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# Supplementary appendix 1

This appendix formed part of the original submission and has been peer reviewed. We post it as supplied by the authors.

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# Supplementary Appendix 1

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# Supplementary Methods

**Search string and screening details**

**Sample search string**

Database: Web of Science

Date of search: initial search 06.12.2019, updated 06.13.2023 for years 2020-2023.

The following keywords were provided to the research librarians by the review coordinator and adapted to each database: Mortality, mortality rate, all-cause mortality, total mortality, death, longevity, survival, life expectancy, Education, educated, educational attainment, education level, socio-economic status, socioeconomic, socioeconomic status, social class, disparities, differences, social inequalities, income, income inequalities, occupation, occupational position, socioeconomic position, occupational inequalities, health inequalities, health equity, schooling, literate, literacy, graduation, years of school, school attendance, diploma, educational status, social status, educational, ethnicity, employment, gender, emigrants, immigrants, poverty, geography, marital status

ALL (education OR educated OR "educational attainment" OR educational OR "educational attainment" OR "education level" OR "socio-economic status" OR socioeconomic OR "socioeconomic status" OR "social class" OR disparities OR differences OR income OR occupation OR "occupational position" OR "occupational inequalities" OR "social inequalities" OR "socioeconomic position" OR "health inequalities" OR "health equity" OR inequalities OR equity OR schooling OR literate OR literacy OR graduation OR "years of school" OR "school attendance" OR diploma OR "educational status" OR "social status" OR ethnicity OR employment OR gender OR emigrant* OR immigrant* OR poverty OR geography OR "marital status") W/10 ( mortality OR "mortality rate" OR "all-cause mortality" OR "all-cause mortality" OR "total mortality" OR death OR longevity OR survival OR "life expectancy") AND PUBYEAR > 1979

**Search string quality**

To test the quality of the search string, titles returned by the initial search were compared to a list of 31 selected articles that complied with our inclusion criteria. Approximately 80% of these test studies were present in the final database selected for systematic review

**Supplementary Table 1. Inclusion and exclusion criteria for systematic review**

| | Inclusion criteria | Exclusion criteria |
|---|---|---|
| **Sample** | No limitations based on the population sample characteristics or size | Studies not providing an accurate sample size for the relevant data |
| **Phenomenon of interest** | Effect measures of adult mortality (individuals 18 years and older) by education level | |
| ***Outcome*** | All-cause mortality | Cause-specific mortality |
| ***Measure of education*** | Literacy status, years of education, or education level | Unclear definitions of education categories.<br>Different education exposures (eg, general vs vocational) with the same number of years or overlapping years of education |
| **Design** | Retrospective cohort<br>Prospective cohort<br>Cross-sectional<br>Case-control<br>Randomised controlled trial<br>Non-randomised controlled trial<br>Non-randomised trial | Case-crossover<br>Ecological |
| **Evaluation** | *Data:* Study utilized individual level data on education and mortality<br>*Measures:*<br>Relative risk<br>Hazard ratio<br>Odds ratio<br>Rate ratio<br>Minimum descriptive data | *Data:* Aggregated-level, country-level, rounded effect sizes or neighbourhood-level only<br>*Measures:*<br>Standardised incidence ratio only<br>Standardised mortality ratio only<br>Time-to-event ratio only<br>Incidence only<br>Risk difference only<br>Relative index of inequality |

| | | |
|---|---|---|
| | | Concentration index |
| **Research type** | Any academic publication (research articles, reviews, etc.) containing quantitative data | Commentaries, editorials, and letters |
| *Criteria are grouped based on the SPIDER model (Sample, Phenomenon of Interest, Design, Evaluation and Research Type* | | |

**Languages used in full reading stage**

French, Spanish, Norwegian, Swedish, Portuguese, German, English, Romanian, Korean, Japanese

**Screening and exclusions**

**Supplementary Table 2. Studies excluded during screening**

| Reason for exclusion | Number of studies |
|---|---|
| **Total excluded studies at full-text screening** | 1154 |
| **No mortality** | 92 |
| **Cause-specific mortality only** | 62 |
| **No individual level** | 51 |
| **No education** | 652 |
| **Wrong effect measure** | 128 |
| **No adults** | 47 |
| **Study design** | 8 |
| **Publication type** | 22 |
| **Definition of education** | 8 |
| **Full article not found** | 25 |
| **Systematic reviews, meta-analysis, scoping review, narrative review, etc.** | 74 |

