratios for all levels of subnational disaggregation are overlaid in the following "combined" plots separately for each data year.

```
knitr::include_graphics(path=paste0(my_plots_dir,
                                    "sex_ratios_combined_province_name_",
                                    Sys.Date(),
                                    ".pdf"))
```

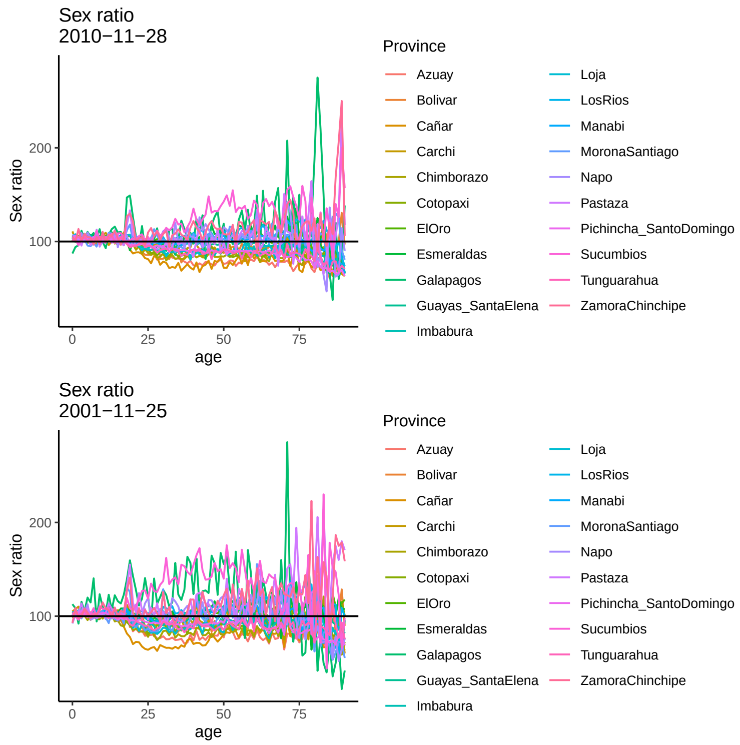


Figure 1: Sex ratios in Ecuador by province, combined plot

3.1.2 View sex ratios in disaggregated plots

Additionally, the sex ratios are plotted in separate figures for each level of subnational disaggregation in the following “disaggregated” plots

```
knitr::include_graphics(path=paste0(my_plots_dir,
                                    "sex_ratios_by_province_name_",
                                    Sys.Date(),
                                    ".pdf"))
```

