Balancing the scales: Towards a more objective measure of sex differences in health

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Abstract

Background: The answer to whether females or males have better health, and which sex is the more disadvantaged depends on who you ask, as there is a tendency to highlight disadvantages that best align with their existing narratives and interests. This study introduces a new method for analyzing and interpreting sex differences in health outcomes that is both objective and systematic. This method does not rely on prior knowledge or contextual biases to determine which sex is more disadvantaged.

Methods: We calculate the sex ratio of life expectancy at birth and age 5, 15, 35, 50, and 70. We then identify sex-specific frontier countries with the highest 5% of life expectancy and estimate the sex ratio of the frontier. We calculate the adjusted sex ratio for each country by multiplying the original and frontier sex ratios. This assumes that theoretically, under the current risk and healthcare environments, females all over the world have the potential to live up to the life expectancy of the females in the frontier countries, and separately, all males have the potential to live up to their male-specific frontier. An adjusted ratio of greater than one indicates male disadvantage, while below one indicates female disadvantage. To focus on adjusted ratios which are unlikely to be due to noise, we set a buffer for each measure within which we do not classify disadvantage. For mortality measures, this buffer includes 30% of countries with the ratio or difference close to one or zero, respectively.

Findings: The adjustment process reveals significant reclassifications in sex-based disadvantages. Before adjustment, males in all countries and ages (except one country) had lower life expectancy than females. For life expectancy at birth, 30 countries shift from male to female disadvantage after adjustment. The number of countries categorized as female disadvantaged increases with age, peaking at 77 countries for life expectancy at age 70. Notably, Central and Eastern Europe consistently show substantial male disadvantage across nearly all ages. In India and approximately half of the countries in Middle East and North Africa, North Atlantic, sub-Saharan Africa, and Western Pacific and Southeast Asia show female disadvantage.

Interpretation: This study provides a novel, objective method for assessing sex differences in health outcomes, challenging existing narratives and highlighting the complexity of gender inequality in health.

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Introduction

A recent World Economic Forum report introduced the concept of the “women’s health gap”, defined as the extra health burden women face compared to men.[1] The report emphasized the urgency of closing this gap for the benefit of all nations, stating that our “collective future rests on closing the women’s health gap”.[2] In contrast, it is also widely acknowledged that women generally live longer than men across the globe, although this longevity gap varies, widening in some countries and narrowing in others over time.[3,4] Hawkes & Buse have critiqued these different perspectives as “gender myths”, highlighting the dilemma in global health debates: some groups stress the disproportionate health burden on women, while others focus on higher mortality rates and risk exposures among men.[5]

Are these messages contradicting? When it comes to health outcomes, which sex or gender are the most disadvantaged? The examples above are just two among the many publications and reports that assert the disadvantage of one sex or gender, and they depict some of the key challenges when discussing gender inequality in health. First, health can be measured in various ways, including mortality, morbidity, prevalence, well-being and functioning. Males die younger but females suffer more when alive, so the selection of the measure matters. Demographic research across diverse populations, including those in monastic settings, suggests that the biological sex difference in life expectancy is approximately 2-3 years in favor of females, with the remaining disparity attributed to environmental and gender-related factors.[6–8] Second, global health initiatives are inclined to prioritize issues specifically affecting women and girls. Only 2% of all global health initiatives have a male-specific focus (cite GH50/50 report). For example, the United Nation’s Gender Inequality Index uses maternal mortality and adolescent fertility to capture gender inequality in the health domain. There is no mention of males nor non-reproductive female health. With this bias, many conclude that women are generally the disadvantaged gender.[1] Third, outside of health outcomes – such as labor force participation and political representation – women generally fare worse than men. This disparity complicates the assertion that men are the disadvantaged gender in health.

These observations demonstrate that various groups highlight sex or gender disadvantages in health outcomes that best align with their existing narratives and interests. Furthermore, researchers may also interpret sex differences at the country level based on their existing knowledge of the context. For example, given India’s well-documented systemic discrimination against women, many conclude that Indian females are disadvantaged, despite their longer life expectancy compared to males. Conversely, in Eastern Europe, where high alcohol consumption among males is notorious, higher rates of premature mortality in males lead to conclusions of male disadvantage, often without comprehensive knowledge of the conditions affecting females. This bias becomes particularly apparent when researchers address countries like Mauritius or Monaco, where less global attention leads to fewer preconceived notions about the state of health among genders.

In response to these challenges, this study aims to develop a method for analyzing and interpreting sex differences in health outcomes that is both objective and systematic. This method does not rely on prior knowledge or contextual biases to determine which sex is more disadvantaged. We aim to improve the measure of gender inequality in health, with full recognition that our measure is far from perfect. We apply a comprehensive set of sensitivity analyses to test our approach.

Methods

Sex differences in health outcomes can be expressed either in ratios or differences. This analysis extends this approach to compare country- and region-specific outcomes to best observed performance on the same measure globally. Doing so relaxes the assumption that a sex ratio of 1.0 or a sex difference of 0 for a given country indicates no measurable inequality by sex. This paper uses life expectancy at different ages as the main health outcome of interest, but the method can be applied to any other outcomes.

In the ratio space, let $L_{f,i}$ be females life expectancy for a given location i, and $L_{m,i}$ for male. Let $R_i = \frac{L_{f,i}}{L_{m,i}}$ be the ratio of females over males. We calculate $R^* = \frac{L_f^*}{L_m^*}$ as the frontier ratio of best performing countries, where L_f^* and L_m^* are each drawn independently of one another from the highest performing countries in life expectancy for each sex. Note that with this calculation, the countries which inform L_f^* are not necessarily the same as those used to calculate L_m^*. Our approach takes the country-specific sex ratio adjusted by the frontier ratio, $N_i = \frac{R_i}{R^*}$ as our outcome of interest. Here we are assuming that theoretically under the current risk and healthcare environments, females all over the world have the potential to live up to the life expectancy of the females in the frontier countries, and separately, all males have the potential to live up to their male-specific frontier. A N_i greater than one indicates male disadvantage, while a N_i below one indicates female disadvantage. We refer to N_i as the adjusted ratio.

For each age group, frontier performance is measured as the highest 5th percentile in life expectancy (representing the top performing 13 countries). Adjusted ratios are calculated at the country and region level. The choice of the 5th percentile as the frontier were tested in the sensitivity analyses. In cases where life expectancy is high for both sexes or the absolute difference between the two is small, an adjusted ratio may take a value slightly above or below 1.0 even though the sex difference is negligible. In order to focus on adjusted ratios which are unlikely to be due to noise, we set a buffer for each measure within which we do not classify disadvantage. For mortality measures, this buffer includes 30% of countries with the ratio or difference close to one or zero, respectively. We also test the buffer range in the sensitivity analyses.

Similar approach is taken in the difference space. We calculate the adjusted differences for each country. An adjusted difference greater than zero indicate male disadvantage, and an adjusted difference below zero indicate female disadvantage. The results presented by ratios are qualitatively similar to results in differences. We therefore only include the ratios in the paper and present the differences in the appendix. We took life expectancy at different ages (at birth, age 5, 15, 35, 50, and 70) and calculated the adjusted ratios and differences. Data came from the World Population Prospects 2022. We applied the regional categorization from the Lancet Commission on Investing in Health 3.0.

Sensitivity analyses

- Will include different percentiles for setting the frontier
- Will include a range of reasonable buffers

Results

Frontier countries

[to be added]

Sex ratios and adjusted ratios

Figure 1 shows the distribution of ratios and adjusted ratios in 2019 by life expectancy at each age group.

Table 1 displays the count of countries by the disadvantage implied by the original sex ratios and by the adjusted sex ratios. In the original sex ratios, only one country in one age group (Nigeria age 5) had a female disadvantage. Life expectancy of males in all other countries and all other ages were lower than that of females. With the adjustment process, many countries that were originally classified as “male disadvantage” are reclassified. The adjustment process allows countries to be grouped into three categories which require different attention. The first is countries which show a female disadvantage in measures after adjustment, which is nearly unobservable when looking at original sex ratios (column A). The second is those which show a male disadvantage even after adjustment (column B). The final category is those which have a male disadvantage in original sex ratios, but when adjusted the sex ratio fall within our buffer (column C). For this third category, the adjusted sex ratios are not different enough from the expected frontier ratio for us do claim a sex disadvantage. A large proportion of countries fall under the remaining two categories: countries that show a male disadvantage in the original ratio but switch to showing either female disadvantage or equal ratio after adjustment (columns A and C). Most countries in these categories experience longer life expectancy for females than males, but with a greater sex gap at females' expense than if the best observed outcomes for each sex were being achieved. For life expectancy at birth (age 0), despite all females having higher life expectancy, once adjusted by the frontier ratio, 30 countries switched to being categorized as female disadvantaged. The number of countries that are now categorized as female advantaged increase with age, with the highest number of countries, 77 countries, at age 70. We discuss these countries more detail below.

Adjusted ratios by life expectancy for the 30 most populous countries in 2019 is presented in Figure 2.

We estimated the adjusted ratio for each country by the CIH regions (Figure 3). In Central and Eastern Europe, there is consistent and substantial male disadvantage across nearly all ages, with a few exceptions in Bosnia and Herzegovina and Albania.

In Central Asia, males experience a disadvantage in life expectancy in all countries except Tajikistan. Kazakhstan, Kyrgyzstan, and Mongolia show substantial disparities in mortality against males, while Pakistan, Afghanistan, and Tajikistan show disadvantage towards females at age 70.

[to be added]

Figure 4 compares the adjusted ratios and adjusted differences for each age. [discuss discordant country-age pairs]

Discussion

This study suffers from the following limitations. First, we only discuss sex and not gender differences. This is in line with the large data gap on measuring health outcomes by gender beyond women and men. Second, the selection of the frontier and the range of buffers are objective (i.e., no prior biases are involved) but there are likely better alternatives with strong justification than what we have provided. We attempt to show this in the sensitivity analysis.

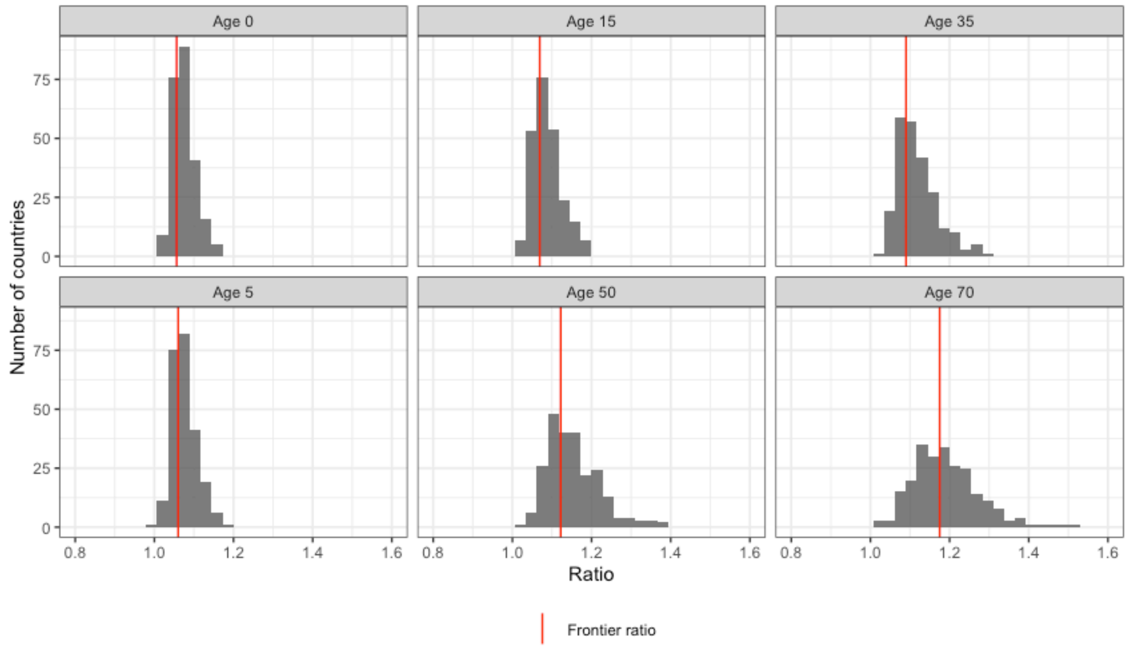
Table 1. Number of countries with equal sex ratio or female/male disadvantage in life expectancy

		Adjusted sex ratio		
	Original sex ratio	(A) Female disadvantage	(B) Male disadvantage	(C) No disadvantage*
Age 0	Male disadvantage	30	136	70
Age 5	Female disadvantage	1	0	0
	Male disadvantage	42	123	70
Age 15	Male disadvantage	45	121	70
Age 35	Male disadvantage	46	120	70
Age 50	Male disadvantage	54	112	70
Age 70	Male disadvantage	77	89	70

* The number of countries categorized as "No disadvantage" is the same across ages because we set the buffer range at 30% of all countries.

