Package 'WHORiskCalculator'

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Title WHO Cardiovascular Disease Risk Calculator

Version 1.1.0

Description Implements the 2019 World Health Organization (WHO) cardiovascular disease (CVD) risk prediction models, as described in Kaptoge et al. (2019) <doi:10.1016/S2214-109X(19)30318-3>. Provides two validated models for estimating 10-year risk of fatal and non-fatal cardiovascular events (myocardial infarction and stroke): a laboratory-based model using age, sex, systolic blood pressure, total cholesterol, smoking status, and diabetes history; and a non-laboratory-based model substituting body mass index (BMI) for cholesterol and diabetes, suitable for resource-limited settings. Risk estimates are recalibrated to 21 Global Burden of Disease regions (or to individual countries) using the authors' recalibration parameters, fitted to Global Burden of Disease 2017 incidence rates and Non-Communicable Disease Risk Factor Collaboration risk factor levels. Functions are fully vectorized for efficient batch calculations and support automatic country-to-region mapping via ISO 3166-1 alpha-3 country codes.

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Author WHO CVD Risk Chart Working Group [aut], Andrea Pedot [cre, ctb]

Maintainer Andrea Pedot <andrea.pedot@unimi.it>

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`calculate_who_risk` *Calculate WHO 10-Year CVD Risk (Laboratory-Based Model)*

Description

Calculates the 10-year risk of cardiovascular disease (fatal and non-fatal myocardial infarction and stroke) using the WHO laboratory-based model. This model requires total cholesterol measurement.

Usage

```
calculate_who_risk(
  age,
  sex,
  sbp,
  cholesterol,
  smoking,
  diabetes,
  region = NULL,
  country = NULL,
  recalibration = c("region", "country"),
  year = 2017
)
```

Arguments

`age`	Numeric vector. Age in years (valid range: 40-80).
`sex`	Character vector. Sex: "male" or "female".
`sbp`	Numeric vector. Systolic blood pressure in mmHg.
`cholesterol`	Numeric vector. Total cholesterol in mmol/L. To convert from mg/dL to mmol/L, divide by 38.67.
`smoking`	Logical vector. Current smoking status (TRUE = current smoker).
`diabetes`	Logical vector. History of diabetes (TRUE = diabetic).
`region`	Character vector. WHO/GBD region name. One of the 21 global regions (see `get_regions` for valid values). If NULL and `country` is provided, region will be determined automatically.

`country`	Character vector. ISO 3166-1 alpha-3 country code (e.g., "USA", "GBR", "IND"). Used to determine region if `region` is NULL, and required for `recalibration = "country"`. See `get_country_codes` for valid values.
`recalibration`	Character. Level of recalibration: `"region"` (default) recalibrates to the WHO/GBD region, as in the published WHO risk charts; `"country"` recalibrates to the individual country and requires `country`. See the *Recalibration* section.
`year`	Integer vector. Calendar year of the recalibration target population (1990-2017, default 2017). Years up to 2015 use the 5-year period they fall in (1990, 1995, ..., 2015).

Details

The model uses Cox proportional hazards regression with the following predictors:

- Age (with interactions for all other predictors)
- Total cholesterol
- Systolic blood pressure
- Diabetes status
- Current smoking status

Risk is calculated separately for myocardial infarction/CHD death and stroke, then combined assuming independence of the two outcomes:

$$P_{CVD} = 1 - (1 - P_{MI}) \times (1 - P_{stroke})$$

Each endpoint risk is first computed from the derivation model, $P = 1 - S_0^{\exp(LP)}$, using the baseline survival S_0 of the derivation cohort, and then recalibrated on the complementary log-log scale:

$$P_{cal} = 1 - \exp(-\exp(c + s \log(-\log(1 - P))))$$

where the intercept c and slope s are specific to region (or country), sex, endpoint and year. These parameters were fitted by the authors to GBD 2017 incidence rates and NCD-RisC risk factor levels and are taken from their Stata implementation (`whocvdrisk`).

Value

Numeric vector of 10-year CVD risk as a proportion (0-1). Multiply by 100 to get percentage.

Recalibration

Region-level (default). `recalibration = "region"` uses one set of parameters per WHO/GBD region, sex and year. This reproduces the published WHO risk charts (Kaptoge et al. 2019) and the default output of the authors' Stata program `whocvdrisk`. When only `country` is given, it is used solely to look up the region (see `country_to_region`); all countries in a region get the same risk.