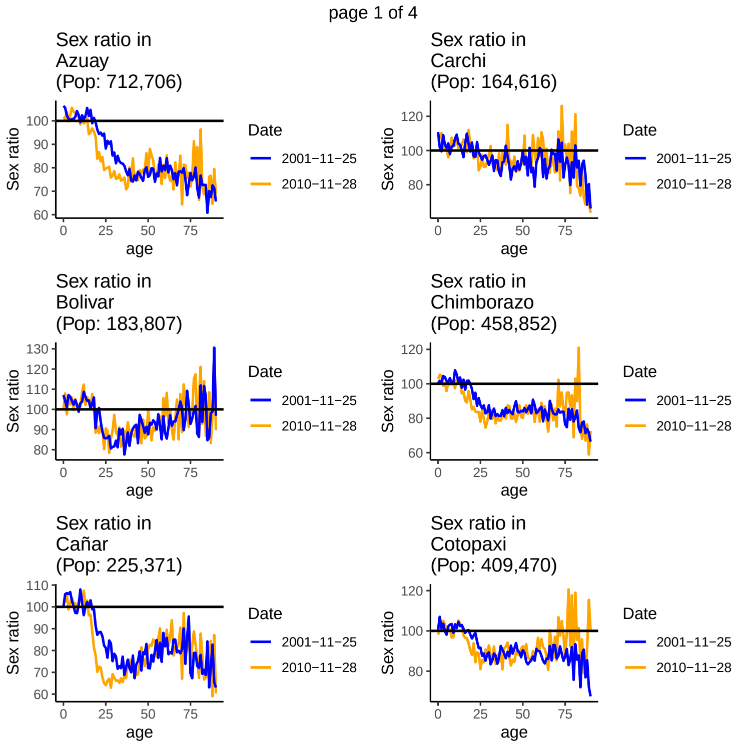


Figure 2: Sex ratios in Ecuador by province, disaggregated plots

3.1.3 View sex ratios in table

The object returned by `PlotSexRatios()` is a table that shows us the sex ratios for each combination of province, sex, and single-year age in the `sex_ratio_1` column (for the 2001 Census) and the `sex_ratio_2` column (for the 2010 Census).

```
s %>% select(province_name, age, pop1, pop2, sex_ratio_1, sex_ratio_2) %>%
      head()
```

```
##   province_name age  pop1  pop2 sex_ratio_1 sex_ratio_2
## 1         Azuay   0 12073 13092       101.7       106.4
## 2         Azuay   1 13060 13596       100.8       105.6
## 3         Azuay   2 14195 14014       103.9       102.4
## 4         Azuay   3 14217 14124        99.8       100.9
## 5         Azuay   4 14012 13911       102.2       100.2
## 6         Azuay   5 12815 13736       105.6       100.8
```

3.2 Age ratios: PlotAgeRatios()

Another step in our demographic data quality assessment is using the PlotAgeRatios() function in the SubnationalCRVS package to compute and plot age ratios within each combination of province and sex for the 2001 and 2010 data stored in ecuador_five_year_ages.

```
a <- PlotAgeRatios(data=ecuador_five_year_ages_combined,
              name.disaggregations="province_name",
              name.males="m",
              name.females="f",
              name.age="age",
              name.sex="sex",
              name.date1="date1",
              name.date2="date2",
              name.population.year1="pop1",
              name.population.year2="pop2",
              label.subnational.level="Province",
              name.national="National",
              plots.dir=my_plots_dir)
```

The arguments we provided to PlotAgeRatios() are actually identical to those we specified for PlotSexRatios(), except now we are using the tabulation with five-year age groups (ecuador_five_year_ages) instead of the tabulation with single-year ages.

3.2.1 View age ratios in combined plot

The following "combined" plots, saved in the Plots/ folder, show the age ratios for all levels of subnational disaggregation, separately for males and females in each data year.

```
knitr::include_graphics(path=paste0(my_plots_dir,
                                    "age_ratios_combined_province_name_",
                                    Sys.Date(),
                                    ".pdf"))
```