Figure 1. Distribution of ratios and adjusted ratios in 2019, by age

Panel A: Ratios



Panel B: Adjusted ratios

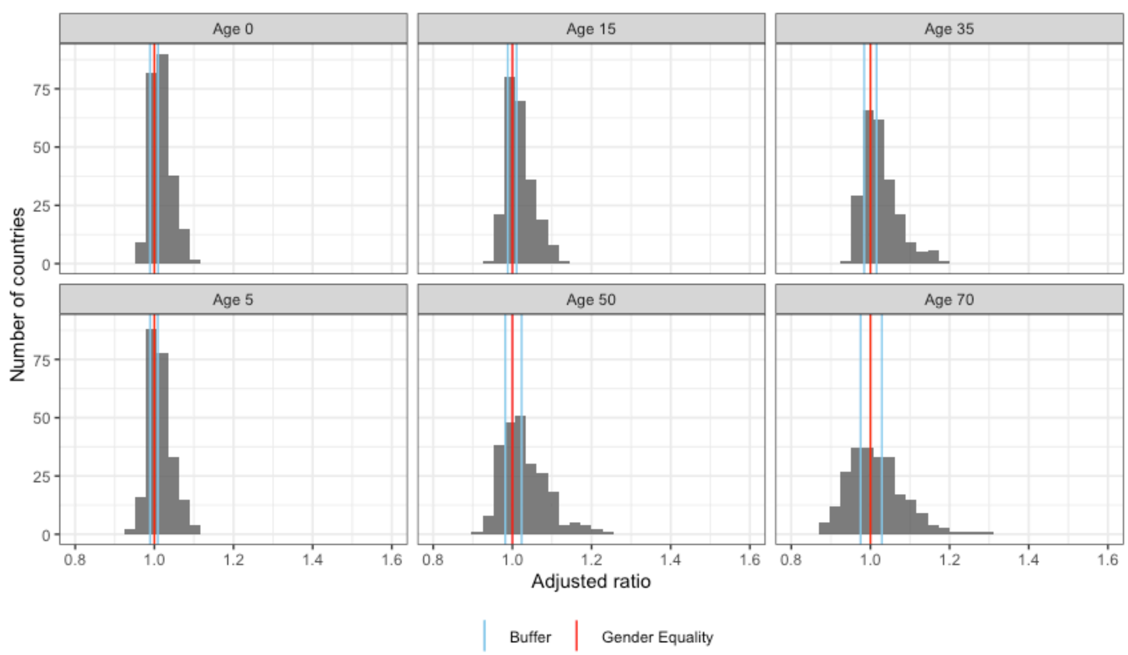
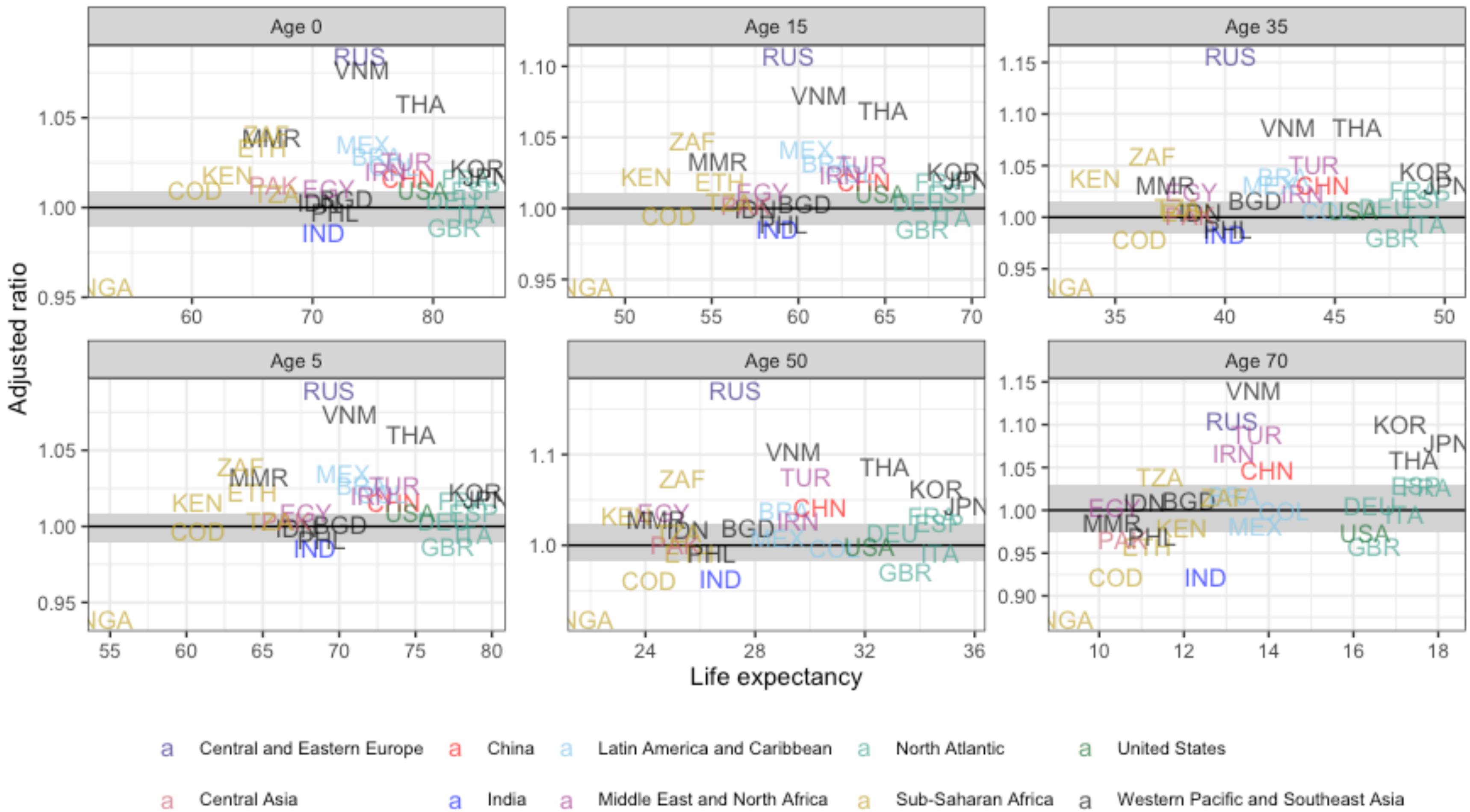
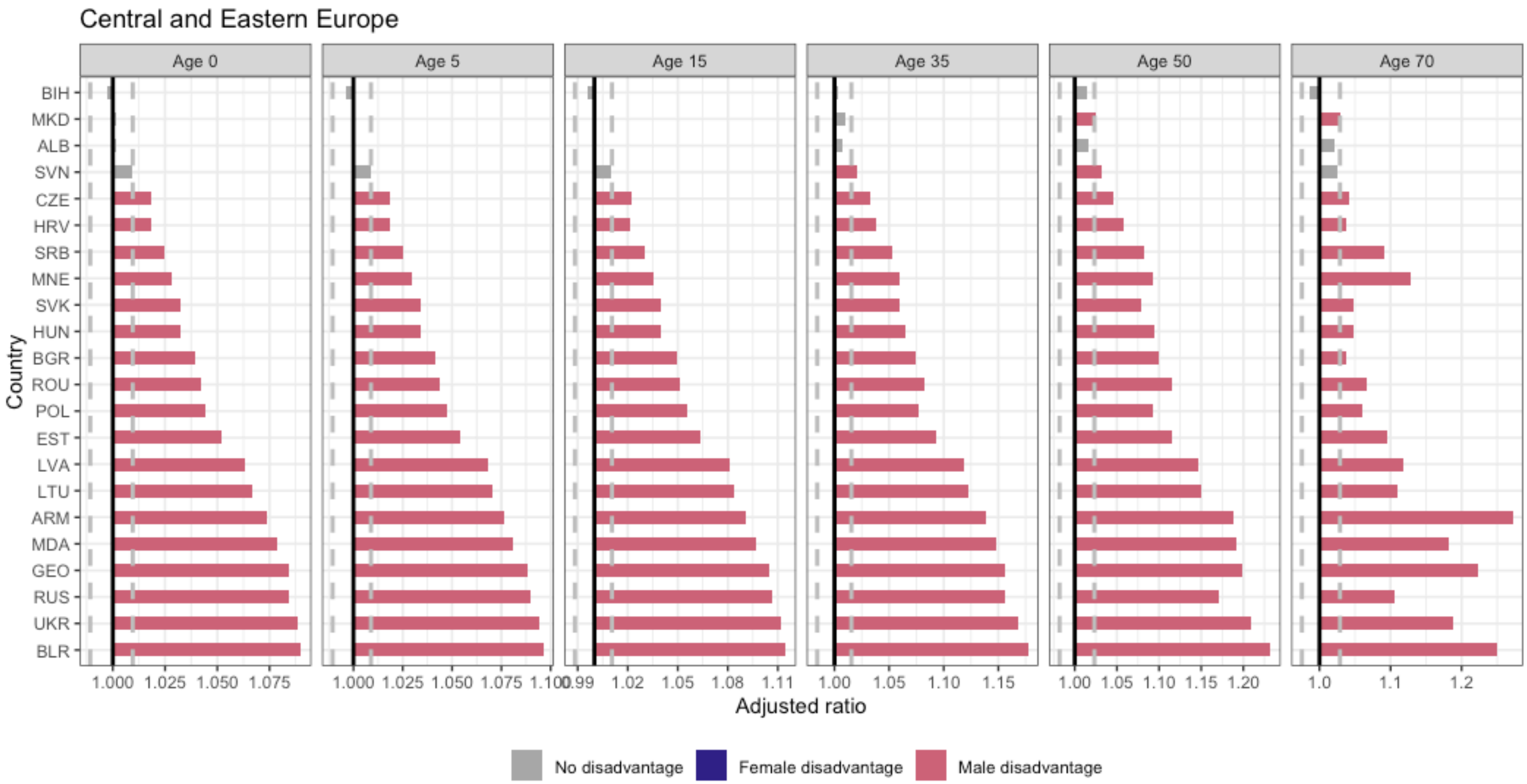


