WHO MMR Package PDF Write-Up

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Description

This document serves as documentation for the package WHOmmr that aims to help analyze the data collected by the World Health Organization (WHO) on Maternal Mortality Ratio (MMR) around the world. WHO defines MMR as "the number of maternal deaths per 100,000 live births." WHOmmr is a collection of functions that work on estimates of maternal mortality between 2000 and 2017 (though we are focusing on 2010 to 2017) to gain insight about the projected MMR for every country between 2016 and 2030. In particular, this package is meant to assist WHO in the achieving the standard development goal (SDG) of a global MMR of 70 by 2030, with no single country having an MMR above 140, to reduce inequality in this sector.

We compare MMR projections following the observed, Business As Usual (BAU) trends with these SDG projections that WHO hopes to achieve. The Average Rate of Reduction (ARR) is the average annual reduction in MMR a particular country or region experiences, and this ARR is used to calculate the desired projections.

Each function below has more information about its purpose.

Calc BAU ARR

Calculates the observed (BAU) ARR of each country based on the observed ARR from time1 to time2.

Base Equation: ARR (for period t1 to t2) = -1/(t2 - t1) * log(MMR(t2) / MMR(t1))

Tests
- Check inputs (stop if inputs for arguments are not as expected), both in terms of data type and in terms of if the numerical arguments are within an acceptable range.
- Test to see if correct values are returned (using toy data) based on base equation in function.

```
calc_bau_arr_tibble <-
  calc_bau_arr(mmr_est_unrounded_pwider, 3, 10)
kable(calc_bau_arr_tibble[1:5, ])
```

iso	arr
AFG	0.0575322
ALB	0.0454474
DZA	0.0038326
AGO	0.0429199
ATG	0.0062833

MMR Projections (for one country)

Calculates the MMR projections for one country for a specified period using data from baseyear 2015 and the country's respective BAU ARR. The single country is specified by using its assigned ISO code.

Base Equation: MMR(t) = MMR(2015) * exp(-ARR * (t - 2015))

Tests:
- Check inputs (stop if inputs for arguments are not as expected), both in terms of data type and in terms of if the numerical arguments are within an acceptable range.
- Test to see if correct values are returned (using toy data) based on base equation in function.
- Check that this function's call to calc_bau_arr produces the correct results.

```
bau_mmr_single_country_proj(mmr_est_unrounded_pwider, "AFG", 3, 10, 2016, 2030)
```

```
##  [1] 661.9616 624.9523 590.0122 557.0255 525.8830 496.4817 468.7241
##  [8] 442.5185 417.7779 394.4206 372.3691 351.5505 331.8959 313.3401
## [15] 295.8217
```

MMR Projections (all countries)

Calculates the MMR projections for all countries for a specified period using data from baseyear 2015 and each country's respective BAU ARR.

Base Equation: MMR(t) = MMR(2015) * exp(-ARR * (t - 2015))

Tests:
- Check inputs (stop if inputs for arguments are not as expected), both in terms of data type and in terms of if the numerical arguments are within an acceptable range.
- Test to see if correct values are returned (using toy data) based on base equation in function.
- Check that this function's call to bau_mmr_single_country_proj (and thus calc_bau_arr, as well) produces the correct results.

```
bau_mmr_proj_tibble <-
  bau_mmr_all_countries_proj(mmr_est_unrounded_pwider, 3, 10, 2016, 2030)
bau_mmr_proj_tibble <- format(bau_mmr_proj_tibble, digits = 2)
kable(bau_mmr_proj_tibble[1:6, 1:5])
```

	iso	name	2016	2017	2018
col	AFG	Afghanistan	662.0	625.0	590.0
col.1	ALB	Albania	14.3	13.7	13.1
col.2	DZA	Algeria	113.1	112.7	112.3
col.3	AGO	Angola	240.3	230.2	220.6
col.4	ATG	Antigua and Barbuda	43.0	42.8	42.5
col.5	ARG	Argentina	39.9	38.4	37.0

```
kable(bau_mmr_proj_tibble[1:6, 6:11])
```

	2019	2020	2021	2022	2023	2024
col	557.0	525.9	496.5	468.7	442.5	417.78
col.1	12.5	11.9	11.4	10.9	10.4	9.94
col.2	111.8	111.4	111.0	110.6	110.1	109.71
col.3	211.3	202.4	193.9	185.8	178.0	170.49
col.4	42.2	42.0	41.7	41.4	41.2	40.93