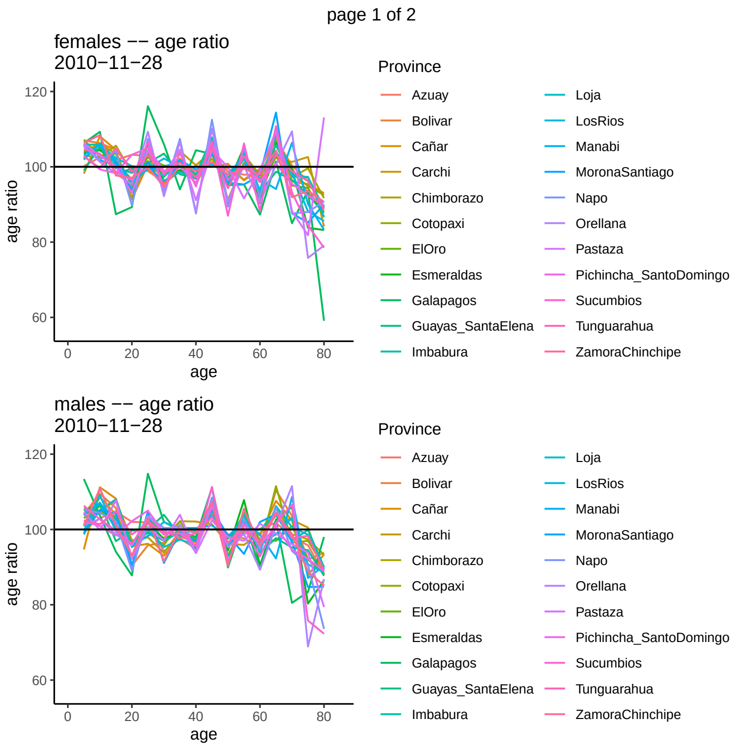
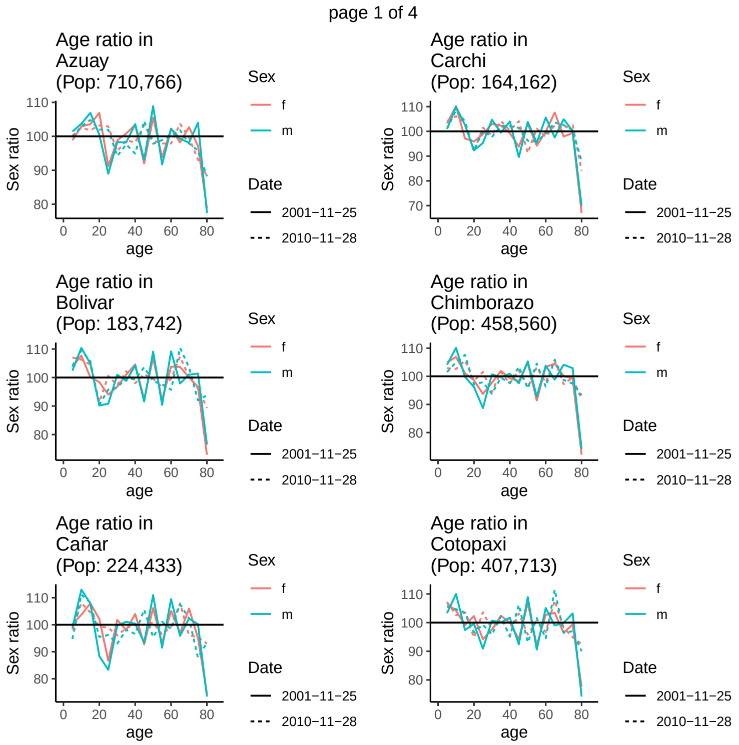


Figure 3: Age ratios in Ecuador by province, combined plot

3.2.2 View age ratios in disaggregated plots

In addition, `PlotAgeRatios()` also creates the following "disaggregated" plots, saved in the `Plots/` folder, where the age ratios for each level of disaggregation are shown in separate plots, with different sexes and data years overlaid within each plot.

```
knitr::include_graphics(path=paste0(my_plots_dir,
                                    "age_ratios_by_province_name_",
                                    Sys.Date(),
                                    ".pdf"))
```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Age ratio in Azuay (Pop: 710,766)

Age ratio in Carchi (Pop: 164,162)

Age ratio in Bolivar (Pop: 183,742)

Age ratio in Chimborazo (Pop: 458,560)

Age ratio in Cañar (Pop: 224,433)

Age ratio in Cotopaxi (Pop: 407,713)

Figure 4: Age ratios in Ecuador by province, disaggregated plots

3.2.3 View age ratios in table

Just as the `PlotSexRatios()` function returns a table of disaggregated sex ratios, `PlotAgeRatios()` returns a table of disaggregated age ratios.

```
a %>% select(province_name, age, pop1, pop2, age_ratio_1, age_ratio_2) %>%
      head()
```

```
##   province_name age  pop1  pop2 age_ratio_1 age_ratio_2
## 1         Azuay   0 33491 33876          NA          NA
## 2         Azuay   5 33817 35701        98.8       100.2
## 3         Azuay  10 34975 37366       102.9       102.5
## 4         Azuay  15 34181 37215       103.6       101.8
## 5         Azuay  20 31000 35753       106.9       103.2
## 6         Azuay  25 23844 32054        91.2       102.9
```