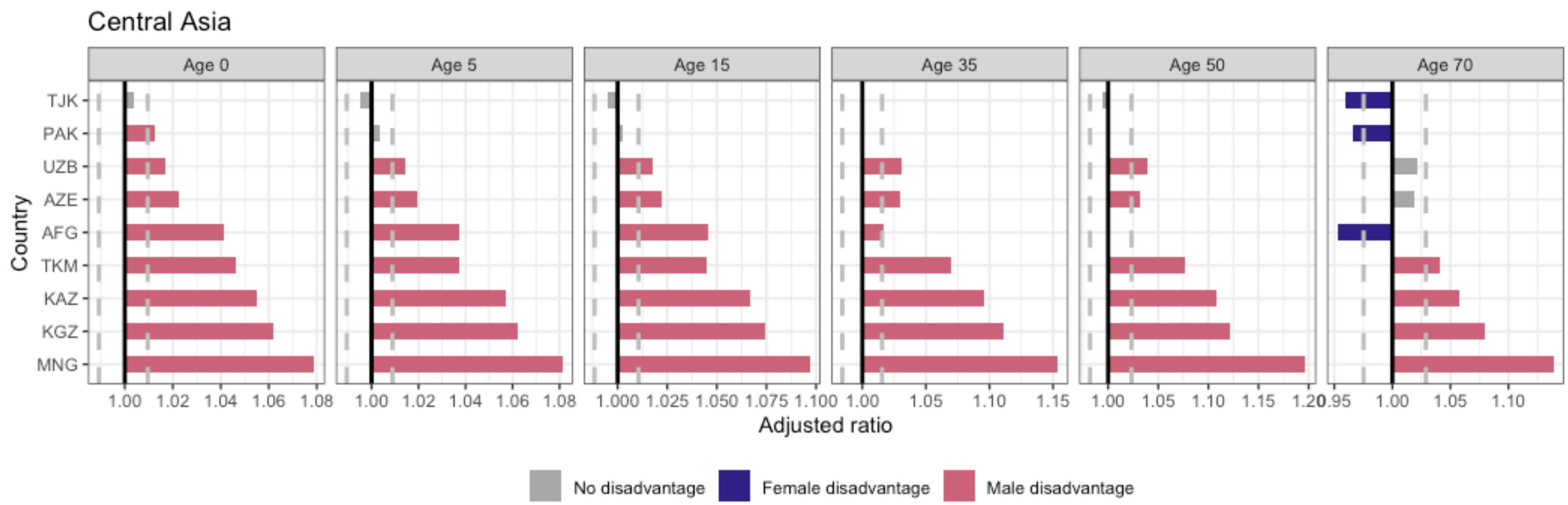
Figure 2. Adjusted ratios by life expectancy for the 30 most populous countries, 2019, by age

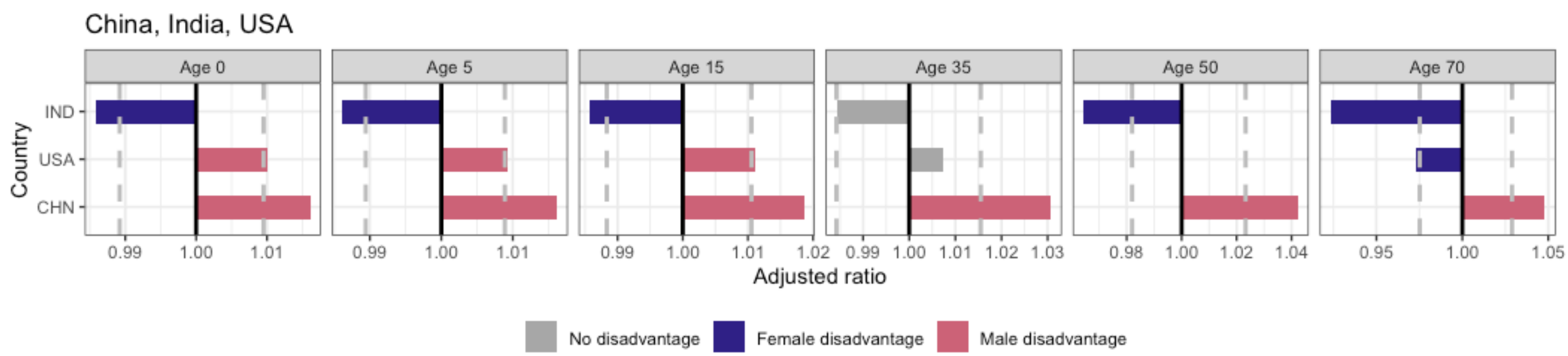


The shaded gray area represents the buffer.

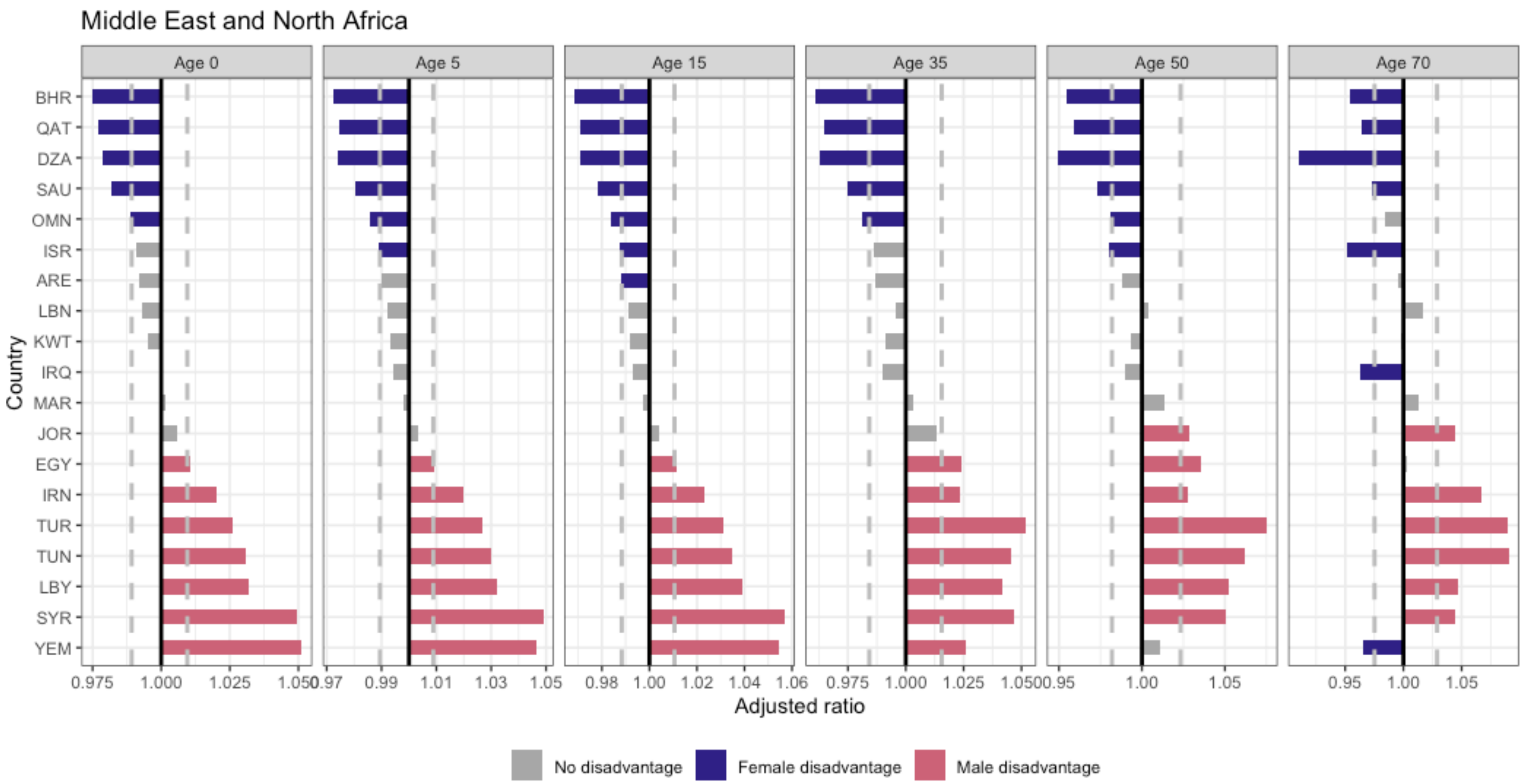
Figure 3. Adjusted ratios by CIH regions, 2019, by age

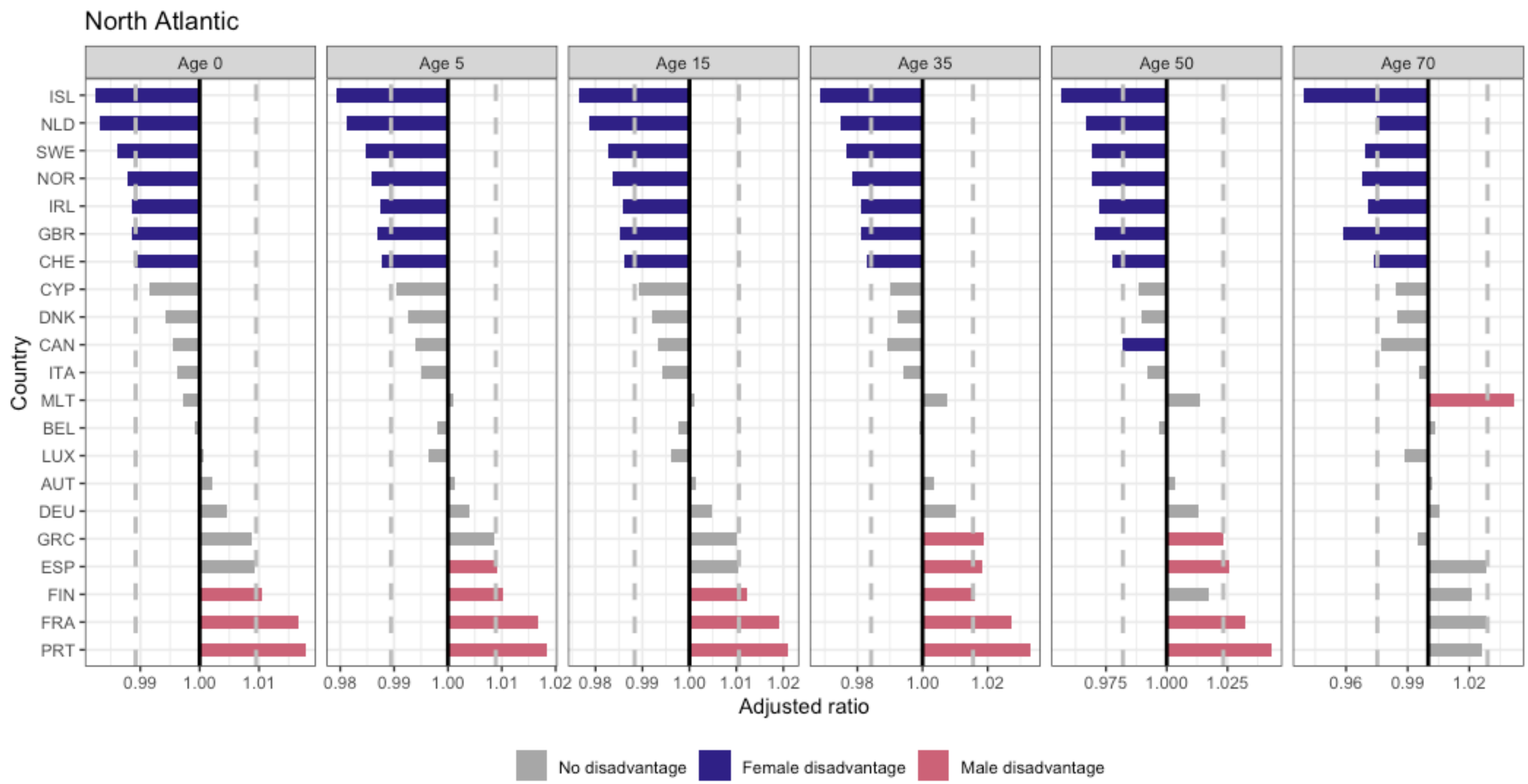



Central Asia
Age 0
Age 5
Age 15
Age 35
Age 50
Age 70
Country
TJK
PAK
UZB
AZE
AFG
TKM
KAZ
KGZ
MNG
1.00 1.02 1.04 1.06 1.08
1.00 1.02 1.04 1.06 1.08
1.000 1.025 1.050 1.075 1.100
1.00 1.05 1.10 1.15
1.00 1.05 1.10 1.15 1.20
0.95 1.00 1.05 1.10
Adjusted ratio
No disadvantage
Female disadvantage
Male disadvantage

