

Supplemental Online Appendix - Dependency Ratios in Healthy Ageing

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Description of our disability dependency ratio (DDR)

We propose a DR that measures population ageing based on health characteristics of the population. The indicator is built following the characteristics approach developed by Sanderson and Scherbov (2013) which provides a method that facilitates comparability with other ageing indicators. Following their notation, the general form of their indicators is given by:

$$MN_t = g(S(a, t), H(a, t)) \quad (1)$$

Where, MN_t is the ageing measure at time t , $S(a, t)$ is a vector that contains the age structure of the population, and $H(a, t)$ is a vector of age-specific characteristics. Vector S can be broken up by sex or other demographic dimensions of the population, if required. Vector H could include physiological, psychological, behavioural, or any other characteristic that would add qualitative information about the ageing process that it is not present in purely chronological indicators^{22, 1}

The Elder Ratios are ageing indicators based on the characteristics approach. Elder Ratios sum the age population groups s multiplied by the vector of age-specific characteristics h , and divide the summatory over the rest of the population. Both s and h vary over time t .

$$Elder Ratios_t = \sum_a s_{a,t} h_{a,t} / \sum_a s_{a,t} (1 - h_{a,t}) \quad (2)$$

The key to use Elder Ratios is to understand the schedule of characteristics h , which varies over a and t . For example, the prospective dependency ratio divides the population with less than 15 years of life

¹ MN stands for new measure, as Sanderson and Schervob were comparing it with conventional measures (MC) of population ageing.

expectancy over the rest of the adult population (those over 19 years of age). In this case, the schedule of characteristics indicates the exact age at which life expectancy goes below 15, at each moment t . Suppose that this number equals 68 in a particular year for the studied population. Then, h would be a dichotomic variable where $h = 1$ for $a \geq 68$ & $h = 0$ for $20 \leq a < 68$ ¹³.

For our indicator, matrix H contains does not contain dichotomic values (0 or 1) based on age thresholds, but the values of the characteristic itself. Namely, the average disability prevalence in age group a at time t , in percent of the age-group's total population. Following Sanderson and Scherbov (2010) who proposed a DR based on disability where those with at least 20 years old and disabilities are divided by those with at least 20 years and without disabilities. The indicator is multiplied by 100 as the United Nation's OADR.

Scenarios

The following section describes our assumptions and calculations for each scenario. Under all scenarios, the population for each country grows according to UN demographic projections². The only difference derives from the assumptions for disability prevalence projections.

(1) Constant Prevalence Scenario

Under this scenario, the rate of disability prevalence for each age group is keep at its 2015 value during the projection period (2015-2050).

(2) Past-Trends Scenario

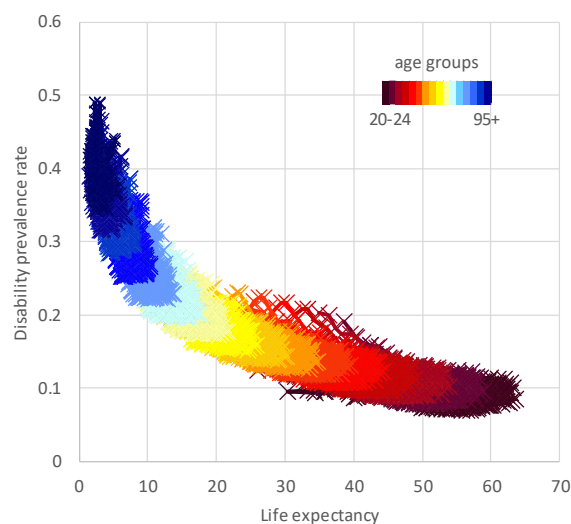
For this scenario, we calculate the average percent change in disability prevalence rates by age group and country, for the 1990-2015 period. Then, we assume that disability prevalence rates continue growing at the historical average rates during the projection period.

(3) Life Expectancy Scenario

For this scenario, we regress disability prevalence rates (explained variable) over life expectancy (explanatory variable), for the 1990-2015 period. A visual inspection of the data shows that the relationship increases with age, (Appendix Figure 1). Thus, we regress each age group separately. We consider that countries may have unobservable characteristics that correlate with disability prevalence, for example, higher income levels or better healthcare systems may reduce disability prevalence rates. The Hausman test reinforces this hypothesis, thus we run a linear and a fixed effects panel model.