3.3 Potential age heaping: PlotPotentialAgeHeaping()

To give us a sense of whether “age-heaping” is occurring within the levels of disaggregation present in our `ecuador_single_year_ages` dataset, we turn to the `PlotPotentialAgeHeaping()` function and actually provide the same arguments we used in the `PlotSexRatios()` function.

```
PlotPotentialAgeHeaping(data=ecuador_single_year_ages_combined,
            name.disaggregations="province_name",
              name.males="m",
              name.females="f",
              name.age="age",
              name.sex="sex",
              name.date1="date1",
              name.date2="date2",
              name.population.year1="pop1",
              name.population.year2="pop2",
              name.national="National",
              label.subnational.level="Province",
              plots.dir=my_plots_dir)
```

3.3.1 View potential age heaping in combined plot

The following "combined" plots show us estimated population counts by single-year ages with different provinces represented with different overlaid colors, and separate plots for each sex and data year.

```
knitr::include_graphics(path=paste0(my_plots_dir,
                                    "potential_age_heaping_combined_province_name_",
                                    Sys.Date(),
                                    ".pdf"))
```

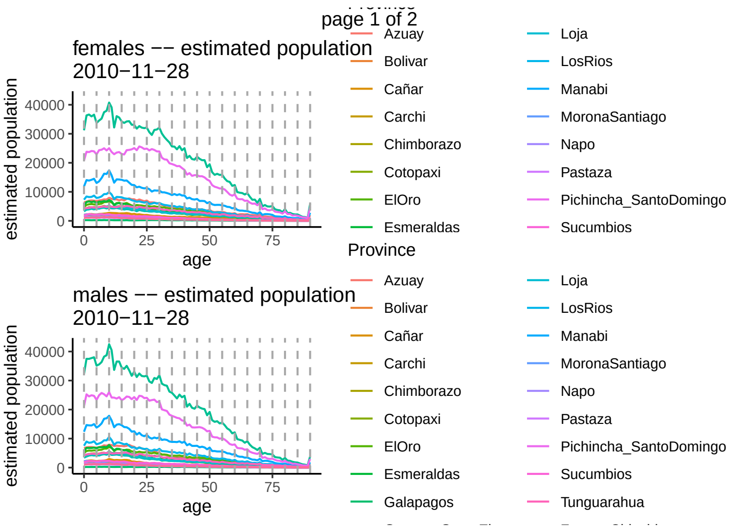

Figure 5: Population counts in Ecuador by single-year age, combined plot

3.3.2 View potential age heaping in disaggregated plots

`PlotPotentialAgeHeaping()` present separate plots of population counts for each province in Ecuador, with different sexes and data years overlaid within each plot.

```
knitr::include_graphics(path=paste0(my_plots_dir,
                                    "potential_age_heaping_by_province_name_",
                                    Sys.Date(),
                                    ".pdf"))
```