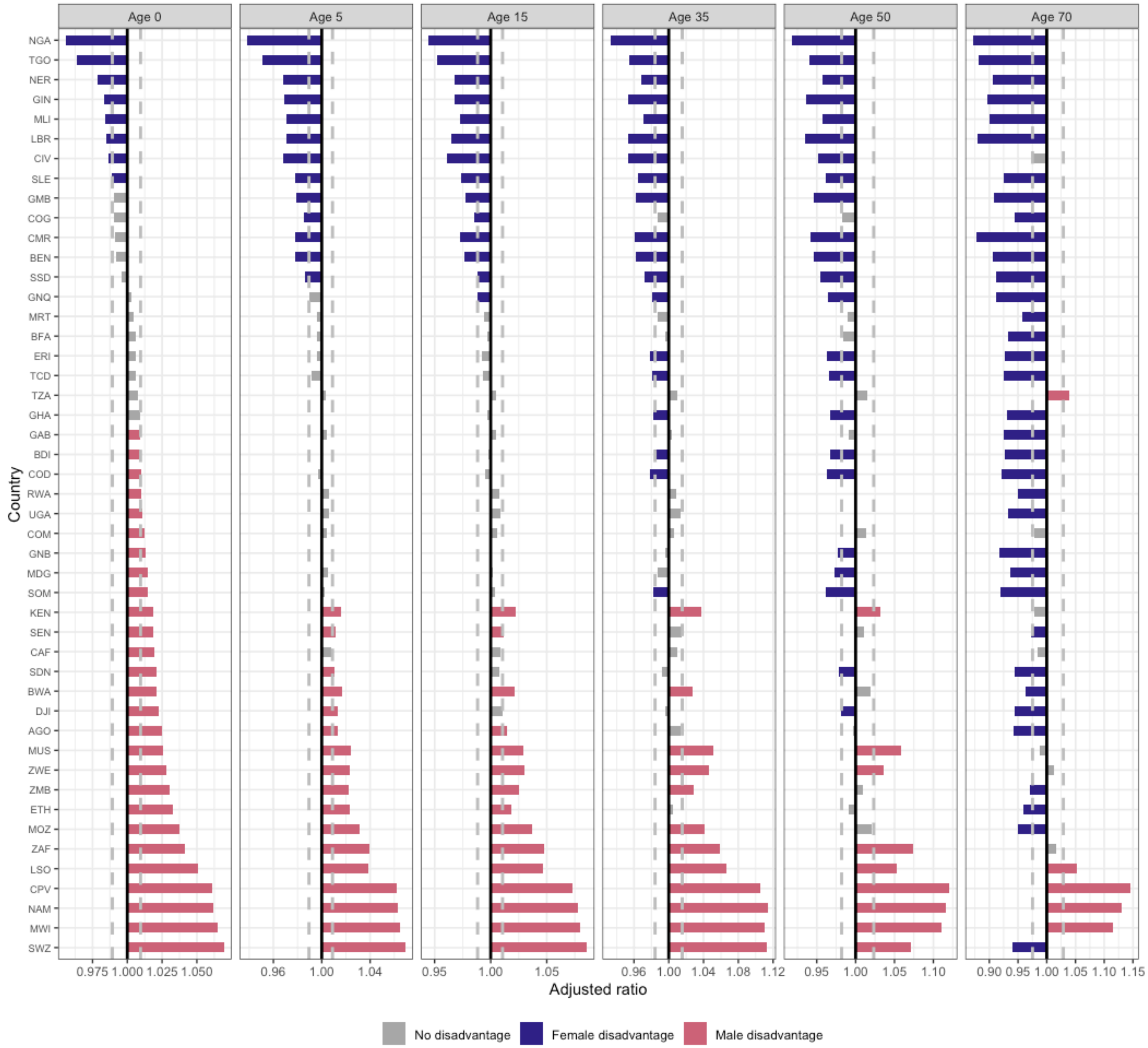

China, India, USA
Age 0
Age 5
Age 15
Age 35
Age 50
Age 70
Country
IND
USA
CHN
0.99 1.00 1.01
0.99 1.00 1.01
0.99 1.00 1.01 1.02
0.99 1.00 1.01 1.02 1.03
0.98 1.00 1.02 1.04
0.95 1.00 1.05
Adjusted ratio
No disadvantage
Female disadvantage
Male disadvantage

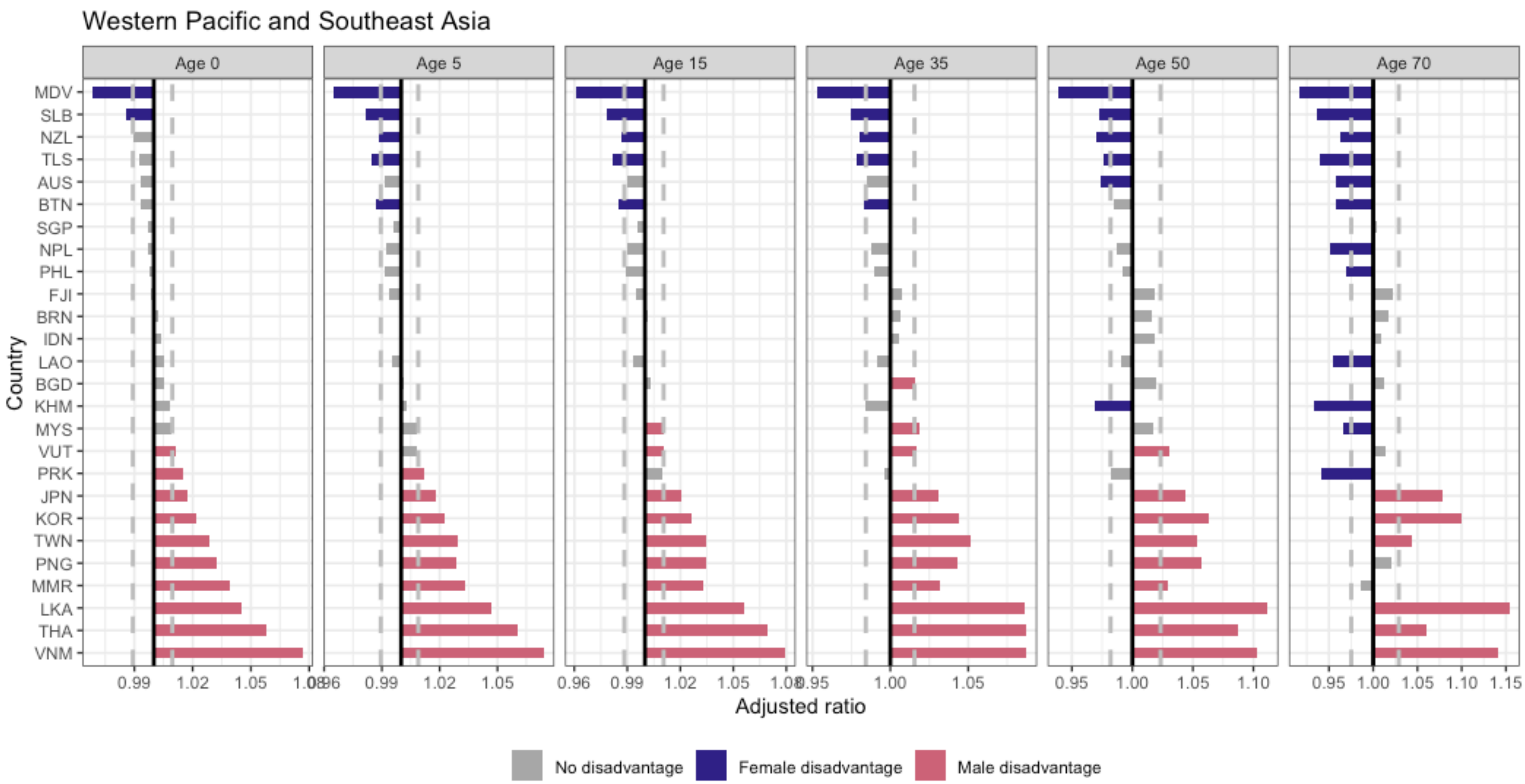
Latin America and Caribbean
Age 0
Age 5
Age 15
Age 35
Age 50
Age 70
Country
JAM
CHL
PER
CUB
CRI
HND
ECU
GTM
PRY
BOL
BHS
COL
PAN
NIC
BRA
BLZ
DOM
ARG
MEX
TTO
SUR
HTI
GUY
URY
VEN
SLV
Adjusted ratio
No disadvantage
Female disadvantage
Male disadvantage


Middle East and North Africa
Age 0
Age 5
Age 15
Age 35
Age 50
Age 70
BHR
QAT
DZA
SAU
OMN
ISR
ARE
LBN
KWT
IRQ
MAR
JOR
EGY
IRN
TUR
TUN
LBY
SYR
YEM
Country
0.975 1.000 1.025 1.050
0.97 0.99 1.01 1.03 1.05
0.98 1.00 1.02 1.04 1.06
0.975 1.000 1.025 1.050
0.95 1.00 1.05
0.95 1.00 1.05
Adjusted ratio
No disadvantage
Female disadvantage
Male disadvantage


North Atlantic
Age 0
Age 5
Age 15
Age 35
Age 50
Age 70
Country
ISL
NLD
SWE
NOR
IRL
GBR
CHE
CYP
DNK
CAN
ITA
MLT
BEL
LUX
AUT
DEU
GRC
ESP
FIN
FRA
PRT
0.99 1.00 1.01
0.98 0.99 1.00 1.01 1.02
0.98 0.99 1.00 1.01 1.02
0.98 1.00 1.02
0.975 1.000 1.025
0.96 0.99 1.02
Adjusted ratio
No disadvantage
Female disadvantage
Male disadvantage