	2019	2020	2021	2022	2023	2024
col.5	35.7	34.3	33.1	31.9	30.7	29.58

```
kable(bau_mmr_proj_tibble[1:6, 12:17])
```

	2025	2026	2027	2028	2029	2030
col	394.42	372.4	351.55	331.90	313.34	295.82
col.1	9.50	9.1	8.68	8.29	7.92	7.57
col.2	109.29	108.9	108.46	108.04	107.63	107.22
col.3	163.33	156.5	149.89	143.59	137.56	131.78
col.4	40.67	40.4	40.16	39.91	39.66	39.41
col.5	28.50	27.5	26.44	25.47	24.54	23.64

SDG MMR Calculation, Categorization, and Adjustment

Calculates the MMR projections for all using a fixed value of the ARR for a single year t > 2015 using baseyear 2015, then adjusts the projections to be less than or equal to 140, as specified by the WHO's SDG.

Base Equation: MMR(t) = MMR(2015) * exp(-ARR * (t - 2015))
For countries with mmr_target2030 > 140, replace mmr_target by 140

Tests:
- Check inputs (stop if inputs for arguments are not as expected), both in terms of data type and in terms of if the numerical arguments are within an acceptable range.
- Test to see if correct values are returned (using toy data) based on base equation in function.

```
mmr_sdg_proj <- get_mmr_sdg_proj(mmr2015, global_arr, 15)
kable(mmr_sdg_proj[1:5, ])
```

x
140.000000
9.937566
75.404901
140.000000
28.755982

Squared Diff

Calculates the squared difference of the global mmr of a specified year and the SDG goal of a global MMR of 70.

Base Equation: (global_mmr - 70)^2

Tests:
- Check inputs (stop if inputs for arguments are not as expected), both in terms of data type and in terms of if the numerical arguments are within an acceptable range.
- Test to see if correct values are returned (using toy data) based on base equation in function.
- Check that this function's call to get_mmr_sdg_proj produces the correct results.

```
squared_diff(global_arr, mmr2015, live_birth_projections2030, 15)
```

```
## [1] 257.1634
```

Get ARR SDG Target

Calculates the target ARR needed to achieve WHO's SDG goal of a global MMR of 70, with no country with an MMR above 140, by 2030.

Base Equation: N/A, R minimizes the results of the squared_diff function which calls get_mmr_sdg_proj

Tests:
- Check inputs (stop if inputs for arguments are not as expected), both in terms of data type and in terms of if the numerical arguments are within an acceptable range.
- Test to see if correct values are returned (using toy data) based on base equation in the function.
- Check that this function's call to squared_diff (and thus get_mmr_sdg_proj, as well) produces the correct results.

```
get_arr_sdg_target(mmr2015, live_birth_projections2030, 15)
```

```
## $minimum
## [1] 0.05603232
##
## $objective
## [1] 6.010324e-05
```

Calculate SDG ARR for each country Based on SDG MMR

Calculates the specific ARR for each country needed to achieve WHO's SDG goal of a global MMR of 70, with no country with an MMR above 140, by 2030. Each country-specific ARR is based on the single target SDG ARR calculated.

Base Equation: -1/nproject * log(mmr_sdg_projections_using_sdg_arr/2015_mmr_all_countries)

Tests:
- Check inputs (stop if inputs for arguments are not as expected), both in terms of data type and in terms of if the numerical arguments are within an acceptable range.
- Test to see if correct values are returned (using toy data) based on base equation in the function.
- Check that this function's call to get_mmr_sdg_proj and get_arr_sdg_proj (and thus squared_diff, as well) produces the correct results.

```
arr_sdg_target_country <-
  calc_sdg_arr(mmr_est_unrounded_pwider,
               mmr2015,
               live_birth_projections2030,
               15)
kable(arr_sdg_target_country[1:5, ])
```

iso	sdg_arr
AFG	0.1074065
ALB	0.0560323
DZA	0.0560323
AGO	0.0560323
ATG	0.0560323

(BAU) MMR Regional Summaries

1. Produces a table of all the projected BAU MMRs by SDG region for a specified period.

2. Produces a line graph of all the projected BAU MMRs by SDG region.

Base Equation: MMR(region) = sum(region_mmr_proj * region_total_births) / sum(region_total_births)