**Supplementary Table 3. Studies excluded post-full text screening**

| Study | Reason for exclusion |
|---|---|
| Kannan VD, Brown TM, Kunitz SJ, Chapman BP. Political parties and mortality: The role of social status and personal responsibility. Soc Sci Med. 2019 Feb; 223:1-7. | Dose–response form effect measure with underlying 12 categories of education shown, upon review were unable to determine lower reference category for standardisation. |
| Elstad JI, Dahl E, Hofoss D. Skjev inntektsfordeling og geografiske forskjeller i dødelighet [Skewed income distribution and geographical mortality differences]. Tidsskr Nor Laegeforen. 2005 Nov 17;125(22):3082-4. Norwegian. | Dose–response form effect measure with underlying education in five-part scale – from higher university education (code 0) to primary school (code 4), in the model '0 = high, 4 = lowest', upon review unsure about reference category and unable to standardise. |
| Everett, B. G., Rehkopf, D. H., & Rogers, R. G. (2013). The Nonlinear Relationship between Education and Mortality: An Examination of Cohort, Race/Ethnic, and Gender Differences. Population Research and Policy Review, 32(6) | Dose–response form effect measure with unclear reference group. Additional quality concerns related to education levels and uncertainty measures presented in table 3, unable to standardise. |
| Sullivan, A. R. (2010). Mortality Differentials and Religion in the U.S.: Religious Affiliation and Attendance. Journal for the Scientific Study of Religion, 49(4), 740–753. | Preprint and/or duplicate of study by same author, published later date, which is included. |

**Analysis methods and displaying of data**

**Standardising and displaying non-standard data**

Select studies with ages less than 18, but greater than 15, were grouped with 18 years of age to optimise data coverage. List of studies affected:

1. Yang K, Zhang Y, Saito E, Rahman MS, Gupta PC, Sawada N, et al. Association between educational level and total and cause-specific mortality: a pooled analysis of over 694 000 individuals in the Asia Cohort Consortium. BMJ Open. 2019;9(8):e026225.
2. Chaisson RE, Keruly JC, Moore RD. Race, sex, drug use, and progression of human immunodeficiency virus disease. N Engl J Med. 1995;333(12):751-6.
3. Nikoi CA, Odimegwu C. The association between socioeconomic status and adult mortality in rural Kwazulu-Natal, South Africa. Oman Med J. 2013;28(2):102.
4. Razzaque A, Carmichael GA, Streatfield PK. Adult mortality in Matlab, Bangladesh: levels, trends, socio-demographic differentials and causes of death. Asian Population Studies. 2009;5(1):85-100
5. Bopp M, Braun J, Gutzwiller F, Faeh D, Swiss National Cohort Study G. Health risk or resource? Gradual and independent association between self-rated health and mortality persists over 30 years. PLoS One. 2012;7(2):e30795.
6. Weitoft GR, Rosén M. Is perceived nervousness and anxiety a predictor of premature mortality and severe morbidity? A longitudinal follow up of the Swedish survey of living conditions. J Epidemiol Community Health. 2005;59(9):794-8.
7. Batty GD, Shipley MJ, Mortensen LH, Boyle SH, Barefoot J, Gronbaek M, et al. IQ in late adolescence/early adulthood, risk factors in middle age and later all-cause mortality in men: the Vietnam Experience Study. J Epidemiol Community Health. 2008;62(6):522-31.
8. Wilper AP, Woolhandler S, Lasser KE, McCormick D, Bor DH, Himmelstein DU. Health insurance and mortality in US adults. Am J Public Health. 2009;99(12):2289-95.

A total of 18 studies required recalculations of effect measures from raw data. Missing or non-standard format measures of uncertainty including exact and relative p-values, non-95% confidence intervals, and otherers were transformed to standard error and 95% CIs for all effect measures. If no measure of uncertainty was given, standard errors were estimated utilising information on study sample size and other sample-size standard error relationships in the input dataset.