Country-level (optional). `recalibration = "country"` uses parameters fitted to each country's own GBD 2017 incidence rates and NCD-RisC risk factor levels (the `cal1` parameters of `whocvdrisk`). It requires `country`. Use it when you need country-specific estimates rather than chart-equivalent ones; results can differ substantially from the region-level ones. For example, for a 45-year-old

male smoker in the United Kingdom (SBP 140 mmHg, total cholesterol 5.5 mmol/L, no diabetes), the lab model gives about 7.0% with region-level and 9.4% with country-level recalibration.

Country-specific estimates are not available for South Sudan (SSD), the US Virgin Islands (VIR), American Samoa (ASM), Guam (GUM) and the Northern Mariana Islands (MNP), nor for Greenland (GRL), Bermuda (BMU) and Puerto Rico (PRI) before 2015. For these, region-level parameters are used and a warning is issued.

Year. `year` selects the calendar year of the recalibration target population (default 2017, as in the charts). Parameters exist for 1990, 1995, 2000, 2005, 2010, 2015, 2016 and 2017; other years up to 2015 use the 5-year period they fall in (e.g. 2003 uses 2000).

Centering Values

Variables are centered at:

- Age: 60 years
- Systolic blood pressure: 120 mmHg
- Total cholesterol: 6 mmol/L

See Also

`calculate_who_risk_nonlab` for the non-laboratory-based model, `get_regions` for available regions, `get_country_codes` for country code lookup.

Examples

```
# Single calculation
calculate_who_risk(
  age = 55,
  sex = "male",
  sbp = 140,
  cholesterol = 5.5,
  smoking = TRUE,
  diabetes = FALSE,
  region = "western_europe"
)

# Using country code instead of region
calculate_who_risk(
  age = 60,
  sex = "female",
  sbp = 130,
  cholesterol = 6.0,
  smoking = FALSE,
  diabetes = TRUE,
  country = "ITA"
)

# Country-specific instead of region-level recalibration
calculate_who_risk(
  age = 45,
```

```
  sex = "male",
  sbp = 140,
  cholesterol = 5.5,
  smoking = TRUE,
  diabetes = FALSE,
  country = "GBR",
  recalibration = "country"
)

# Vectorized calculation
calculate_who_risk(
  age = c(45, 55, 65),
  sex = c("male", "female", "male"),
  sbp = c(120, 140, 160),
  cholesterol = c(5.0, 6.0, 7.0),
  smoking = c(FALSE, TRUE, FALSE),
  diabetes = c(FALSE, FALSE, TRUE),
  country = c("USA", "GBR", "IND")
)
```

`calculate_who_risk_nonlab` *Calculate WHO 10-Year CVD Risk (Non-Laboratory-Based Model)*

Description

Calculates the 10-year risk of cardiovascular disease using the WHO non-laboratory-based model. This model uses BMI instead of cholesterol and does not require diabetes status, making it suitable for resource-limited settings where laboratory testing may not be available.

Usage

```
calculate_who_risk_nonlab(
  age,
  sex,
  sbp,
  bmi,
  smoking,
  region = NULL,
  country = NULL,
  recalibration = c("region", "country"),
  year = 2017
)
```

Arguments

age	Numeric vector. Age in years (valid range: 40-80).

`sex`	Character vector. Sex: "male" or "female".
`sbp`	Numeric vector. Systolic blood pressure in mmHg.
`bmi`	Numeric vector. Body mass index in kg/m².
`smoking`	Logical vector. Current smoking status (TRUE = current smoker).
`region`	Character vector. WHO/GBD region name. One of the 21 global regions (see `get_regions` for valid values). If NULL and `country` is provided, region will be determined automatically.
`country`	Character vector. ISO 3166-1 alpha-3 country code. Used to determine region if `region` is NULL, and required for `recalibration = "country"`.
`recalibration`	Character. Level of recalibration: `"region"` (default) recalibrates to the WHO/GBD region, as in the published WHO risk charts; `"country"` recalibrates to the individual country and requires `country`. See the *Recalibration* section.
`year`	Integer vector. Calendar year of the recalibration target population (1990-2017, default 2017). Years up to 2015 use the 5-year period they fall in (1990, 1995, ..., 2015).