Tests:
- Check inputs (stop if inputs for arguments are not as expected), both in terms of data type and in terms of if the numerical arguments are within an acceptable range.
- Test to see if correct values are returned (using toy data) based on base equation in the function.
- Check that this function's call to the two helper functions and bau_mmr_all_countries_proj (and thus bau_mmr_single_countriy_proj, as well) produces the correct results.

```
#Part 1: Table
regional_proj_summaries <-
  bau_mmr_regional_projection_summaries(mmr_est_unrounded_pwider,
                                        countries_and_regions,
                                        live_birth_projections2030,
                                        3,
                                        10,
                                        2016,
                                        2030)
knitr::kable(regional_proj_summaries[, 1:4])
```

SDG Region	2016	2017	2018
Global	243.814883	237.103765	230.656921
Australia and New Zealand	7.025024	7.114045	7.207496
Central Asia and Southern Asia	159.756448	151.538318	143.747630
Eastern Asia and South-eastern Asia	75.232046	72.977137	70.799787
Latin America and the Caribbean	75.871411	74.449118	73.077279
Northern America and Europe	12.527506	12.532424	12.556428
Oceania / Oceania excluding Australia and New Zealand	133.088692	130.086088	127.155523
Sub-Saharan Africa	557.115234	544.861528	533.001751
Western Asia and Northern Africa	93.611651	91.049495	88.605206

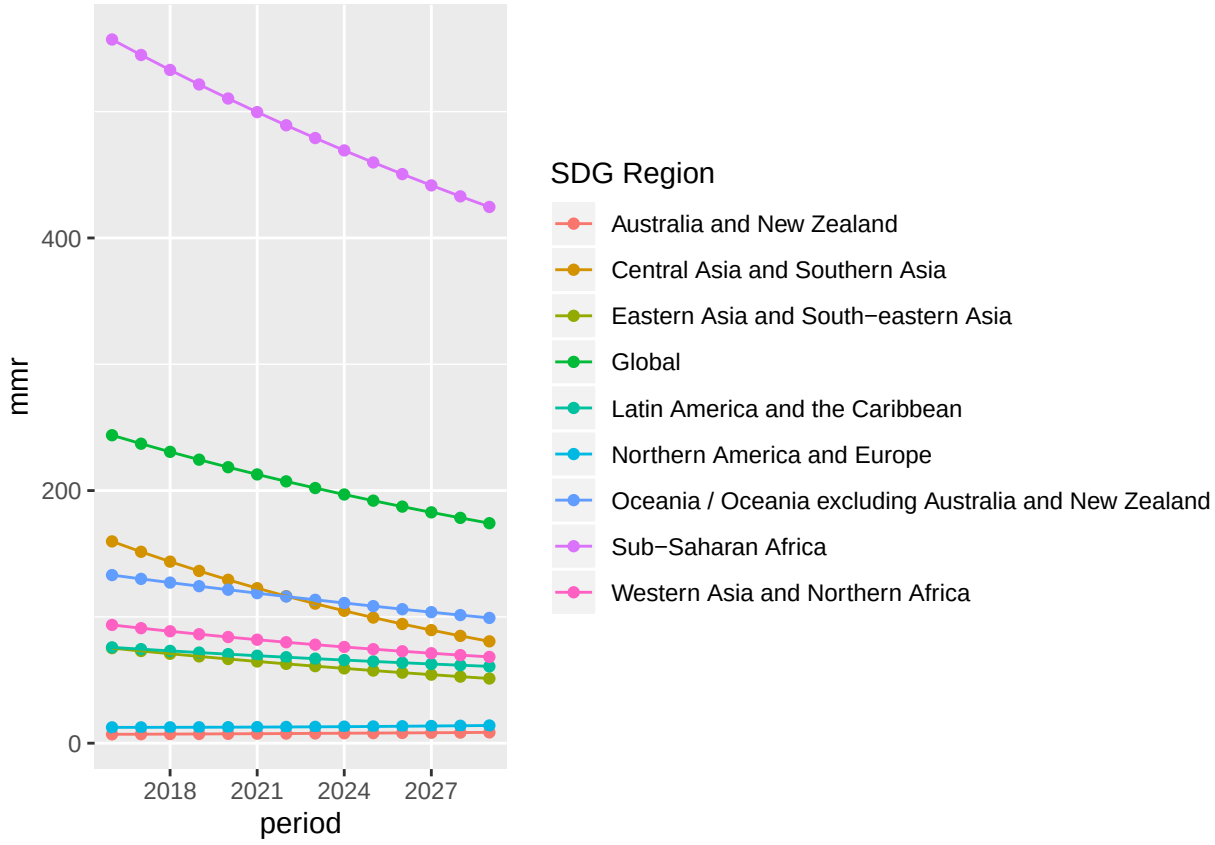
```
knitr::kable(regional_proj_summaries[, 5:11])
```