The estimated coefficients under the fixed effects model are smaller but close to the those under the simple linear regression. Thus, we use the once obtained in the latter option and interpret the result as a best-case scenario, where increases in life expectancy do not only affect disability prevalence directly but also indirectly through the unobservable country characteristics. For example, as life

expectancy increases, countries with low life expectancy catch-up with the rest in other dimensions such as income or health spending.



Appendix Figure 1. Disability prevalence rates and life expectancy by age group and country (1990-2017)

Source: UN and GBD

We use the results to predict future levels of disability prevalence rates, by country and age group, based on the UN's projections of life expectancy². We do not use the predictions of the model but apply the growth rates of the predictions to the projection period.

Table 1. Results of panel regression for life expectancy scenario

age group	variable		constant		N	R2
	coefficient	standard error	coefficient	standard error		
20-24	-0.0708***	0.0055	12.78***	0.29	1116	0.13
25-29	-0.1018***	0.0070	15.13***	0.33	1116	0.16
30-34	-0.139***	0.0079	17.3***	0.34	1116	0.22
35-39	-0.1818***	0.0089	19.38***	0.35	1116	0.27
40-44	-0.2147***	0.0099	20.93***	0.34	1116	0.30
45-49	-0.2697***	0.0111	22.91***	0.34	1116	0.35
50-54	-0.3158***	0.0124	24.24***	0.32	1116	0.37
55-59	-0.3789***	0.0143	25.86***	0.32	1116	0.39
60-64	-0.4559***	0.0175	27.72***	0.32	1116	0.38
65-69	-0.5916***	0.0224	30.56***	0.33	1116	0.39
70-74	-0.7394***	0.0282	33.03***	0.33	1116	0.38
75-79	-0.9171***	0.0366	35.38***	0.33	1116	0.36
80-84	-1.0817***	0.0473	37.74***	0.32	1116	0.32
85-89	-1.1291***	0.0601	39.21***	0.30	1116	0.24

90-94	-1.1928***	0.0811	40.84***	0.29	1116	0.16
95+	-1.243***	0.1117	42.46***	0.30	1116	0.10

Source: UN and GBD and own calculations.

Notes: Disability prevalence rate expressed in percent for the regression. The coefficient indicates the change in the rate when life expectancy increases in one year. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

(4) Catch Up Scenario

In this scenario, the disability prevalence rate of each age group linearly transitions from its historical value in 2015 to a target value in 2100. The value in 2100 corresponds to the minimum rate for the correspondent age group across all countries in 2015.

Results by Country

The countries included in the analysis were determined by data restrictions. The Global Burden of Disease database provides data for 195 countries. 11 of them were dropped because there was no population or income group data. Table 2 shows the results of the projections by country and the composition of the Income groups.

Table 2. Disability dependency ratio projections for all countries.

Region	2015	2050	2015	2050	2015	2050	2015	2050
	DDR_CP	DDR_CP	DDR_LE	DDR_LE	DDR_PT	DDR_PT	DDR_CU	DDR_CU
World	16.2	18.9	16.2	18.4	16.2	17.5	16.2	17.3
Low income	15.9	16.8	15.9	16.3	15.9	13.6	15.9	14.9
Afghanistan	21.8	23.4	21.8	22.7	21.8	19.6	21.8	18.7
Benin	15.7	16.2	15.7	16.0	15.7	11.0	15.7	14.5
Burkina Faso	14.6	15.3	14.6	14.7	14.6	8.4	14.6	13.8
Burundi	15.2	15.7	15.2	15.1	15.2	16.0	15.2	14.1
Central African Republic	17.9	18.3	17.9	16.6	17.9	15.2	17.9	15.7
Chad	16.3	16.7	16.3	16.1	16.3	14.7	16.3	14.6
Comoros	13.7	14.9	13.7	14.5	13.7	11.1	13.7	13.8
Dem. People's Republic of Korea	15.0	18.2	15.0	16.7	15.0	19.1	15.0	17.1
Democratic Republic of the Congo	17.4	17.7	17.4	16.7	17.4	14.6	17.4	15.2
Eritrea	16.2	17.5	16.2	16.2	16.2	10.2	16.2	15.4
Ethiopia	14.2	15.6	14.2	14.6	14.2	10.8	14.2	14.3
Gambia	15.8	16.3	15.8	16.0	15.8	14.9	15.8	14.4
Guinea	15.4	16.1	15.4	15.0	15.4	13.8	15.4	14.4
Guinea-Bissau	16.0	17.1	16.0	16.5	16.0	15.2	16.0	15.0
Haiti	16.3	18.1	16.3	17.7	16.3	17.6	16.3	16.2
Liberia	19.1	19.8	19.1	18.7	19.1	20.2	19.1	16.6
Madagascar	14.5	15.6	14.5	14.6	14.5	13.6	14.5	14.2
Malawi	14.4	15.4	14.4	14.2	14.4	12.4	14.4	14.0
Mali	15.6	16.0	15.6	15.3	15.6	12.0	15.6	14.1
Mozambique	16.8	17.0	16.8	16.0	16.8	15.9	16.8	14.9
Nepal	16.8	19.6	16.8	17.8	16.8	16.1	16.8	17.3