Details

This model is designed for use in resource-limited settings where laboratory measurements (cholesterol, glucose) may not be readily available. It uses BMI as a proxy for metabolic risk.

Risks for CHD/MI and stroke are computed from the derivation model, recalibrated on the complementary log-log scale with the authors' non-laboratory model parameters, and combined assuming independence (see `calculate_who_risk` for the formulas).

Important limitations:

- The non-laboratory model tends to underestimate risk in people with diabetes because diabetes is a strong predictor not included in this model.
- For individuals identified as high risk (>10%) by this model, laboratory-based assessment is recommended.

Value

Numeric vector of 10-year CVD risk as a proportion (0-1).

Centering Values

Variables are centered at:

- Age: 60 years
- Systolic blood pressure: 120 mmHg
- BMI: 25 kg/m²

Recalibration

Region-level (default). `recalibration = "region"` uses one set of parameters per WHO/GBD region, sex and year. This reproduces the published WHO risk charts (Kaptoge et al. 2019) and the default output of the authors' Stata program `whocvdrisk`. When only `country` is given, it is used solely to look up the region (see `country_to_region`); all countries in a region get the same risk.

Country-level (optional). `recalibration = "country"` uses parameters fitted to each country's own GBD 2017 incidence rates and NCD-RisC risk factor levels (the `cal1` parameters of `whocvdrisk`). It requires `country`. Use it when you need country-specific estimates rather than chart-equivalent ones; results can differ substantially from the region-level ones. For example, for a 45-year-old male smoker in the United Kingdom (SBP 140 mmHg, total cholesterol 5.5 mmol/L, no diabetes), the lab model gives about 7.0% with region-level and 9.4% with country-level recalibration.

Country-specific estimates are not available for South Sudan (SSD), the US Virgin Islands (VIR), American Samoa (ASM), Guam (GUM) and the Northern Mariana Islands (MNP), nor for Greenland (GRL), Bermuda (BMU) and Puerto Rico (PRI) before 2015. For these, region-level parameters are used and a warning is issued.

Year. `year` selects the calendar year of the recalibration target population (default 2017, as in the charts). Parameters exist for 1990, 1995, 2000, 2005, 2010, 2015, 2016 and 2017; other years up to 2015 use the 5-year period they fall in (e.g. 2003 uses 2000).

See Also

`calculate_who_risk` for the laboratory-based model.

Examples

```
# Single calculation
calculate_who_risk_nonlab(
  age = 55,
  sex = "male",
  sbp = 140,
  bmi = 28,
  smoking = TRUE,
  region = "south_asia"
)

# Using country code
calculate_who_risk_nonlab(
  age = 60,
  sex = "female",
  sbp = 135,
  bmi = 26,
  smoking = FALSE,
  country = "KEN"
)

# Country-specific recalibration, for an earlier year
calculate_who_risk_nonlab(
  age = 60,
  sex = "female",
```

```
  sbp = 135,
  bmi = 26,
  smoking = FALSE,
  country = "KEN",
  recalibration = "country",
  year = 2010
)
```

`country_to_region` *Map Country Code to Region*

Description

Utility function to map ISO 3166-1 alpha-3 country codes to WHO/GBD regions.

Usage

```
country_to_region(country)
```

Arguments

`country`	Character vector of ISO 3166-1 alpha-3 country codes.

Value

Character vector of region names.

Examples

```
country_to_region(c("USA", "DEU", "JPN"))
```

`get_country_codes` *Get Country Code to Region Mapping*

Description

Returns a named vector mapping ISO 3166-1 alpha-3 country codes to their corresponding WHO/GBD regions.

Usage

```
get_country_codes(country = NULL)
```

Arguments

country	Optional character vector of country codes to look up. If NULL (default), returns the complete mapping.

Value

If country is NULL, returns a named character vector where names are country codes and values are region names. If country is provided, returns the corresponding region(s).

Examples

```
# Get all mappings
head(get_country_codes())

# Look up specific countries
get_country_codes(c("USA", "GBR", "IND"))
```

---

get_regions *Get Available Region Names*

Description

Returns a character vector of valid WHO/GBD region names that can be used with the risk calculation functions.

Usage

```
get_regions()
```

Value

Character vector of 21 GBD region names.

Examples

```
get_regions()
```

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