2019	2020	2021	2022	2023	2024	2025
224.462487	218.509179	212.786268	207.283548	201.991310	196.900320	192.001788
7.305417	7.407852	7.514844	7.626444	7.742701	7.863672	7.989413
136.361943	129.360007	122.721698	116.427960	110.460742	104.802953	99.438400
68.697071	66.666183	64.704435	62.809245	60.978140	59.208745	57.498782
71.753886	70.477021	69.244848	68.055611	66.907632	65.799304	64.729088
12.599236	12.660604	12.740322	12.838221	12.954165	13.088052	13.239813
124.295103	121.502993	118.777409	116.116619	113.518944	110.982752	108.506457
521.520237	510.402020	499.632809	489.198953	479.087407	469.285708	459.781944
86.274129	84.051823	81.934056	79.916789	77.996175	76.168544	74.430401

```
knitr::kable(regional_proj_summaries[, 12:16])
```

2026	2027	2028	2029	2030
187.287356	182.749065	178.379344	174.170986	170.117132
8.119984	8.255448	8.395873	8.541327	8.691883
94.351748	89.528472	84.954813	80.617735	76.504891
55.846064	54.248493	52.704051	51.210806	49.766897
63.695516	62.697178	61.732729	60.800879	59.900394
13.409412	13.596845	13.802138	14.025347	14.266560
106.088521	103.727448	101.421787	99.170126	96.971095
450.564728	441.623174	432.946872	424.525867	416.350636
72.778415	71.209415	69.720379	68.308433	66.970840

```
#Part 2: Graph
bau_mmr_regional_global_graph(mmr_est_unrounded_pwider,
                              countries_and_regions,
                              live_birth_projections2030,
                              3,
                              10,
                              2016,
                              2030)
```



SDG MMR Projections

Calculates the SDG MMR projections for all countries for a specified period using data from baseyear 2015 and each country's respective BAU ARR.

Base Equation: MMR(t) = MMR(2015) * exp(-ARR * (t - 2015))

Tests:
- Check inputs (stop if inputs for arguments are not as expected), both in terms of data type and in terms of if the numerical arguments are within an acceptable range.
- Test to see if correct values are returned (using toy data) based on base equation in the function.
- Check that this function's call to sdg_mmr_single_country_proj produces the correct results.

```
sdg_mmr_single_country_proj(mmr_est_unrounded_pwider, arr_tibble, "AFG", 2016, 2030)
```

```
##  [1] 629.7565 565.6225 508.0198 456.2833 409.8156 368.0802 330.5951
##  [8] 296.9275 266.6885 239.5291 215.1356 193.2263 173.5482 155.8741
## [15] 140.0000
```

```
sdg_mmr_proj <-
  sdg_mmr_allcountries_proj(mmr_est_unrounded_pwider, arr_tibble, 2016, 2030) %>%
  select(-c("bau arr"))
kable(sdg_mmr_proj[1:6, 1:6])
```

	name	iso	sdg arr	2016	2017	2018
col	Afghanistan	AFG	0.1074065	629.75655	565.62246	508.01975
col.1	Albania	ALB	0.0560323	14.15102	13.37991	12.65082
col.2	Algeria	DZA	0.0560323	107.37599	101.52492	95.99268
col.3	Angola	AGO	0.0560323	237.20391	224.27833	212.05709
col.4	Antigua and Barbuda	ATG	0.0560323	40.94830	38.71696	36.60722
col.5	Argentina	ARG	0.0560323	39.14660	37.01344	34.99653

```
kable(sdg_mmr_proj[1:6, 7:12])
```