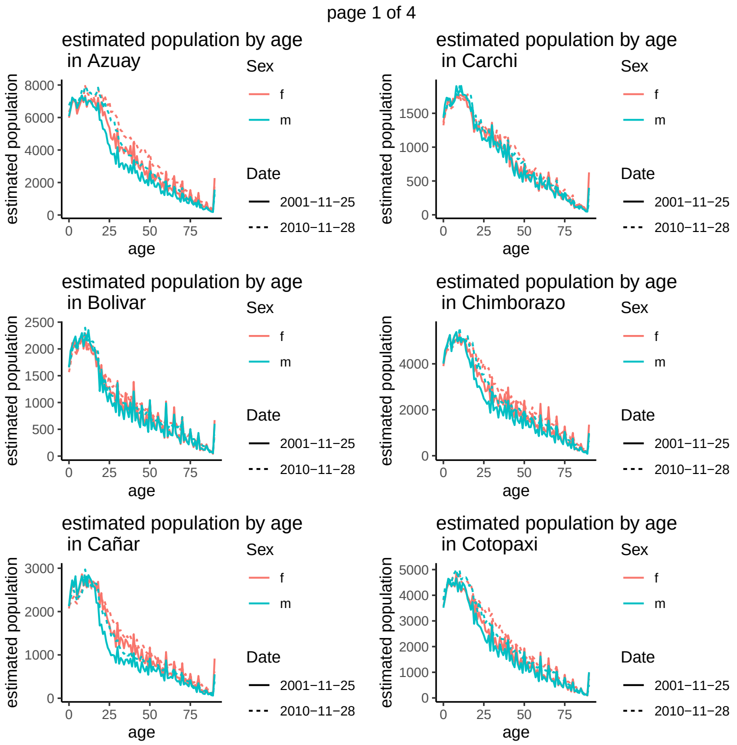

Figure 6: Population counts in Ecuador by single-year age, disaggregated plots

3.4 Age heaping indices: PlotAgeHeapingScores()

As a more concise summary of potential age-heaping suggested by the visualizations from `PlotPotentialAgeHeaping`, we now use the `PlotAgeHeapingScores` function with the same arguments we provided to the `PlotAgeRatios` function.

```
ageheaping <- PlotAgeHeapingScores(data=ecuador_single_year_ages_combined,
                                     name.disaggregations="province_name",
                                     name.males="m",
                                     name.females="f",
                                     name.age="age",
                                     name.sex="sex",
                                     name.date1="date1",
                                     name.date2="date2",
                                     name.population.year1="pop1",
                                     name.population.year2="pop2",
                                     name.national="National",
                                     label.subnational.level="Province",
                                     plots.dir=my_plots_dir)
```

3.4.1 View age heaping indices in plots

`PlotAgeHeapingScores` plots the values of three age-heaping indices within each combination of province, sex, and data year: Roughness, Whipple, and Myers. The indices are computed with the `DemoTools::check_heaping_roughness`, `DemoTools::check_heaping_Whipple`, and `DemoTools::check_heaping_myers` functions, respectively, from the `DemoTools` package.

```
knitr::include_graphics(path=paste0(my_plots_dir,
                                    "age_heaping_scores_combined_province_name_",
                                    Sys.Date(),
                                    ".pdf"))
```