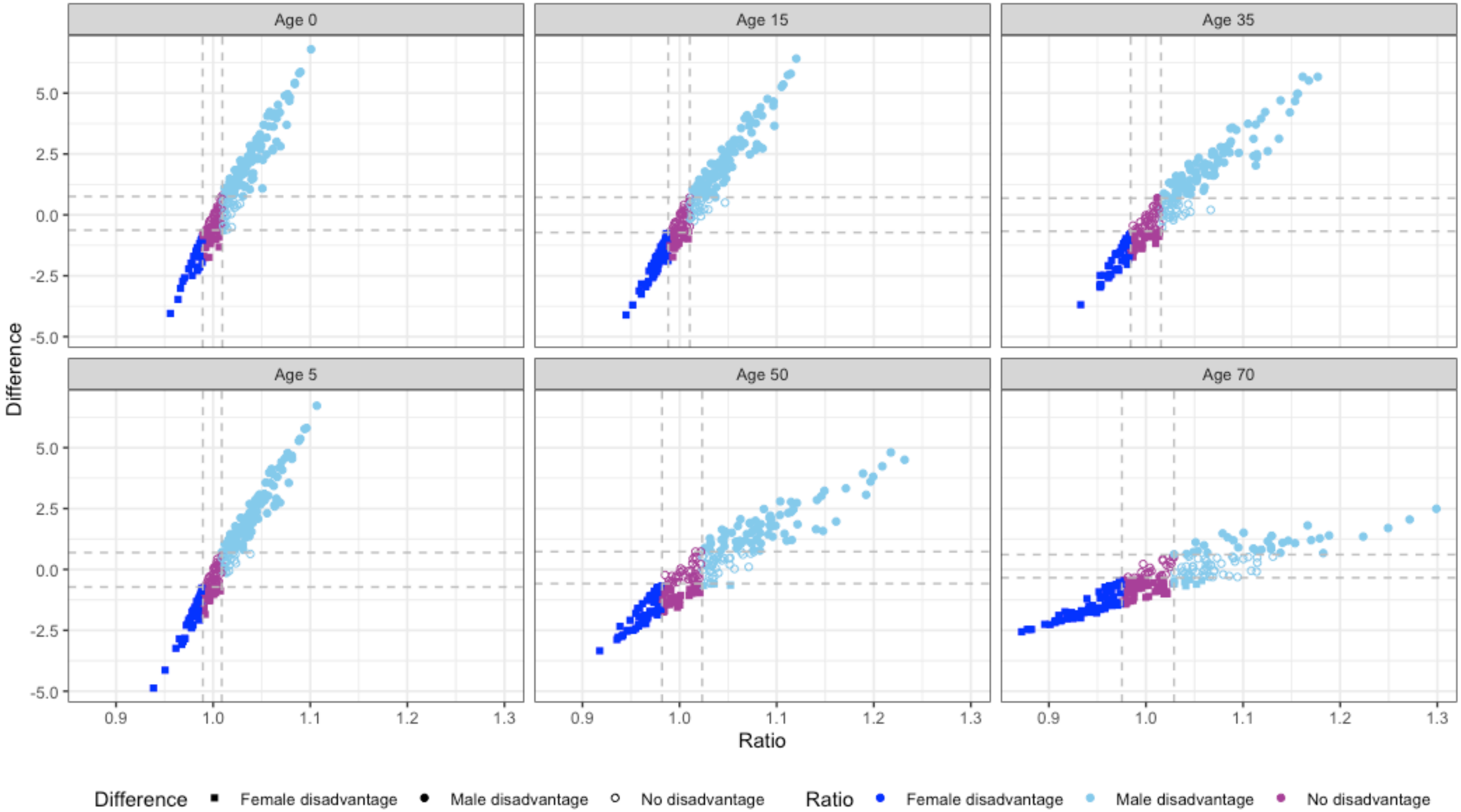
Sub-Saharan Africa





Western Pacific and Southeast Asia
Age 0
Age 5
Age 15
Age 35
Age 50
Age 70
Country
MDV
SLB
NZL
TLS
AUS
BTN
SGP
NPL
PHL
FJI
BRN
IDN
LAO
BGD
KHM
MYS
VUT
PRK
JPN
KOR
TWN
PNG
MMR
LKA
THA
VNM
Adjusted ratio
No disadvantage
Female disadvantage
Male disadvantage

Figure 4. Comparison of adjusted ratios and adjusted differences, by age



The gray dashed lines indicate the 30% buffer.

References

1 World Economic Forum. Closing the Women's Health Gap to Improve Lives and Economies. World Econ. Forum. 2024; published online Jan. https://www.weforum.org/publications/closing-the-women-s-health-gap-a-1-trillion-opportunity-to-improve-lives-and-economies/ (accessed May 10, 2024).

2 World Economic Forum. New Global Alliance for Women's Health Could Help Boost Global Economy by $1 Trillion Annually by 2040. World Econ. Forum. 2024. https://www.weforum.org/press/2024/01/wef24-new-global-alliance-for-womens-health-could-boost-global-economy-by-1-trillion-annually-by-2040/ (accessed May 10, 2024).

3 Yan BW, Arias E, Geller AC, Miller DR, Kochanek KD, Koh HK. Widening Gender Gap in Life Expectancy in the US, 2010-2021. *JAMA Intern Med* 2024; **184**: 108–10.

4 Allel K, Salustri F, Haghparast-Bidgoli H, Kiadaliri A. The contributions of public health policies and healthcare quality to gender gap and country differences in life expectancy in the UK. *Popul Health Metr* 2021; **19**: 40.

5 Hawkes S, Buse K. Gender myths in global health. *Lancet Glob Health* 2017; **5**: e871.

6 Luy M. The impact of biological factors on sex differences in life expectancy: insights gained from a natural experiment. 2016.

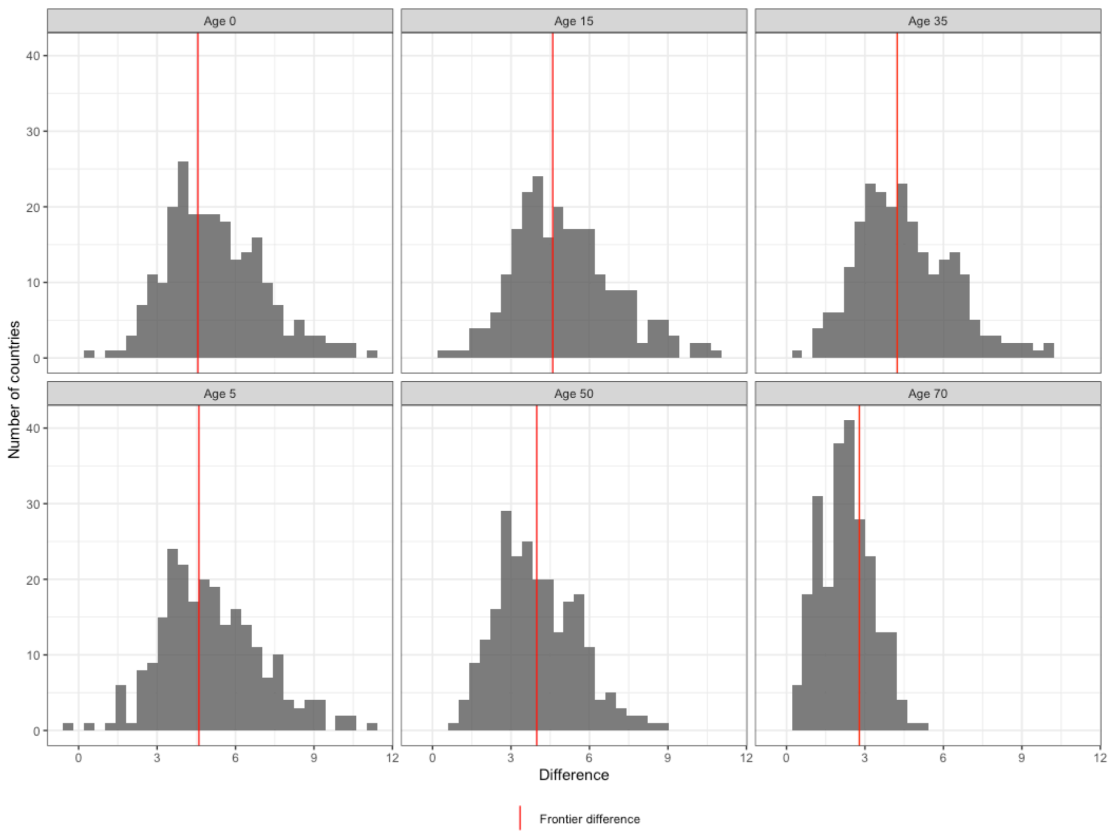
7 Luy M. The impact of biological factors on sex differences in life expectancy: insights from a natural experiment. *Gend-Specif Life Expect Eur 1850-2010 Ed Dinges Weigl* 2016.

8 Zarulli V, Jones JAB, Oksuzyan A, Lindahl-Jacobsen R, Christensen K, Vaupel JW. Women live longer than men even during severe famines and epidemics. *Proc Natl Acad Sci* 2018; **115**: E832–40.

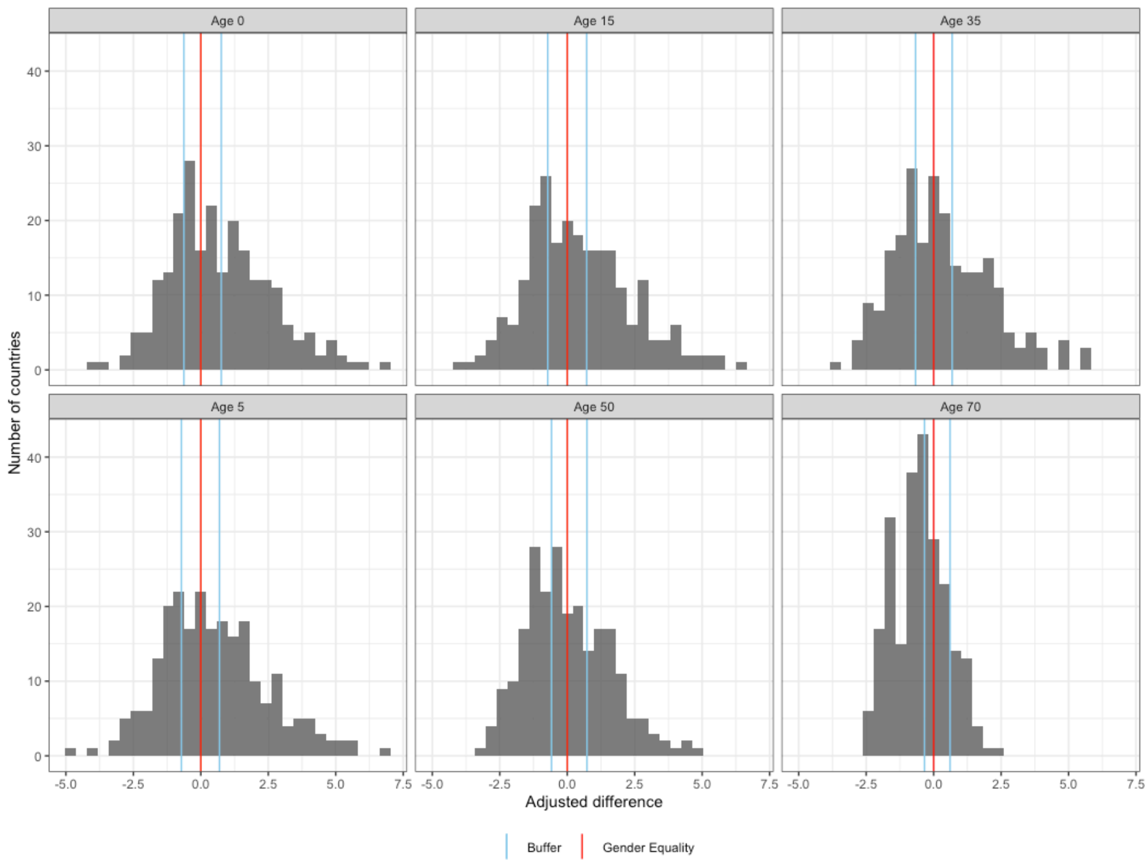
Supplementary Materials

Appendix Figure 1. Distribution of differences and adjusted differences in 2019, by age

