WHO MMR Final Package 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.

Below, a description of each function is provided about its purpose and an example is given for its implementation

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.

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

iso	arr
AFG	0.0503407
ALB	0.0397664
DZA	0.0033535
AGO	0.0375549
ATG	0.0054979

MMR Projections (single country)

Calculates the MMR projections for one country during a specified period using data from baseyear 2015 and the country's respective ARR. The single country is specified by using its assigned ISO code. (This function can be used for any MMR projections when provided with an tibble of ARRs for each country.)

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.

```
#BAU MMR Projections for Afghanistan
mmr_proj_single_country(mmr_est_unrounded_pwider, bau_arr_tibble, 2, "AFG", 2016, 2030)
```

```
##  [1] 666.7393 634.0060 602.8798 573.2816 545.1366 518.3734 492.9240
##  [8] 468.7241 445.7123 423.8303 403.0225 383.2363 364.4215 346.5303
## [15] 329.5176
```

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 ARR. (This function can be used for any MMR projections when provided with an tibble of ARRs for each country.)

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 mmr_proj_single_country produces the correct results.

```
#BAU Projections for all countries between 2016 and 2030
bau_mmr_proj <-
  mmr_proj_all_countries(mmr_est_unrounded_pwider, bau_arr_tibble, 2, 2016, 2030)
kable(bau_mmr_proj[1:6, 1:5])
```

	iso	name	2016	2017	2018
col	AFG	Afghanistan	666.73931	634.00602	602.87976
col.1	ALB	Albania	14.38308	13.82234	13.28346
col.2	DZA	Algeria	113.18407	112.80514	112.42749
col.3	AGO	Angola	241.62757	232.72156	224.14380
col.4	ATG	Antigua and Barbuda	43.07077	42.83462	42.59977
col.5	ARG	Argentina	40.07116	38.78246	37.53520

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

	2019	2020	2021	2022	2023	2024
col	573.28164	545.13662	518.37336	492.92404	468.72414	445.71233
col.1	12.76559	12.26791	11.78963	11.33000	10.88828	10.46379

	2019	2020	2021	2022	2023	2024
col.2	112.05109	111.67596	111.30208	110.92945	110.55807	110.18794
col.3	215.88221	207.92513	200.26133	192.88001	185.77075	178.92353
col.4	42.36620	42.13392	41.90291	41.67316	41.44467	41.21744
col.5	36.32805	35.15973	34.02897	32.93459	31.87540	30.85027

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

	2025	2026	2027	2028	2029	2030
col	423.83027	403.022501	383.236281	364.421458	346.530340	329.517579
col.1	10.05585	9.663809	9.287054	8.924988	8.577037	8.242652
col.2	109.81904	109.451382	109.084951	108.719748	108.355767	107.993004
col.3	172.32869	165.976917	159.859266	153.967102	148.292113	142.826296
col.4	40.99145	40.766707	40.543191	40.320901	40.099829	39.879970
col.5	29.85812	28.897869	27.968502	27.069024	26.198473	25.355920

MMR Projections (by region)

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

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

These main two functions can be used for any MMR projections when provided with an tibble of MMR projections for all countries. However, note that the large, wrapper functions can only be used on data formatted in exactly the same way as the WHO MMR data with the same region definitions and names. Using the individual global and regional prediction functions is suitable for data formatted slightly differently.

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 the 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 produces the correct results.

```
#Part 1: Table - BAU Regional Projections for 2016 to 2030
bau_regional_proj_summaries <-
  mmr_proj_all_regions(mmr_est_unrounded_pwider,
                       bau_mmr_proj,
                       countries_and_regions,
                       births2030,
                       2016,
                       2030)
knitr::kable(bau_regional_proj_summaries[, 1:4])
```

SDG Region	2016	2017	2018
Global	244.672968	238.756292	233.04428
Australia and New Zealand	7.014206	7.091376	7.17193
Central Asia and Southern Asia	160.814934	153.551874	146.62050

SDG Region	2016	2017	2018
Eastern Asia and South-eastern Asia	75.519513	73.533476	71.60739
Latin America and the Caribbean	76.052848	74.799881	73.58594
Northern America and Europe	12.528249	12.529393	12.54521
Oceania / Oceania excluding Australia and New Zealand	133.469179	130.829910	128.24616
Sub-Saharan Africa	558.675455	547.887395	537.40401
Western Asia and Northern Africa	93.940448	91.678797	89.50830