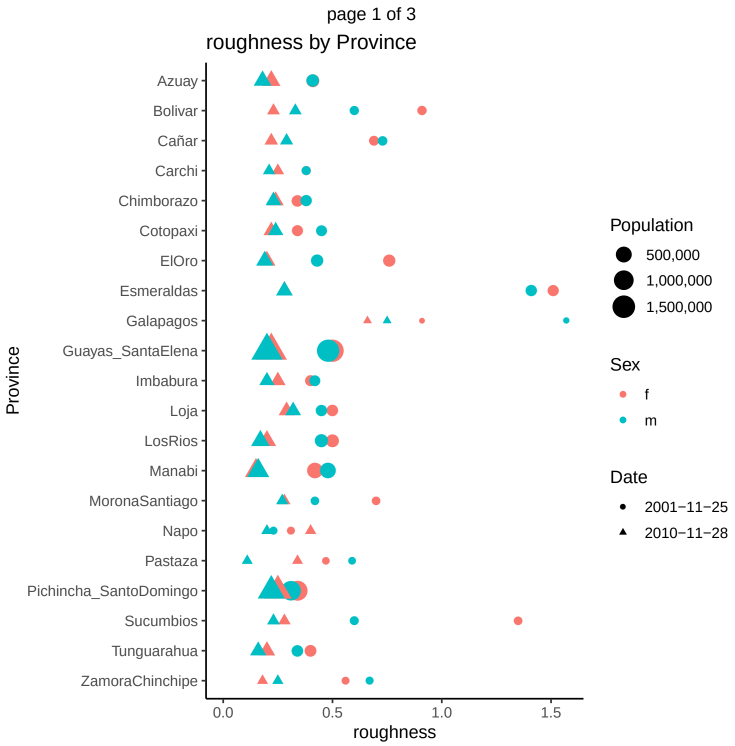

Figure 7: Age heaping indices in Ecuador by province

We can also view the age-heaping indices in the table returned by `PlotAgeHeapingScores`

3.4.2 View age heaping indices in table

```
head(ageheaping)
```

```
##   province_name       date total_pop sex roughness Whipple Myers
## 1         Azuay 2001-11-25    319983   f      0.41    1.18  4.21
## 2       Bolivar 2001-11-25     86256   f      0.91    1.37  7.39
## 3         Cañar 2001-11-25    112041   f      0.69    1.22  4.89
## 4        Carchi 2001-11-25     77172   f      0.38    1.18  3.75
## 5    Chimborazo 2001-11-25    213106   f      0.34    1.25  5.44
## 6      Cotopaxi 2001-11-25    180328   f      0.34    1.27  5.99
```

3.4.3 View Noumbissi age-heaping indices: ComputeAgeHeapingScores()

We can also use the `ComputeAgeHeapingScores` function – which is called within `PlotAgeHeapingScores` – with the optional argument `Noumbissi.display=TRUE` to view the Noumbissi index computed for single-year ages ending with 0, 1, 2,. . . , 9.

```
ageheaping_with_Noumbissi <- ComputeAgeHeapingScores(data=ecuador_single_year_ages_combined,
                                     name.disaggregations="province_name",
                                     name.males="m",
                                     name.females="f",
                                     name.age="age",
                                     name.sex="sex",
                                     name.date1="date1",
                                     name.date2="date2",
                                     name.population.year1="pop1",
                                     name.population.year2="pop2",
                                     Noumbissi.display=TRUE)
head(ageheaping_with_Noumbissi)
```

```
##         date sex province_name total_pop roughness Whipple Myers Noumbissi_0
## 1 2001-11-25   f         Azuay    319983      0.41    1.18  4.21        1.18
## 2 2001-11-25   f       Bolivar     86256      0.91    1.37  7.39        1.35
## 3 2001-11-25   f         Cañar    112041      0.69    1.22  4.89        1.22
## 4 2001-11-25   f        Carchi     77172      0.38    1.18  3.75        1.15
## 5 2001-11-25   f    Chimborazo    213106      0.34    1.25  5.44        1.23
## 6 2001-11-25   f      Cotopaxi    180328      0.34    1.27  5.99        1.25
##   Noumbissi_1 Noumbissi_2 Noumbissi_3 Noumbissi_4 Noumbissi_5 Noumbissi_6
## 1        0.91        1.02        0.98        0.95        1.08        0.98
## 2        0.84        1.03        0.91        0.86        1.22        0.97
## 3        0.90        1.02        0.98        0.91        1.11        0.98
## 4        0.91        1.05        0.96        0.92        1.11        0.98
## 5        0.88        1.01        0.97        0.89        1.12        0.98
## 6        0.88        1.02        0.95        0.90        1.18        0.98
##   Noumbissi_7 Noumbissi_8 Noumbissi_9
## 1        0.94        1.04        0.86
## 2        0.92        1.03        0.75
## 3        0.95        1.03        0.80
## 4        0.96        1.04        0.86
## 5        0.94        1.05        0.82
## 6        0.91        1.06        0.80
```

4 DDM Estimation of Death Registration Completeness

The structure of the `ecuador_five_year_ages` dataset is inspired by the requirements for the `DDM::ddm` function from the `DDM` package, which uses established Death Distribution Methods (DDM) to estimate death registration completeness between two consecutive Censuses. As a result, the `SubnationalCRVS` package offers the `EstimateDDM` function as a simple wrapper to `DDM::ddm` to perform DDM estimation of death registration completeness.