Panel A: Differences

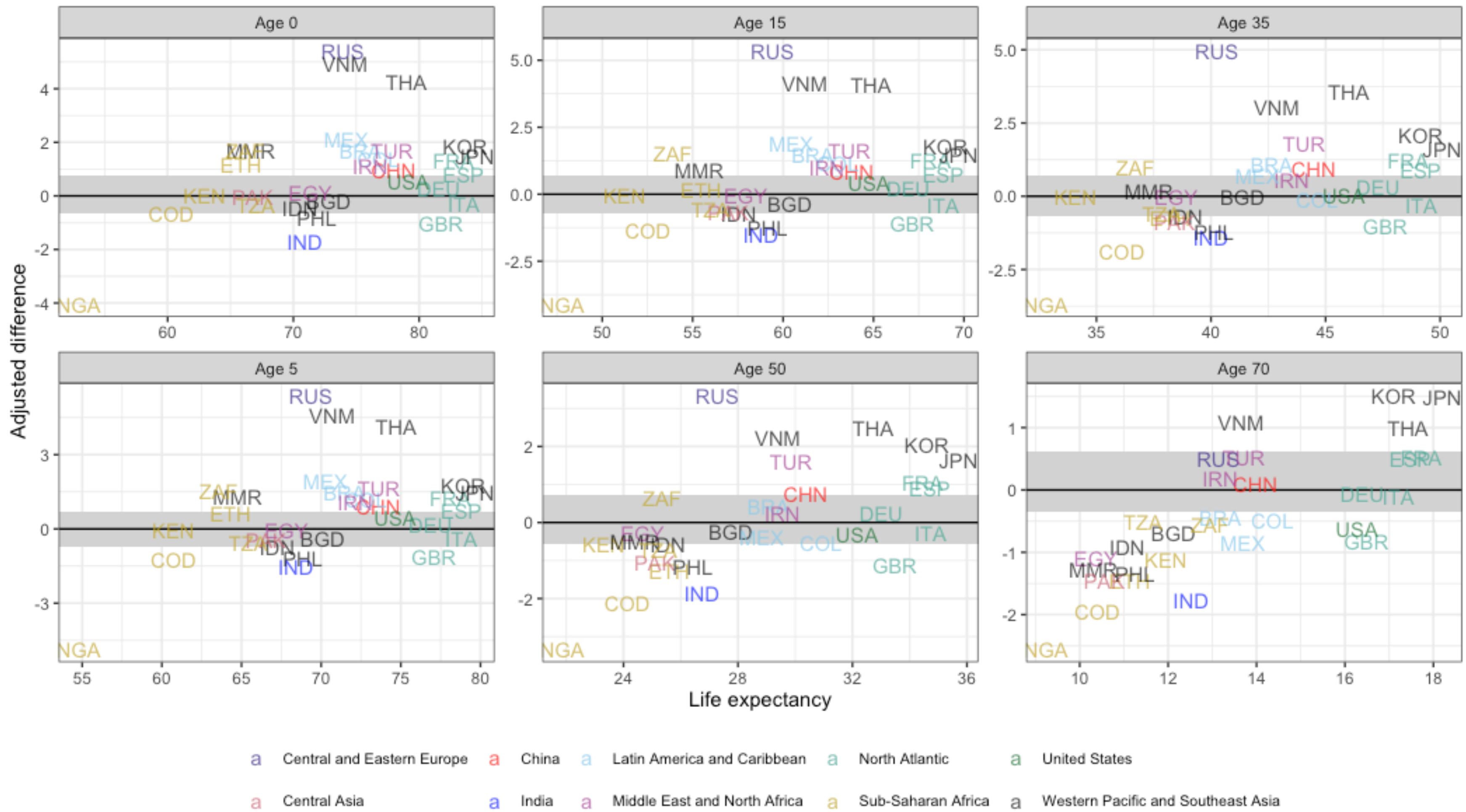


Panel B: Adjusted differences

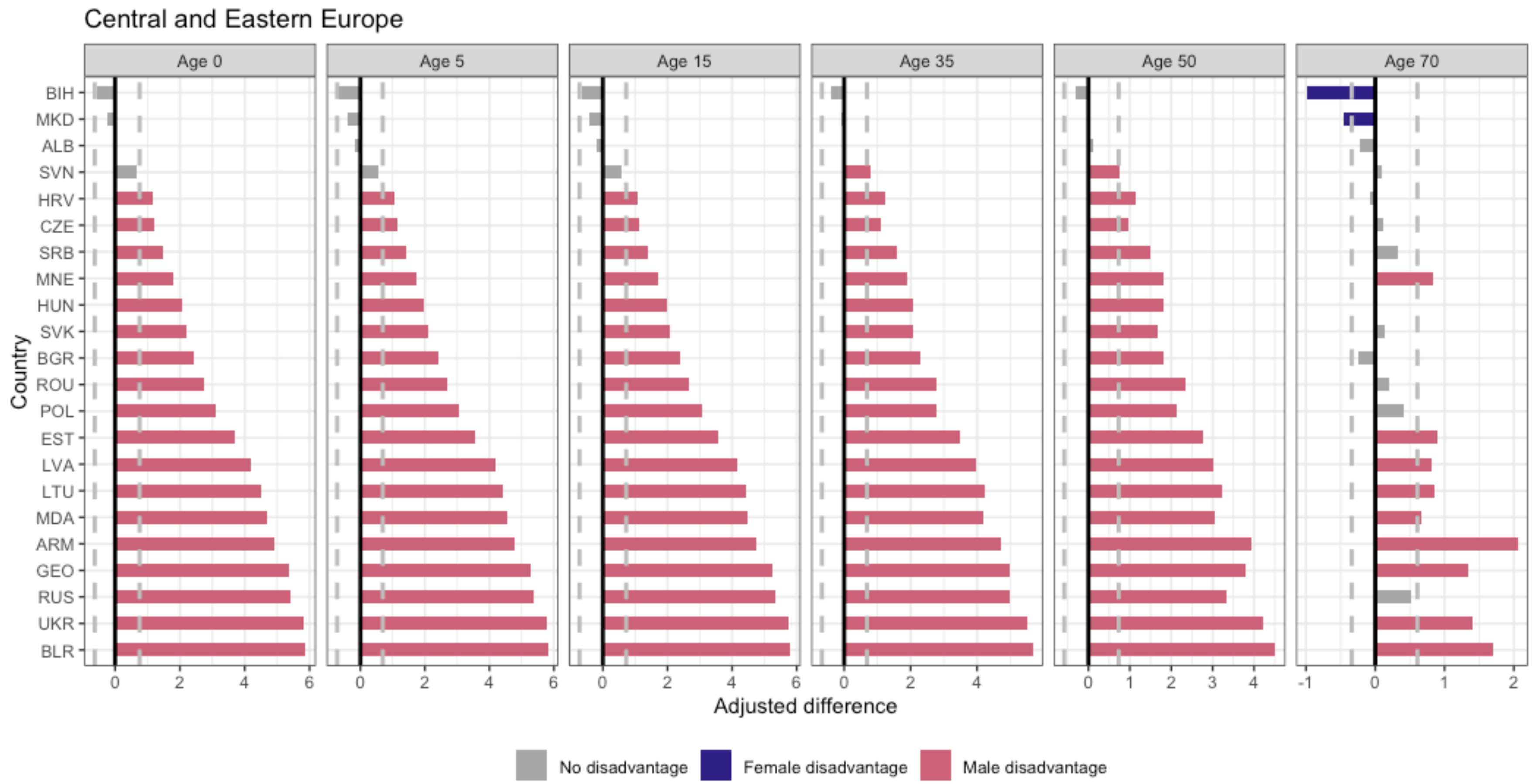


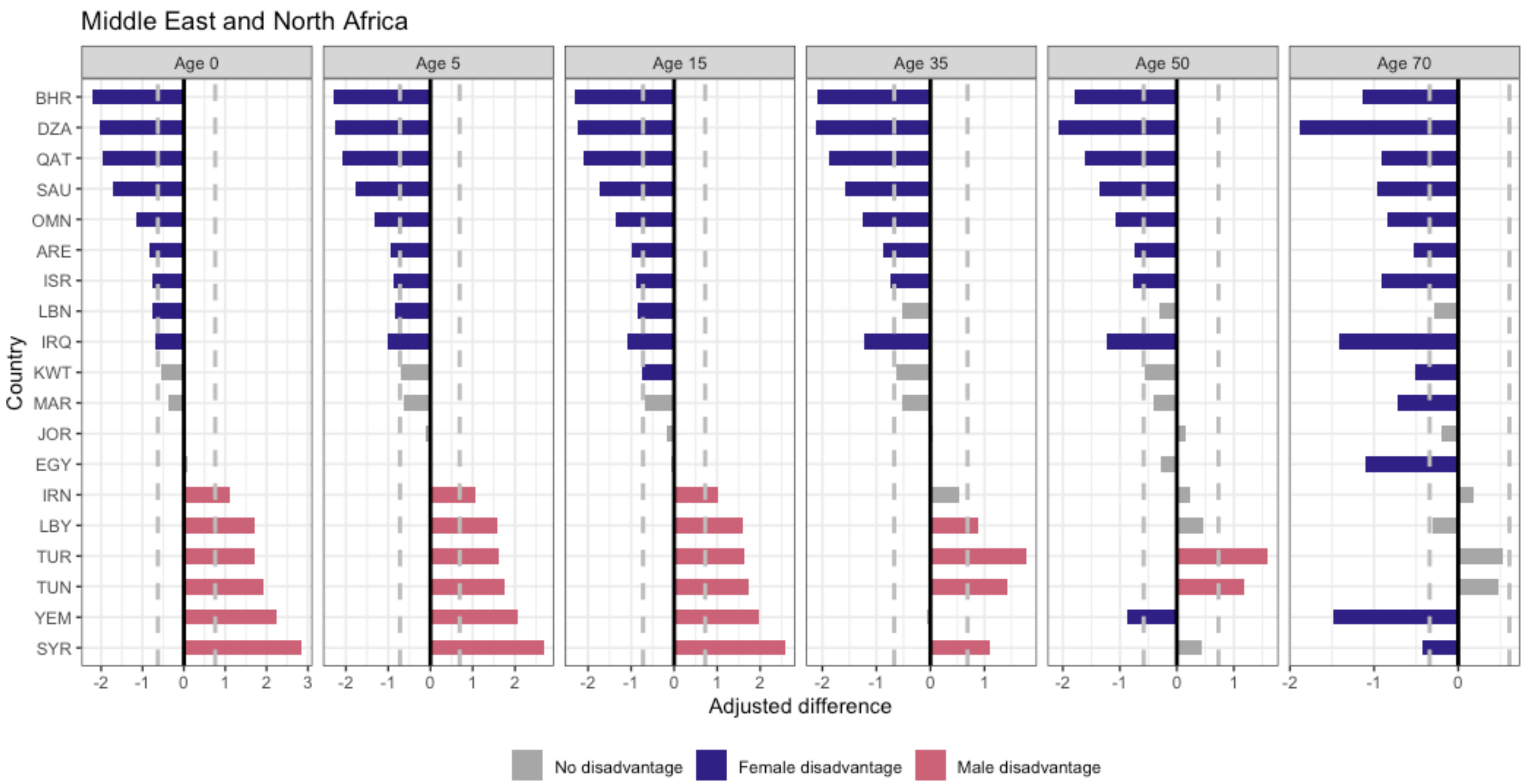
Age 0
Age 15
Age 35
Age 5
Age 50
Age 70
Number of countries
Adjusted difference
Buffer
Gender Equality