Niger	14.6	14.1	14.6	13.5	14.6	11.7	14.6	12.9
Rwanda	14.9	16.4	14.9	15.5	14.9	16.2	14.9	14.9
Senegal	14.8	15.9	14.8	15.0	14.8	13.7	14.8	14.4
Sierra Leone	15.8	16.8	15.8	16.0	15.8	15.3	15.8	14.8
Somalia	14.8	15.0	14.8	14.3	14.8	13.7	14.8	13.5
South Sudan	17.4	18.4	17.4	17.3	17.4	16.8	17.4	15.8
Syrian Arab Republic	17.3	19.6	17.3	17.3	17.3	20.8	17.3	17.2
Tajikistan	14.1	16.5	14.1	15.4	14.1	16.0	14.1	15.1
Togo	15.2	15.9	15.2	15.7	15.2	13.3	15.2	14.3
Uganda	14.7	15.4	14.7	14.6	14.7	7.5	14.7	13.8
United Republic of Tanzania	14.1	14.7	14.1	13.7	14.1	11.0	14.1	13.6
Yemen	19.1	21.1	19.1	20.4	19.1	18.7	19.1	17.5
Zimbabwe	16.1	18.0	16.1	16.8	16.1	18.0	16.1	15.7
Lower middle income	16.0	18.5	16.0	18.1	16.0	16.8	16.0	16.6
Angola	16.6	17.1	16.6	16.5	16.6	14.8	16.6	14.8
Bangladesh	15.7	19.5	15.7	17.4	15.7	17.7	15.7	17.6
Bhutan	14.5	18.7	14.5	17.0	14.5	15.1	14.5	17.2
Bolivia (Plurinational State of)	14.7	16.5	14.7	15.6	14.7	14.6	14.7	15.5
Cabo Verde	14.1	16.7	14.1	15.5	14.1	15.2	14.1	15.6
Cambodia	14.4	17.8	14.4	16.2	14.4	14.3	14.4	16.1
Cameroon	16.0	16.8	16.0	15.8	16.0	12.5	16.0	14.9
Congo	17.1	17.8	17.1	16.7	17.1	14.2	17.1	15.5
Côte d'Ivoire	15.4	15.7	15.4	15.0	15.4	11.3	15.4	14.1
Djibouti	13.5	15.9	13.5	15.5	13.5	15.4	13.5	14.9
Egypt	17.5	19.5	17.5	18.2	17.5	18.8	17.5	17.0
El Salvador	14.3	16.9	14.3	15.4	14.3	15.8	14.3	16.2
Georgia	17.7	20.3	17.7	18.4	17.7	21.4	17.7	18.6
Ghana	15.0	16.0	15.0	15.6	15.0	13.6	15.0	14.6
Honduras	13.2	16.1	13.2	15.2	13.2	16.1	13.2	15.3
India	16.7	19.7	16.7	18.7	16.7	17.5	16.7	17.4
Indonesia	14.3	17.2	14.3	16.4	14.3	16.1	14.3	16.0
Kenya	14.0	15.9	14.0	14.8	14.0	16.6	14.0	14.6
Kiribati	17.1	19.1	17.1	18.3	17.1	21.8	17.1	16.6
Kyrgyzstan	14.7	16.9	14.7	16.0	14.7	14.8	14.7	15.6
Lao People's Democratic Republic	13.3	16.0	13.3	15.1	13.3	13.6	13.3	15.0
Lesotho	19.6	20.9	19.6	19.3	19.6	25.6	19.6	17.3
Mauritania	14.4	15.6	14.4	15.3	14.4	13.2	14.4	14.2
Mongolia	14.9	18.0	14.9	16.8	14.9	18.1	14.9	16.3
Morocco	18.6	21.9	18.6	19.7	18.6	21.2	18.6	19.1
Myanmar	15.0	17.5	15.0	17.2	15.0	14.2	15.0	16.1
Nicaragua	13.2	16.7	13.2	15.1	13.2	14.0	13.2	16.0
Nigeria	16.0	16.4	16.0	15.5	16.0	15.1	16.0	14.5
Pakistan	15.2	17.1	15.2	16.8	15.2	16.5	15.2	15.4
Papua New Guinea	17.3	19.0	17.3	18.6	17.3	19.4	17.3	16.4
Philippines	14.7	16.7	14.7	16.1	14.7	15.7	14.7	15.3
Republic of Moldova	18.0	22.1	18.0	20.6	18.0	20.0	18.0	19.8
Sao Tome and Principe	14.2	15.4	14.2	15.1	14.2	14.5	14.2	14.2
Solomon Islands	15.5	17.6	15.5	16.0	15.5	19.3	15.5	15.7