4.1 Compute DDM estimates: EstimateDDM()

```
ddm_results <- EstimateDDM(data=ecuador_five_year_ages_combined,
            name.disaggregations="province_name",
            name.age="age",
            name.sex="sex",
            name.males="m",
            name.females="f",
            name.date1="date1",
            name.date2="date2",
            name.population.year1="pop1",
            name.population.year2="pop2",
            name.national="National",
            name.deaths="deaths",
            deaths.summed=TRUE)
```

```
## [1] "performing GGB-SEG estimation within each of 21 possible age ranges..."
```

We called `EstimateDDM` above using the same arguments as we used with `PlotAgeRatios`, with two additions:

- `name.deaths` provides the name of the variable represented the count of registered deaths between the two dates represented in `name.date1` and `name.date2`
- `deaths.summed`, which should be set to TRUE when the `name.deaths` variable represents the total number of registered deaths `name.date1` and `name.date2` and set to FALSE when the `name.deaths` variable represents the average number of registered deaths between the two dates.

4.2 Plot DDM estimates: PlotDDM()

We can plot the estimated death registration completeness (using the "hybrid" GGB-SEG method) with the `PlotDDM` function:

```
PlotDDM(ddm_results=ddm_results,
        label.completeness="Estimated Completeness (%)",
        label.subnational.levels="Province",
        plots.dir=my_plots_dir)
```

4.2.1 View estimates of death registration completeness in plot

```
knitr::include_graphics(path=paste0(my_plots_dir,
                                    "ggbseg_point_estimates_combined_province_name_",
                                    Sys.Date(),
                                    ".pdf"))
```

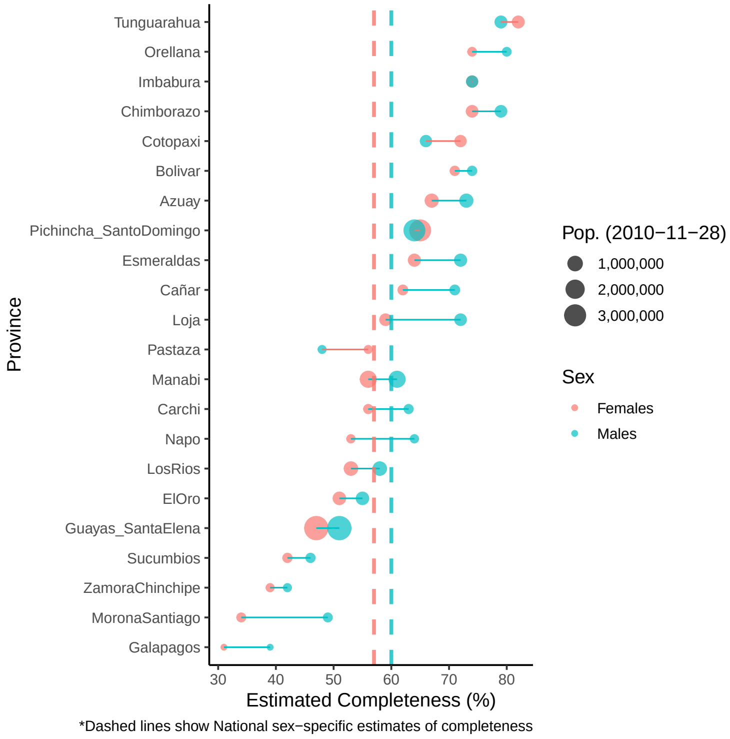

Figure 8: Point estimates of death registration completeness in Ecuador from 2001-2010, using the GGB-SEG method