Education exposures or reference values that were given only as relative measures were transformed to closed categories by top-coding to 18 years of education, eg, >6 was changed to 7 to 18. Studies reporting education level as 'illiterate' were assigned 0 years of education, and 'literate' the range of 1 to 18 years of education. Any descriptions utilising standard description of degrees or school levels were transformed to numerical categories using the International Standard Classification of Education (ISCED).

Dose–response estimates (effect per year of education) were reported in 78 studies and were the only measures reported in 62 studies. The underlying exposure range, when known, was used to convert these continuous exposure measures to categorical exposures, and the effect sizes and uncertainty were adjusted accordingly.

Additional manipulations to reported uncertainty were required to ensure that effect measures calculated on the same underlying population were not over-weighted in our model. These studies tended to be from high-income populations, where authors reported effect measures from multiple model versions (for example, with varying adjustment factors). To not overly weight these various models, we calculated $SE_{adj}$, or the adjusted standard error using the following equation:

$$SE_{adj} = \sqrt{\frac{SE_{orig}}{Rep_n}}$$

Where:

- $SE_{orig}$ is the original standard error of the effect measure
- $Rep_n$ is the effective similarity of the measures, equivalent to the number of times a population was repeated across effect measures within the study

**Displaying nonstandard data**

For data display purposes, in some of the following figures we represent each effect size as the relative risk or log-space relative risk of adult all-cause mortality per year of education. This is necessary as the included studies had inconsistent referent exposure categories and were thus incomparable when viewed in normal, unadjusted space (i.e., one study may report a relative risk with respect to 0 years of education while another may report a relative risk with respect to completed secondary education). This is consistent with the above treatment of the data by the model. The abbreviated method for normalizing this data for visualization purposes divides the effect size by the distance between the midpoints of the referent and alternate exposure windows as follows:

$$\frac{Log(RR)}{Year\ of\ Schooling} = \frac{Log(RR)}{(ref_{lower} + ref_{upper} + alt_{lower} + alt_{upper})/4}$$

**Equations**

For the meta-analysis, we included random intercepts for studies so that multiple effect sizes from the same study did not drive results unnecessarily. There was enormous heterogeneity in reported relative risks for mortality across studies and exposure values. Accordingly, and consistent with other uses of this tool 10% of outliers were trimmed. The model took the following form:

$$y = \left(X_{alt} - X_{ref}\right) \times (X_{cov}\beta_{cov} + \beta + \mu)$$

Where:

- $y$ is the log(relative risk)
- $X_{alt}\ and\ X_{ref}$ are midpoints for alternative and reference intervals for the exposed and unexposed groups measured in the relative risk effect measure
- $X_{cov}$ is a design matrix containing covariates we control for (age, sex, marital status)
- $\beta_{cov}$ are covariate multipliers associated with $X_{cov}$ (covariate::education interaction)
- $\beta$ gives estimates of effect size (effect of unit of education on log relative risk)
- $\mu$ is a study specific random effect

Specifically, we used a random intercept in the mixed-effects model to account for the within-study correlation and used an estimated study-specific random slope with respect to the signal to capture between study heterogeneity. We utilised Fisher's information matrix[1] to estimate uncertainty of the heterogeneity, reported in supplementary table 5.

# Supplementary Results

### Study exposure and reference categories

Education exposure and reference categories were variable across our input data by region, mirroring the underlying educational attainment of the populations. Accordingly, studies from low socio-demographic index areas were more likely to examine the impacts of educational attainment at the primary and secondary school level, whereas high-income areas were more likely to examine the impacts of primary versus secondary or tertiary schooling [Supplementary figure 1]. This compositional bias is significant but was addressed in our modelling framework by allowing the impact of the covariates to vary by education exposure level.

### Exploration of study-level covariates

We observed vast differences in the relative prevalence of different study-level controls across regions [Supplementary Figure 2]. These stark gradients reflect both the differences in theoretical mediation pathways for the effect of education on mortality risk across different contexts, and more practically the presence of high-quality linked datasets and other compositional data across regions available to researchers. Patterns of confounder availability and the underlying pathways being studied across the world have implications on our ability to model a global relationship. We opted to utilise only confounders that both have theoretically consistent impacts globally and had sufficient coverage across all regions and Socio-demographic Index (SDI) values present in our input data. Accordingly, the selected confounders included in the model were relatively prevalent across each region and SDI group.