	2019	2020	2021	2022	2023	2024
col	456.28327	409.81562	368.08020	330.59510	296.927460	266.688517
col.1	11.96146	11.30966	10.69338	10.11068	9.559737	9.038814
col.2	90.76191	85.81616	81.13992	76.71849	72.537988	68.585290
col.3	200.50180	189.57617	179.24589	169.47853	160.243403	151.511513
col.4	34.61244	32.72636	30.94306	29.25692	27.662673	26.155294
col.5	33.08952	31.28642	29.58158	27.96964	26.445532	25.004478

```
kable(sdg_mmr_proj[1:6, 13:18])
```

	2025	2026	2027	2028	2029	2030
col	239.529093	215.135571	193.226272	173.548206	155.874144	140.000000
col.1	8.546276	8.080577	7.640255	7.223927	6.830285	6.458093
col.2	64.847980	61.314321	57.973216	54.814173	51.827271	49.003130
col.3	143.255435	135.449242	128.068421	121.089790	114.491435	108.252634
col.4	24.730055	23.382479	22.108335	20.903620	19.764552	18.687554

	2025	2026	2027	2028	2029	2030
col.5	23.641948	22.353665	21.135582	19.983874	18.894924	17.865313

SDG MMR Regional Summaries

1. Produces a table of all the projected SDG MMRs by SDG region for a specified period.

2. Produces a line graph of all the projected SDG MMRs by SDG region.

Base Equation: MMR(region) = sum(region_mmr_proj * region_total_births) / sum(region_total_births)

Tests:
- Check inputs (stop if inputs for arguments are not as expected), both in terms of data type and in terms of if the numerical arguments are within an acceptable range.
- Test to see if correct values are returned (using toy data) based on base equation in the function.
- Check that this function's call to the two helper functions and get_arr_sdg_proj (and thus squared_diff and get_mmr_sdg_proj„ as well) produces the correct results.

```
#Part 1: Table
sdg_regional_proj_summaries <-
  sdg_mmr_regional_projection_summaries(mmr_est_unrounded_pwider,
                                        arr_tibble,
                                        countries_and_regions,
                                        live_birth_projections2030,
                                        2016,
                                        2030)
knitr::kable(sdg_regional_proj_summaries[, 1:4])
```

SDG Region	2016	2017	2018
Global	229.452590	210.10812	192.565454
Australia and New Zealand	6.562204	6.20462	5.866522
Central Asia and Southern Asia	158.126174	148.50211	139.505084
Eastern Asia and South-eastern Asia	73.340798	69.34435	65.565681
Latin America and the Caribbean	72.799933	68.52786	64.512960
Northern America and Europe	11.858567	11.21238	10.601398
Oceania / Oceania excluding Australia and New Zealand	128.745444	121.72992	115.096685
Sub-Saharan Africa	515.071694	465.94836	421.811415
Western Asia and Northern Africa	91.049218	86.08782	81.396769

```
knitr::kable(sdg_regional_proj_summaries[, 5:11])
```