Sri Lanka	15.0	18.6	15.0	17.0	15.0	16.9	15.0	17.7
Sudan	17.2	18.1	17.2	17.7	17.2	16.9	17.2	15.7
Swaziland	18.8	20.4	18.8	19.9	18.8	25.2	18.8	17.1
Timor-Leste	15.0	15.3	15.0	14.3	15.0	11.7	15.0	13.9
Tunisia	17.2	20.6	17.2	18.6	17.2	20.2	17.2	18.5
Ukraine	20.3	23.2	20.3	21.3	20.3	22.4	20.3	20.5
Uzbekistan	14.5	17.8	14.5	17.0	14.5	16.6	14.5	16.3
Vanuatu	16.3	18.6	16.3	17.1	16.3	19.3	16.3	16.4
Viet Nam	13.6	18.0	13.6	16.3	13.6	15.9	13.6	17.3
Zambia	14.5	15.4	14.5	14.5	14.5	14.0	14.5	14.0
Upper middle income	15.1	19.0	15.1	18.4	15.1	17.8	15.1	17.9
Albania	17.7	22.3	17.7	19.8	17.7	21.7	17.7	20.3
Algeria	16.8	20.2	16.8	18.5	16.8	19.3	16.8	18.0
Armenia	16.8	20.6	16.8	18.8	16.8	19.2	16.8	18.9
Azerbaijan	15.0	18.7	15.0	17.9	15.0	18.7	15.0	17.2
Belarus	19.8	22.5	19.8	20.7	19.8	21.9	19.8	20.0
Belize	13.5	15.4	13.5	14.4	13.5	15.7	13.5	14.6
Bosnia and Herzegovina	20.6	25.2	20.6	22.4	20.6	26.1	20.6	22.0
Botswana	17.7	21.0	17.7	19.3	17.7	21.8	17.7	17.9
Brazil	16.2	19.8	16.2	18.0	16.2	18.5	16.2	18.4
Bulgaria	20.2	23.2	20.2	21.5	20.2	22.2	20.2	20.8
China	14.1	18.5	14.1	16.9	14.1	17.2	14.1	17.9
Colombia	13.0	16.2	13.0	15.2	13.0	14.3	13.0	16.1
Costa Rica	13.6	17.5	13.6	15.7	13.6	16.8	13.6	17.2
Cuba	15.1	19.5	15.1	17.5	15.1	18.3	15.1	19.1
Dominican Republic	14.1	16.6	14.1	15.4	14.1	16.8	14.1	15.9
Ecuador	13.9	16.6	13.9	15.2	13.9	15.8	13.9	15.9
Equatorial Guinea	15.8	17.0	15.8	15.8	15.8	13.2	15.8	14.9
Fiji	17.0	19.6	17.0	18.6	17.0	20.4	17.0	17.4
Gabon	16.8	18.5	16.8	17.4	16.8	16.6	16.8	16.3
Grenada	13.9	16.7	13.9	15.6	13.9	16.0	13.9	16.0
Guatemala	13.5	15.7	13.5	14.5	13.5	13.2	13.5	14.9
Guyana	15.8	17.4	15.8	16.9	15.8	16.6	15.8	15.9
Iran (Islamic Republic of)	18.1	22.9	18.1	20.2	18.1	23.2	18.1	20.0
Iraq	17.8	19.1	17.8	18.4	17.8	15.7	17.8	16.3
Jamaica	14.7	18.1	14.7	16.8	14.7	19.1	14.7	17.3
Jordan	16.0	18.5	16.0	17.3	16.0	17.1	16.0	16.4
Kazakhstan	16.2	18.1	16.2	17.1	16.2	16.4	16.2	16.5
Lebanon	18.6	23.7	18.6	20.8	18.6	23.5	18.6	20.7
Libya	18.0	22.1	18.0	20.7	18.0	24.4	18.0	19.0
Malaysia	12.9	16.5	12.9	15.0	12.9	15.8	12.9	15.8
Maldives	11.8	16.9	11.8	14.4	11.8	11.7	11.8	16.2
Mauritius	17.0	21.3	17.0	19.6	17.0	22.2	17.0	19.4
Mexico	13.9	17.5	13.9	15.9	13.9	17.6	13.9	16.6
Montenegro	19.1	22.8	19.1	20.3	19.1	23.3	19.1	20.4
Namibia	16.6	18.5	16.6	17.1	16.6	17.9	16.6	16.1
Paraguay	15.1	17.3	15.1	16.7	15.1	17.2	15.1	16.0
Peru	13.2	15.8	13.2	14.4	13.2	14.4	13.2	15.5