### Impact of confounders

The relative change in the predicted relationship between education and adult mortality with and without including individual study-level controls reveals the importance of correcting for age, sex, and marital status. Supplementary figure 3 shows the input data stratified by each of these measures, as well as the average RR change over entire exposure range (1−18 years) for each of these study-level controls, relative to predictions with no study-level controls. Controlling for marital status produces the strongest attenuating effect. We hypothesised a portion of the attenuation in effect of education and mortality when controlling for marital status reflects the impacts of income. Marital status and income (or wealth) have similar and overlapping pathways as mediators[2] since marriage likely increases access to resources and can contribute both a social and financial protective effect.

### Effect monotonicity

Supplementary Figure 4 and 5 show the normalised effect sizes extracted from the systematic review and the midpoints of the exposure and referent categories for each extracted effect size as an approximation of the instantaneous slope of the relative risk curve implied by each extracted effect size. This visual provides evidence for the monotonicity of the dose–response relationship between education and adult mortality (ie, the slope of the aggregate relative risk curve is negative across the entire age range, different education exposure ranges, and regions). This approach is complicated by each point having been approximated with a different set of confounders; however, the majority are controlled for at minimum by age or sex.

### Supplementary Table 4. Reduction in adult mortality by schooling level

**Supplementary Table 4.** Percent reduction in mortality across each model and level of schooling.

| Model | 6 Yrs. Of Schooling | 12 Yrs. Of Schooling | 18 Yrs. Of Schooling |
|---|---|---|---|
| Global – All age, both sexes | 13.08% (12.22-13.97) | 24.45% (22.93-26) | 34.34% (32.34-36.35) |
| Age 18 to 49 | 21.77% (20.58-22.92) | 38.74% (36.86-40.54) | 51.99% (49.77-54.08) |
| Age 50 to 59 | 15.55% (14.65-16.44) | 28.68% (27.14-30.18) | 39.76% (37.8-41.66) |
| Age 60 to 69 | 12.24% (11.36-13.14) | 22.97% (21.41-24.56) | 32.39% (30.32-34.48) |
| Age 70+ | 5.19% (3.9-6.47) | 10.01% (7.51-12.46) | 14.49% (10.87-17.98) |

**Supplementary Table 5. Coefficients from meta-analysis.** Education was modelled as a continuous variable, and all interactive variables are operationalised as such. All variables aside from the main exposure and age are binary variables that interact with continuous education and capture study-level qualities alone.

| | Model coefficients |
|---|---|

| | |
|---|---|
| Exposure | |
| Education, years | –0·071 (–0·075 to –0·067) |
| Study-level covariates | |
| Adult sex:education | 0·0027 (0·0015 to 0·0038 |
| Adult age:education | –0·0020 (–0·0027 to –0·0013) |
| Adult marital status:education | 0·009 (0·008 to 0·009) |
| Other covariates | |
| Study population age:education | 0·00064 (0·00057 to –0·00070) |
| Between-study heterogeneity | |
| Random slope (γ) estimated from between-study random effects | 0·00025 (0·00022 to 0·0003) |

**Sensitivity analyses of impacts of education on adult mortality by age, SDI, sex, time and cohort**

Several analyses were conducted to further clarify the effect of education on mortality risk across dimensions of interest. We would expect to see consistency in the relative relationship between education and mortality risk across dimensions of interest both when fitting the model on a subset of the data by group, and by fitting the model on the entire dataset utilising covariates of interest. While the latter is shown in the main article, we include our results utilising the former here to explain the process of selecting or excluding potential covariates of interest.

Age sensitivity analysis

In contrast to the results in [main paper figure 4], Supplementary figure 7 displays results estimated by splitting the input data into four groups and running models separately for each age group, controlled for by the same standardised covariates (minus age). The results confirm the relative order and magnitude of the effects shown in the main paper indicating that age has a stable modifying effect on the outcome of interest.