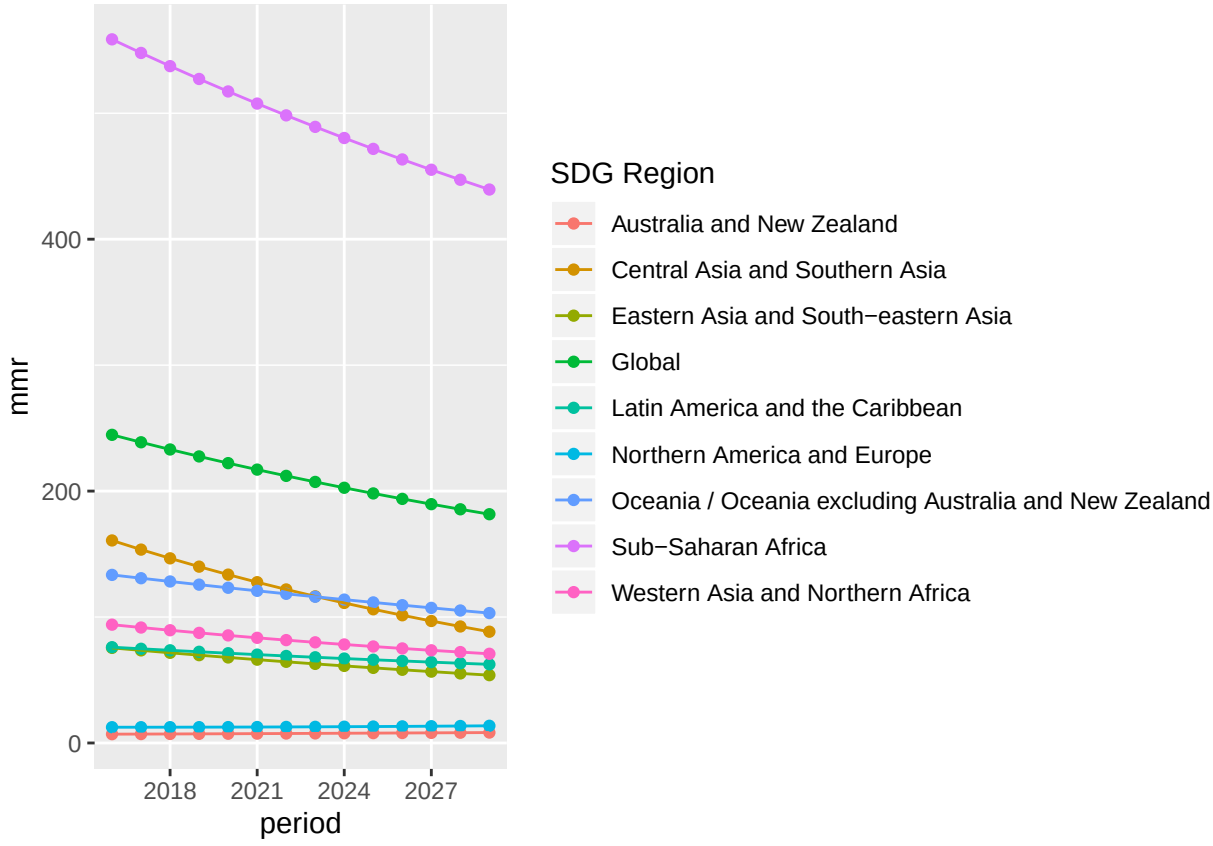
```
knitr::kable(bau_regional_proj_summaries[, 5:11])
```

2019	2020	2021	2022	2023	2024	2025
227.528871	222.202327	217.05726	212.086590	207.283548	202.641649	198.154688
7.255895	7.343299	7.43417	7.528541	7.626444	7.727913	7.832985
140.005517	133.692351	127.66710	121.916517	116.427960	111.189381	106.189292
69.739278	67.927218	66.16937	64.463948	62.809245	61.203606	59.645435
72.409649	71.269710	70.16486	69.093880	68.055611	67.048929	66.072754
12.575498	12.620086	12.67882	12.751568	12.838221	12.938689	13.052903
125.716661	123.240154	120.81543	118.441301	116.116619	113.840258	111.611123
527.214663	517.309113	507.67754	498.310511	489.198953	480.334156	471.707746
87.425798	85.428249	83.51274	81.676482	79.916789	78.231093	76.616929

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

2026	2027	2028	2029	2030
193.816723	189.62207	185.565270	181.641119	177.844619
7.941697	8.05409	8.170206	8.290087	8.413778
101.416735	96.86126	92.512911	88.362177	84.399999
58.133195	56.66540	55.240623	53.857478	52.514635
65.126047	64.20781	63.317084	62.452940	61.614491
13.180811	13.32238	13.477609	13.646492	13.829057
109.428147	107.29029	105.196534	103.145894	101.137405
463.311676	455.13821	447.179911	439.429627	431.880484
75.071933	73.59384	72.180481	70.829774	69.539727

```
#Part 2: Graph - BAU Regional Projections for 2016 to 2030
mmr_proj_all_regions_graph(mmr_est_unrounded_pwider,
                           bau_mmr_proj,
                           countries_and_regions,
                           births2030,
                           2016,
                           2030)
```



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 its inner function, squared_diff (and thus get_mmr_sdg_proj, as well) produces the correct results.

```
get_arr_sdg_target(mmr2015, births, 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.

```
sdg_arr_tibble <-
  calc_sdg_arr(mmr_est_unrounded_pwider, sdg_arr_target, mmr2015, births, 15)
kable(sdg_arr_tibble[1:5, ])
```

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

SDG MMR Projections

These are calculated by the general mmr_proj_all_countries, mmr_proj_all_regions, and mmr_proj_all_regions_graph, respectively. See above for more details.

SDG MMR Projections for 2016 to 2030

```
sdg_mmr_proj <-
  mmr_proj_all_countries(mmr_est_unrounded_pwider, sdg_arr_tibble, 2, 2016, 2030)
kable(sdg_mmr_proj[1:6, 1:5])
```

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

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

	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, 12:17])
```

	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
col.5	23.641948	22.353665	21.135582	19.983874	18.894924	17.865313

SDG MMR Regional Projections

```
#Part 1: Table - SDG Regional Projections for 2016 to 2030
sdg_regional_proj_summaries <-
  mmr_proj_all_regions(mmr_est_unrounded_pwider,
                       sdg_mmr_proj,
                       countries_and_regions,
                       births2030,
                       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
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 Regional Projections for 2016 to 2030
mmr_proj_all_regions_graph(mmr_est_unrounded_pwider,
                           sdg_mmr_proj,
                           countries_and_regions,
                           births2030,
                           2016,
                           2030)
```