Romania	20.2	23.8	20.2	21.8	20.2	21.2	20.2	21.1
Russian Federation	19.9	22.4	19.9	21.1	19.9	21.5	19.9	19.8
Saint Lucia	14.8	18.6	14.8	16.9	14.8	17.3	14.8	17.9
Saint Vincent and the Grenadines	15.0	18.1	15.0	17.1	15.0	18.5	15.0	17.0
Samoa	15.8	17.9	15.8	15.8	15.8	19.1	15.8	16.3
Serbia	20.3	23.1	20.3	21.3	20.3	22.7	20.3	20.5
South Africa	18.1	19.8	18.1	18.8	18.1	21.2	18.1	17.2
Suriname	14.8	17.0	14.8	16.1	14.8	17.9	14.8	16.0
TFYR Macedonia	18.1	22.3	18.1	20.2	18.1	22.0	18.1	20.0
Thailand	14.8	19.4	14.8	17.6	14.8	17.7	14.8	18.7
Tonga	16.1	17.6	16.1	16.2	16.1	18.6	16.1	15.9
Turkey	17.0	20.4	17.0	18.1	17.0	18.1	17.0	18.5
Turkmenistan	13.9	16.2	13.9	15.8	13.9	15.1	13.9	15.1
Venezuela (Bolivarian Republic of)	13.3	16.1	13.3	14.8	13.3	15.8	13.3	15.6
High income	19.1	22.0	19.1	21.2	19.1	22.1	19.1	20.1
Antigua and Barbuda	14.8	17.8	14.8	16.4	14.8	17.2	14.8	16.9
Argentina	16.4	18.2	16.4	16.6	16.4	18.4	16.4	17.0
Australia	18.9	21.2	18.9	19.2	18.9	21.2	18.9	19.2
Austria	19.2	22.2	19.2	20.3	19.2	22.2	19.2	20.6
Bahamas	14.1	17.3	14.1	16.0	14.1	17.1	14.1	16.8
Bahrain	15.6	19.2	15.6	17.7	15.6	17.9	15.6	17.0
Barbados	15.7	18.1	15.7	16.5	15.7	18.4	15.7	17.6
Belgium	20.5	22.8	20.5	20.6	20.5	23.5	20.5	20.6
Brunei Darussalam	13.5	18.3	13.5	16.6	13.5	16.7	13.5	17.3
Canada	18.3	21.0	18.3	19.0	18.3	21.2	18.3	19.5
Chile	17.2	20.8	17.2	18.5	17.2	20.6	17.2	19.1
Croatia	20.8	24.6	20.8	22.0	20.8	23.9	20.8	21.8
Cyprus	16.8	20.2	16.8	18.0	16.8	19.4	16.8	18.8
Czechia	20.9	25.5	20.9	22.8	20.9	24.7	20.9	22.2
Denmark	19.2	21.1	19.2	19.0	19.2	21.3	19.2	19.5
Estonia	20.5	23.5	20.5	21.2	20.5	22.1	20.5	21.1
Finland	20.4	22.0	20.4	20.1	20.4	21.5	20.4	20.1
France	18.2	20.2	18.2	18.3	18.2	19.9	18.2	19.2
Germany	19.7	22.6	19.7	20.2	19.7	22.1	19.7	20.8
Greece	19.3	22.8	19.3	20.5	19.3	22.8	19.3	21.2
Guam	16.3	19.9	16.3	17.4	16.3	22.9	16.3	18.2
Hungary	20.9	24.6	20.9	22.6	20.9	22.0	20.9	21.5
Iceland	17.8	20.6	17.8	18.6	17.8	20.0	17.8	19.1
Ireland	18.3	21.2	18.3	19.1	18.3	21.4	18.3	19.4
Israel	17.3	18.8	17.3	17.1	17.3	18.1	17.3	17.3
Italy	19.3	22.4	19.3	20.2	19.3	21.2	19.3	21.1
Japan	18.4	21.5	18.4	19.4	18.4	22.2	18.4	20.7
Kuwait	15.4	18.9	15.4	17.6	15.4	18.9	15.4	17.0
Latvia	21.3	24.1	21.3	22.2	21.3	23.0	21.3	21.3
Lithuania	21.6	24.2	21.6	22.3	21.6	24.2	21.6	21.3
Luxembourg	19.4	21.9	19.4	19.7	19.4	21.1	19.4	19.6
Malta	18.7	22.0	18.7	19.5	18.7	22.4	18.7	20.3
Netherlands	19.4	22.1	19.4	20.0	19.4	21.7	19.4	20.3