4.2.2 View DDM point estimates in table

The `EstimateDDM` function also returns a list, in which the `ddm_estimates` object contains the estimated death registration completeness with the GGB-SEG approach

```
head(ddm_results$ggbseg_estimates)
```

```
##       cod     sex ggbseg lower_age_range upper_age_range total_pop1 total_pop2
## 1   Azuay Females   0.67              15              60     599313     710766
## 2   Azuay   Males   0.73              15              65     599313     710766
## 3 Bolivar Females   0.71              15              65     170696     183742
## 4 Bolivar   Males   0.74              15              65     170696     183742
## 5   Cañar Females   0.62              15              65     206346     224433
## 6   Cañar   Males   0.71              15              65     206346     224433
```

4.2.3 View sensitivity of DDM point estimates in plot

Additionally, `PlotDDM` presents a visualization of the GGB-SEG estimates of death-registration completeness to the all permitted values of the age range (i.e. sensitivity) that is selected `DDM::ddm()` as part of the fitting procedure underlying its estimation.

```
knitr::include_graphics(path=paste0(my_plots_dir,
                                    "ggbseg_sensitivity_province_name_",
                                    Sys.Date(),
                                    ".pdf"))
```

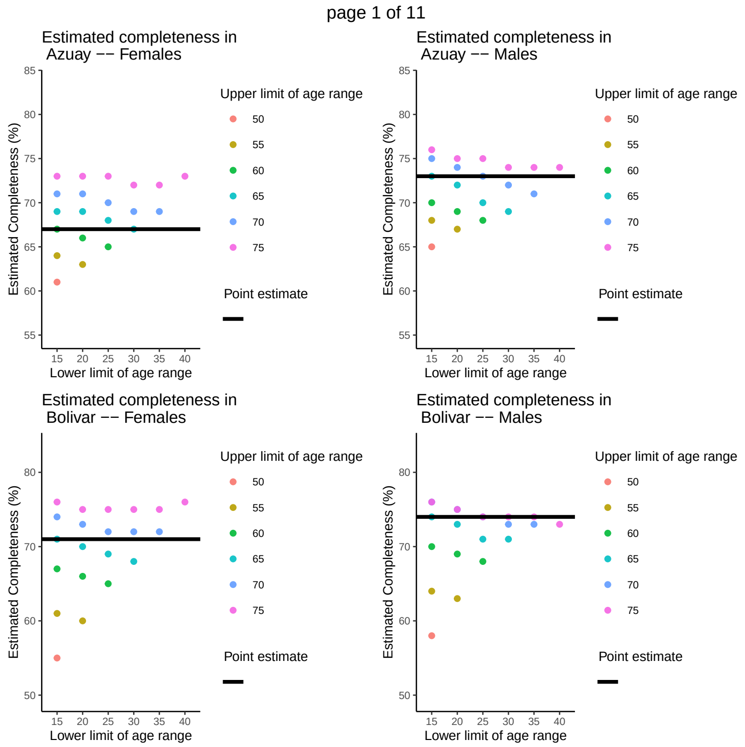

Figure 9: Sensitivity of point estimates of death registration completeness in Ecuador from 2001-2010 to choice of age-range parameter in the GGB-SEG method

4.2.4 View age-range sensitivity of DDM point estimates in table

The sensitivity estimates are also returned in table by `EstimateDDM`, in the `sensitivity_ddm_estimates` element of its list.

```r
head(ddm_results$sensitivity_ggbseg_estimates, n=5)
```

```
##     cod     sex ggbseg lower_age_range upper_age_range total_pop1 total_pop2
## 1 Azuay Females   0.61              15              50     599313     710766
## 2 Azuay Females   0.64              15              55     599313     710766
## 3 Azuay Females   0.63              20              55     599313     710766
## 4 Azuay Females   0.67              15              60     599313     710766
## 5 Azuay Females   0.66              20              60     599313     710766
```