Appendix Figure 2. Adjusted differences by life expectancy for the 30 most populous countries, 2019, by age

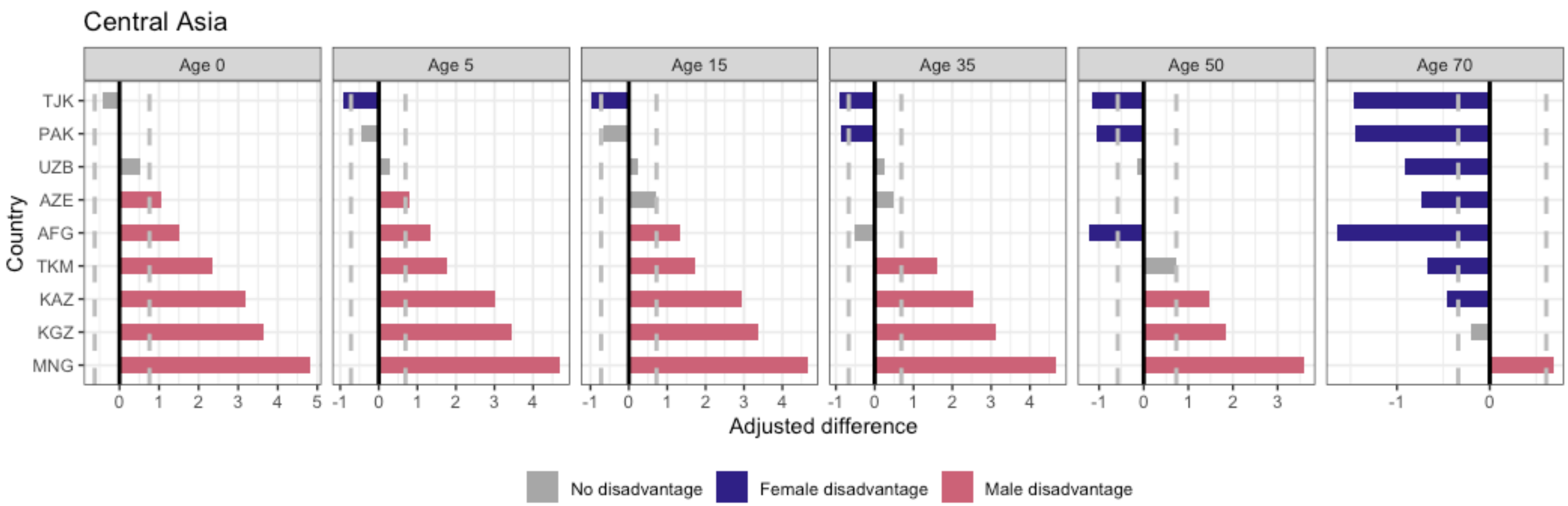


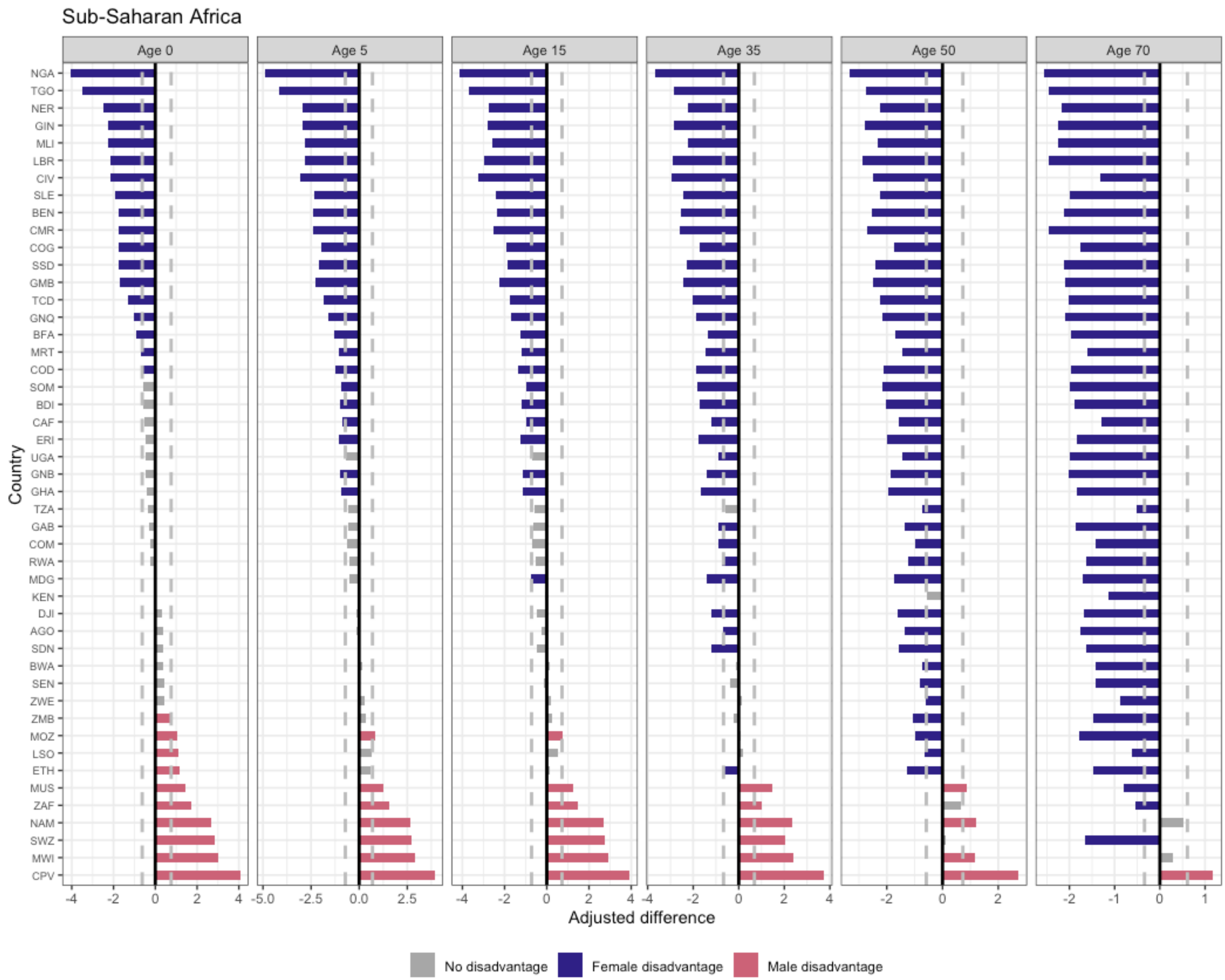
Appendix Figure 3. Adjusted differences by CIH regions, 2019, by age



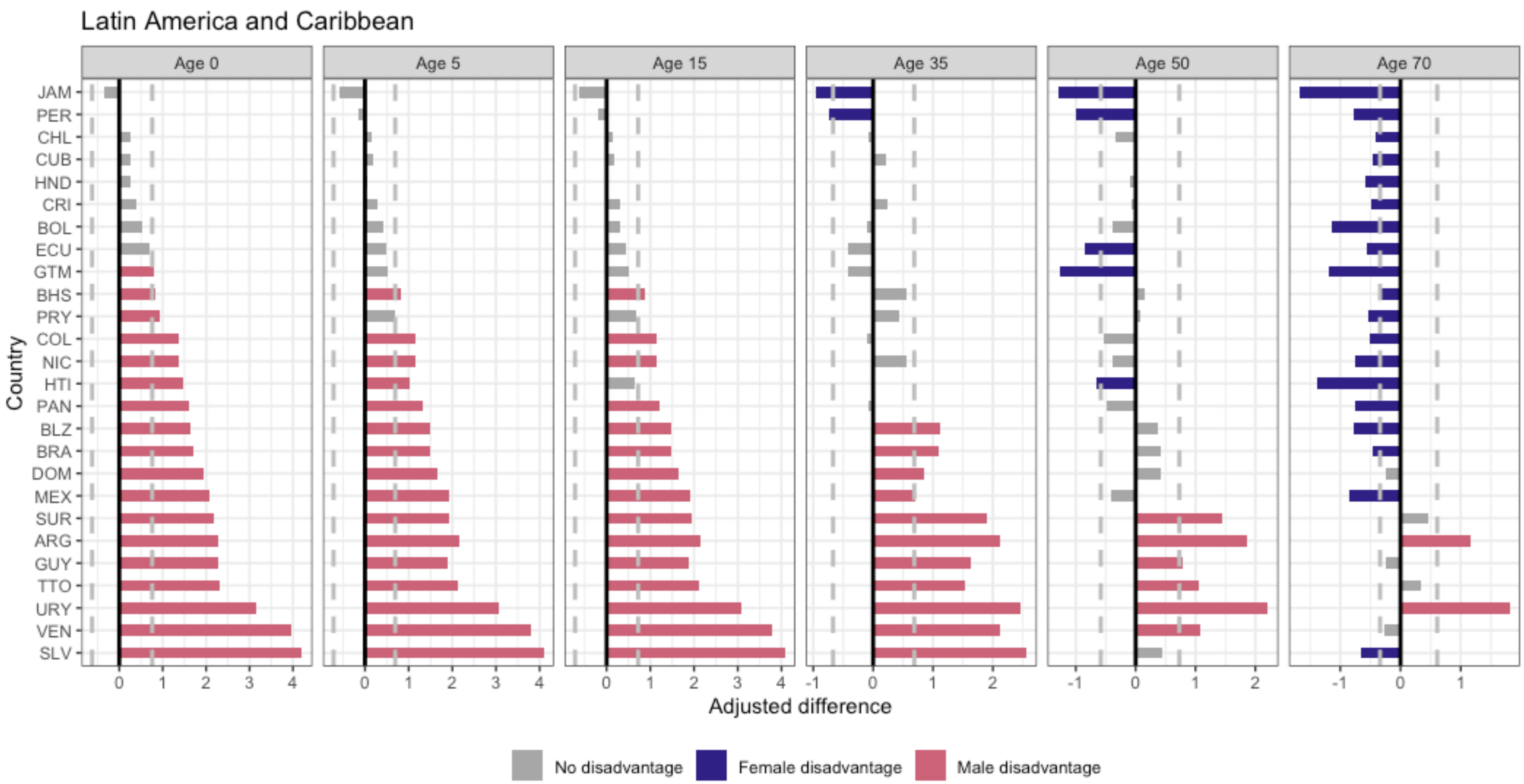


Middle East and North Africa
Age 0
Age 5
Age 15
Age 35
Age 50
Age 70
Country
BHR
DZA
QAT
SAU
OMN
ARE
ISR
LBN
IRQ
KWT
MAR
JOR
EGY
IRN
LBY
TUR
TUN
YEM
SYR
Adjusted difference
No disadvantage
Female disadvantage
Male disadvantage