New Zealand	20.2	23.4	20.2	21.1	20.2	24.0	20.2	20.7
Norway	19.8	21.8	19.8	19.9	19.8	21.6	19.8	19.7
Oman	14.6	19.7	14.6	17.4	14.6	17.9	14.6	17.4
Panama	13.5	16.2	13.5	14.9	13.5	16.0	13.5	15.9
Poland	19.7	25.0	19.7	22.6	19.7	23.8	19.7	22.1
Portugal	19.9	23.4	19.9	21.0	19.9	21.8	19.9	21.6
Qatar	14.2	18.9	14.2	17.2	14.2	16.9	14.2	16.8
Republic of Korea	16.2	22.0	16.2	19.6	16.2	19.4	16.2	20.9
Saudi Arabia	15.4	19.3	15.4	17.9	15.4	18.1	15.4	17.4
Seychelles	14.4	18.5	14.4	16.8	14.4	18.7	14.4	17.5
Singapore	14.4	19.1	14.4	17.1	14.4	16.8	14.4	19.0
Slovakia	19.4	24.4	19.4	22.3	19.4	23.4	19.4	21.5
Slovenia	21.6	26.6	21.6	24.1	21.6	25.6	21.6	23.2
Spain	17.8	21.5	17.8	19.5	17.8	20.5	17.8	20.6
Sweden	19.2	20.9	19.2	18.9	19.2	21.1	19.2	19.3
Switzerland	19.0	21.8	19.0	19.7	19.0	20.8	19.0	20.1
Trinidad and Tobago	15.6	18.3	15.6	17.5	15.6	17.8	15.6	17.2
United Arab Emirates	15.6	19.7	15.6	18.0	15.6	20.1	15.6	17.3
United Kingdom	20.0	22.2	20.0	19.8	20.0	23.5	20.0	20.1
United States of America	20.9	23.5	20.9	21.2	20.9	24.6	20.9	20.6
United States Virgin Islands	16.5	19.2	16.5	17.1	16.5	19.9	16.5	18.7
Uruguay	17.1	19.1	17.1	17.5	17.1	19.2	17.1	17.9

Source: GBD, World Bank, UN, and authors' calculations