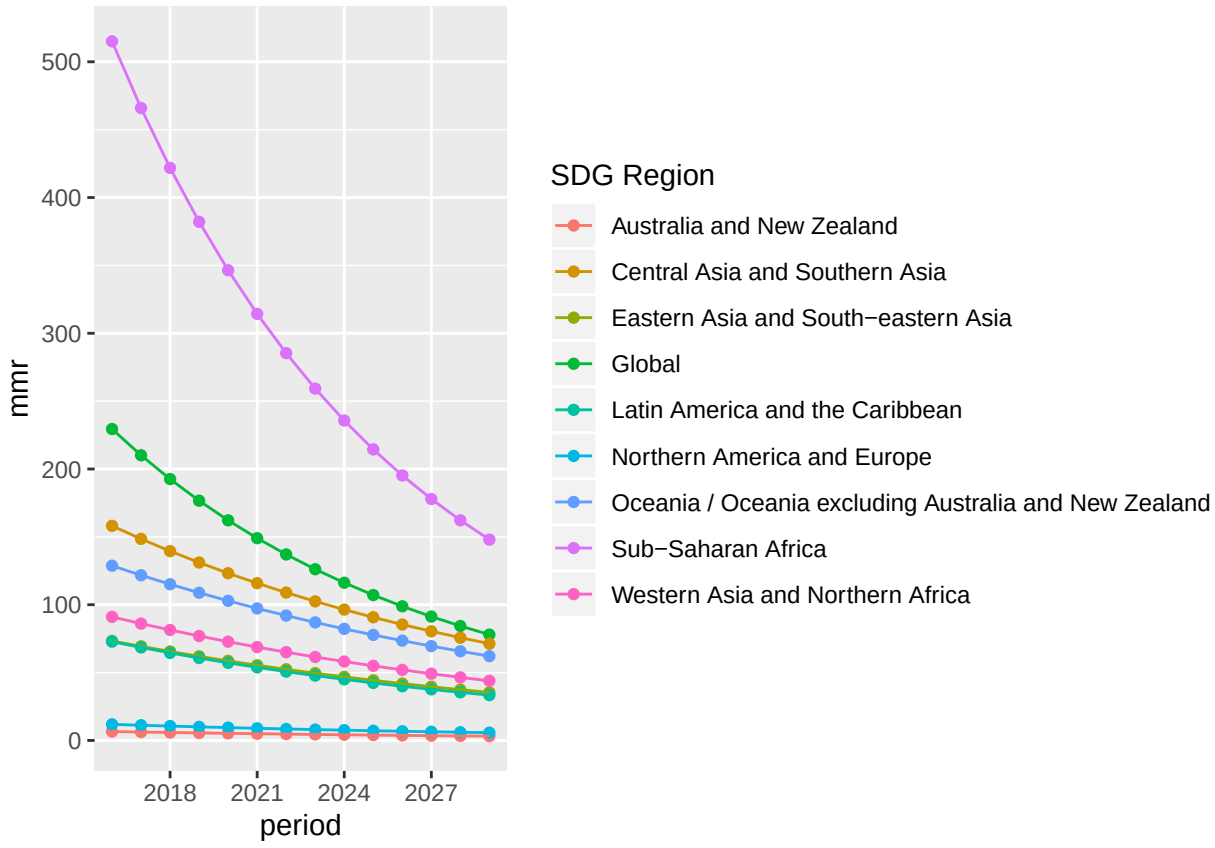
2019	2020	2021	2022	2023	2024	2025
176.642628	162.177178	149.023954	137.053193	126.148824	116.206947	107.134505
5.546847	5.244591	4.958806	4.688593	4.433105	4.191539	3.963136
131.090476	123.217165	115.847225	108.945656	102.480135	96.420795	90.740015
61.992914	58.614832	55.420826	52.400867	49.545469	46.845666	44.292979
60.739280	57.191880	53.856777	50.720887	47.771955	44.998510	42.389805
10.023713	9.477507	8.961064	8.472763	8.011070	7.574535	7.161788
108.824903	102.894879	97.287991	91.986630	86.974148	82.234803	77.753711

2019	2020	2021	2022	2023	2024	2025
382.129313	346.429297	314.290712	285.339099	259.240977	235.699222	214.448984
76.961343	72.767610	68.802400	65.053259	61.508415	58.156734	54.987690

```
knitr::kable(sdg_regional_proj_summaries[, 12:16])
```

2026	2027	2028	2029	2030
98.848092	91.272900	84.341790	77.994459	72.176707
3.747179	3.542990	3.349928	3.167385	2.994790
85.412242	80.413813	75.722809	71.318906	67.183256
41.879392	39.597324	37.439610	35.399472	33.470504
39.935777	37.626994	35.454622	33.410380	31.486506
6.771532	6.402542	6.053658	5.723786	5.411888
73.516801	69.510766	65.723026	62.141684	58.755496
195.254066	177.903725	162.209832	148.004368	135.137189
51.991333	49.158251	46.479548	43.946812	41.552087

```
#Part 2: Graph
sdg_mmr_regional_global_graph(mmr_est_unrounded_pwider,
                              arr_tibble,
                              countries_and_regions,
                              live_birth_projections2030,
                              2016,
                              2030)
```


500
400
300
200
100
0
mmr
2018
2021
2024
2027
period
SDG Region
Australia and New Zealand
Central Asia and Southern Asia
Eastern Asia and South−eastern Asia
Global
Latin America and the Caribbean
Northern America and Europe
Oceania / Oceania excluding Australia and New Zealand
Sub−Saharan Africa
Western Asia and Northern Africa