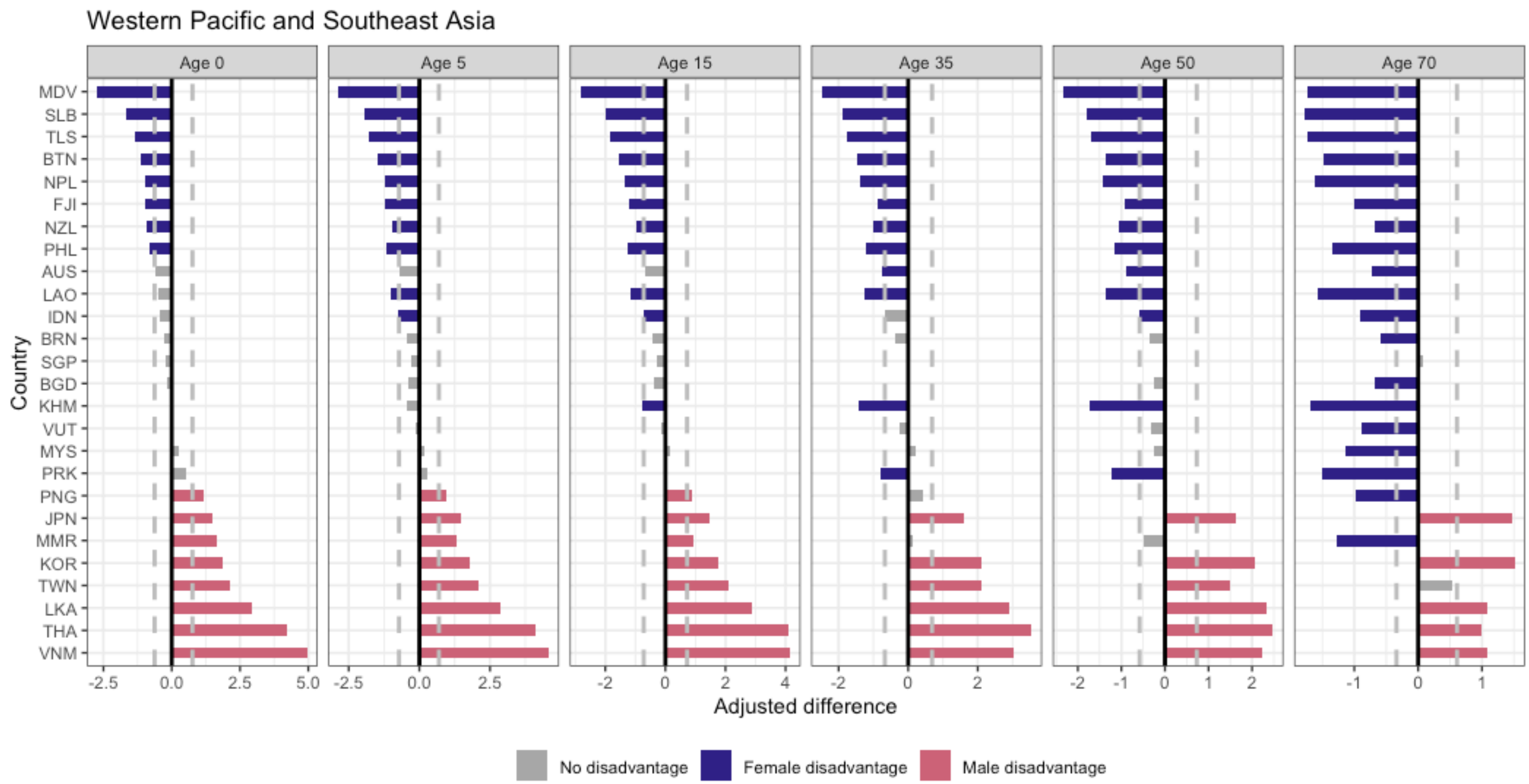

Central Asia
Age 0
Age 5
Age 15
Age 35
Age 50
Age 70
Country
TJK
PAK
UZB
AZE
AFG
TKM
KAZ
KGZ
MNG
Adjusted difference
No disadvantage
Female disadvantage
Male disadvantage

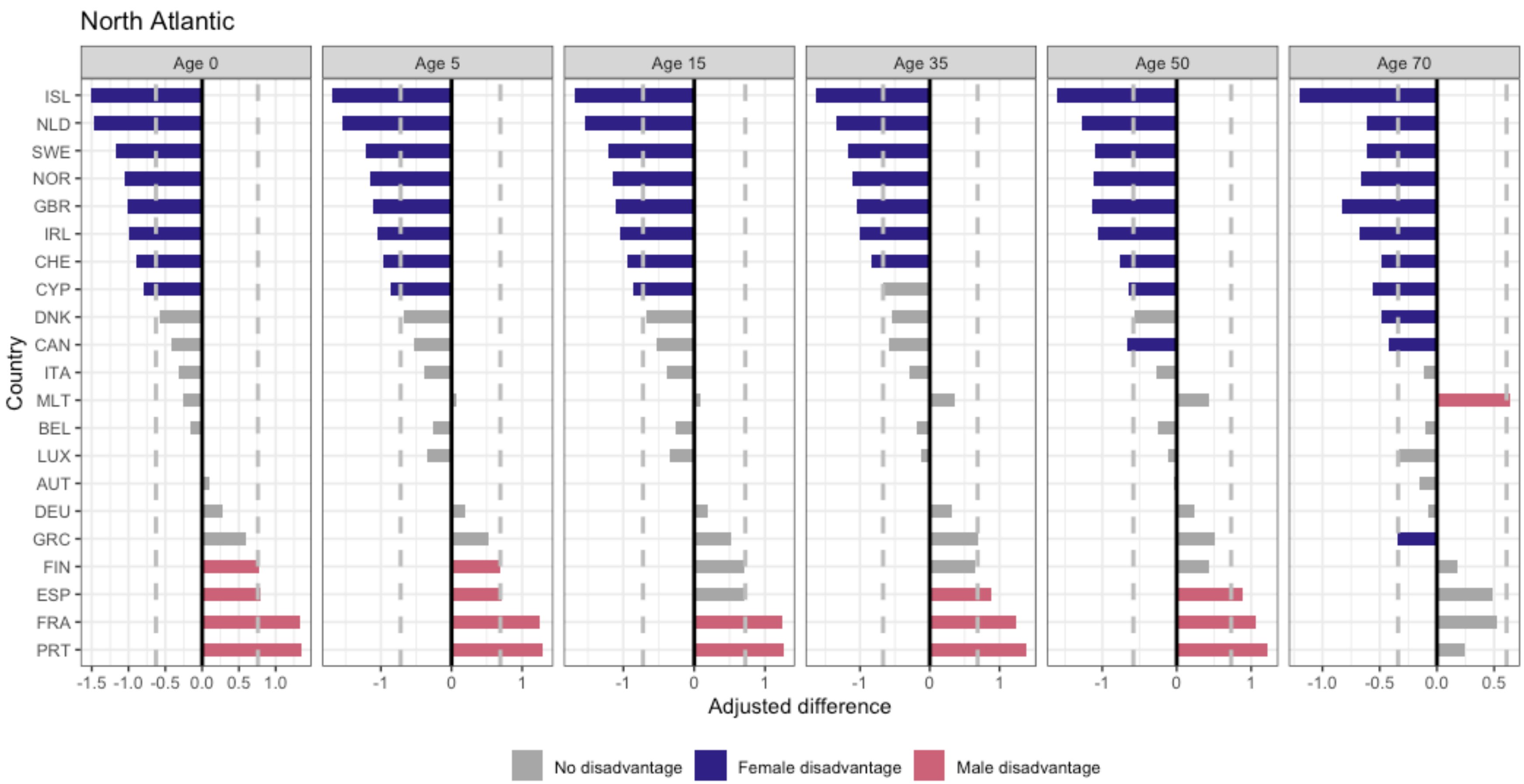


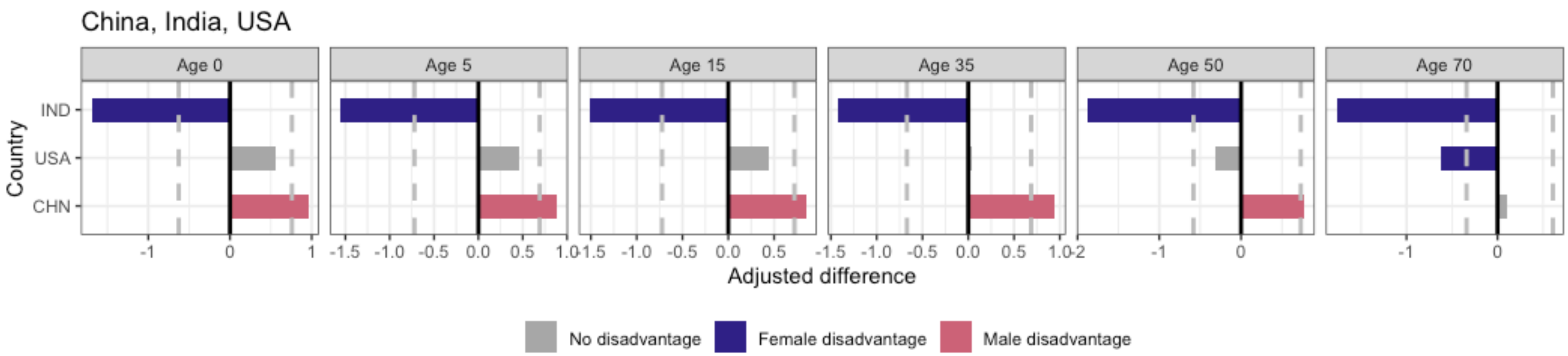
Sub-Saharan Africa
Age 0
Age 5
Age 15
Age 35
Age 50
Age 70
Country
NGA
TGO
NER
GIN
MLI
LBR
CIV
SLE
BEN
CMR
COG
SSD
GMB
TCD
GNQ
BFA
MRT
COD
SOM
BDI
CAF
ERI
UGA
GNB
GHA
TZA
GAB
COM
RWA
MDG
KEN
DJI
AGO
SDN
BWA
SEN
ZWE
ZMB
MOZ
LSO
ETH
MUS
ZAF
NAM
SWZ
MWI
CPV
Adjusted difference
No disadvantage
Female disadvantage
Male disadvantage



Latin America and Caribbean
Age 0
Age 5
Age 15
Age 35
Age 50
Age 70
Country
JAM
PER
CHL
CUB
HND
CRI
BOL
ECU
GTM
BHS
PRY
COL
NIC
HTI
PAN
BLZ
BRA
DOM
MEX
SUR
ARG
GUY
TTO
URY
VEN
SLV
Adjusted difference
No disadvantage
Female disadvantage
Male disadvantage


Western Pacific and Southeast Asia
Age 0
Age 5
Age 15
Age 35
Age 50
Age 70
Country
MDV
SLB
TLS
BTN
NPL
FJI
NZL
PHL
AUS
LAO
IDN
BRN
SGP
BGD
KHM
VUT
MYS
PRK
PNG
JPN
MMR
KOR
TWN
LKA
THA
VNM
-2.5 0.0 2.5 5.0
-2.5 0.0 2.5
-2 0 2 4
-2 0 2
-2 -1 0 1 2
-1 0 1
Adjusted difference
No disadvantage
Female disadvantage
Male disadvantage


North Atlantic
Age 0
Age 5
Age 15
Age 35
Age 50
Age 70
ISL
NLD
SWE
NOR
GBR
IRL
CHE
CYP
DNK
CAN
ITA
MLT
BEL
LUX
AUT
DEU
GRC
FIN
ESP
FRA
PRT
Country
Adjusted difference
No disadvantage
Female disadvantage
Male disadvantage


China, India, USA
Age 0
Age 5
Age 15
Age 35
Age 50
Age 70
IND
USA
CHN
Country
Adjusted difference
No disadvantage
Female disadvantage
Male disadvantage