Effects of education across SDI groups

We examined whether there was evidence of a differential effect of education on mortality risk across different SDI groups, as determined by the SDI level of the study location in the mean study year [Supplementary figure 8]. We were unable to reproduce consistent findings by SDI group utilising the two methodologies. We observed differential impacts of education by SDI category across both methods of analysis described above when characterising by SDI gradient (quintiles) and while utilising SDI as a binary variable indicating high/low SDI level.

The effect of education in the lower SDI group was sometimes greater and sometimes attenuated relative to high SDI, and the direction of this effect was dependent upon on the cut-off point for high/low SDI (at 0.5, 0.6, 0.66 [global mean for 2022], 0.75 [mean of our data], or 0.8). There may be several reasons driving this pattern, including the sparsity of available data in low SDI countries relative to high SDI locations and the variable education exposures available within each group. Our findings could indicate an exaggerated effect of education at low SDI, but one that attenuates quickly over mid ranges of SDI. Given that the effect of SDI was unstable and sensitive to model specification, we opted to exclude it from our models. However, this lack of clear relationship deserves careful exploration in future analyses.

Effects of education across sexes

Of the 10335 observations included in our final dataset, 29.2% and 30.1% were from entirely female or male population, respectively, when matched on location. The effect of education on each sex was not significantly different when utilising all locations; however, the effect was greater in males when looking in high-income regions only (Supplementary figure 9)

Effects of education across time and cohort

We examined whether there was evidence of a differential effect of education on mortality risk across different time periods [Supplementary figure 10 top], as determined by median year of the study (some of which spanned many years), grouped into 1893-1989,1990 to 1999, and 2000-2022 periods. The distribution of data within these categories is below. This analysis shows that there is a stable relationship between education and mortality across different time periods, as well as stable age patterns in mortality.

Further, we explored the relationship between education and mortality across different birth cohorts [Supplementary figure 10, bottom], as determined by median age group of the study subtracted from the median year of the study, grouped into

1870-1929 cohort, 1930-1949 cohort, and the 1950-1990 cohort. While it is challenging to draw clear conclusions about age-pattern and cohort due to differing distributions of ages across each cohort (no older individuals in recent cohort), the results do demonstrate that there remains stable age-patterns in mortality across all cohorts It appears that inequalities in mortality are greater for more recent cohorts compared to oldest cohorts, and this disparity is clearest in the youngest age-group of our analysis, and less clear in other groups. This increased disparity is likely influenced by changing educational attainment distributions across time, as population-level attainment increases the inequality associated with lesser education increases. However, when considering these cohort-effects alongside the lack of period-effects, and stable age patterns, we conclude that if anything, by not disaggregating or controlling for cohort we may be underestimating the effect of education for more recent cohorts.

| Time group | 1893-1989 period | 1990 to 1999 period | 2000-2020 period |
|---|---|---|---|
| Proportion of all data | 0. 21 | 0.47 | 0.31 |
| Cohort group | 1870-1929 cohort | 1930-1949 cohort | 1950-1990 cohort |
| Proportion of data | 0.32 | 0.51 | 0.17 |

Study representativeness sensitivity analysis

Of the 10 355 observations in our dataset, 46.78% are representative of the geography. Others may be representative of an age, sex, or other sub-group of the geography such as city. To ensure that non-representative observations did not affect the final analysis, we conducted the entire estimation process only with studies that are representative of the geography in which they took place and found that the results did not change significantly. In our main results we have included these studies, but we also find that studies from sub-group analyses make up the majority (87%) of the data points trimmed during the outliering phase of the MR-BRT model. For these two reasons we are confident that any studies from non-representative populations do not significantly influence the effect sizes that we report on in our analyses.

**Overview of data availability and effect sizes**

Supplementary Figure 11 displays normalised relative risks per one year of education, shown for all study data separately by region. Axis labels are intentionally small, and full study titles corresponding with the y-axis value are provided in supplementary appendix 3 Key. These figures serve two purposes, one of which is to simply provide an overview of data availability and effect sizes. The second is to allow curious readers to cross-reference specific studies to see how their measured effect sizes compare to other studies' effect sizes after standardisation of exposure/reference direction and confidence intervals.

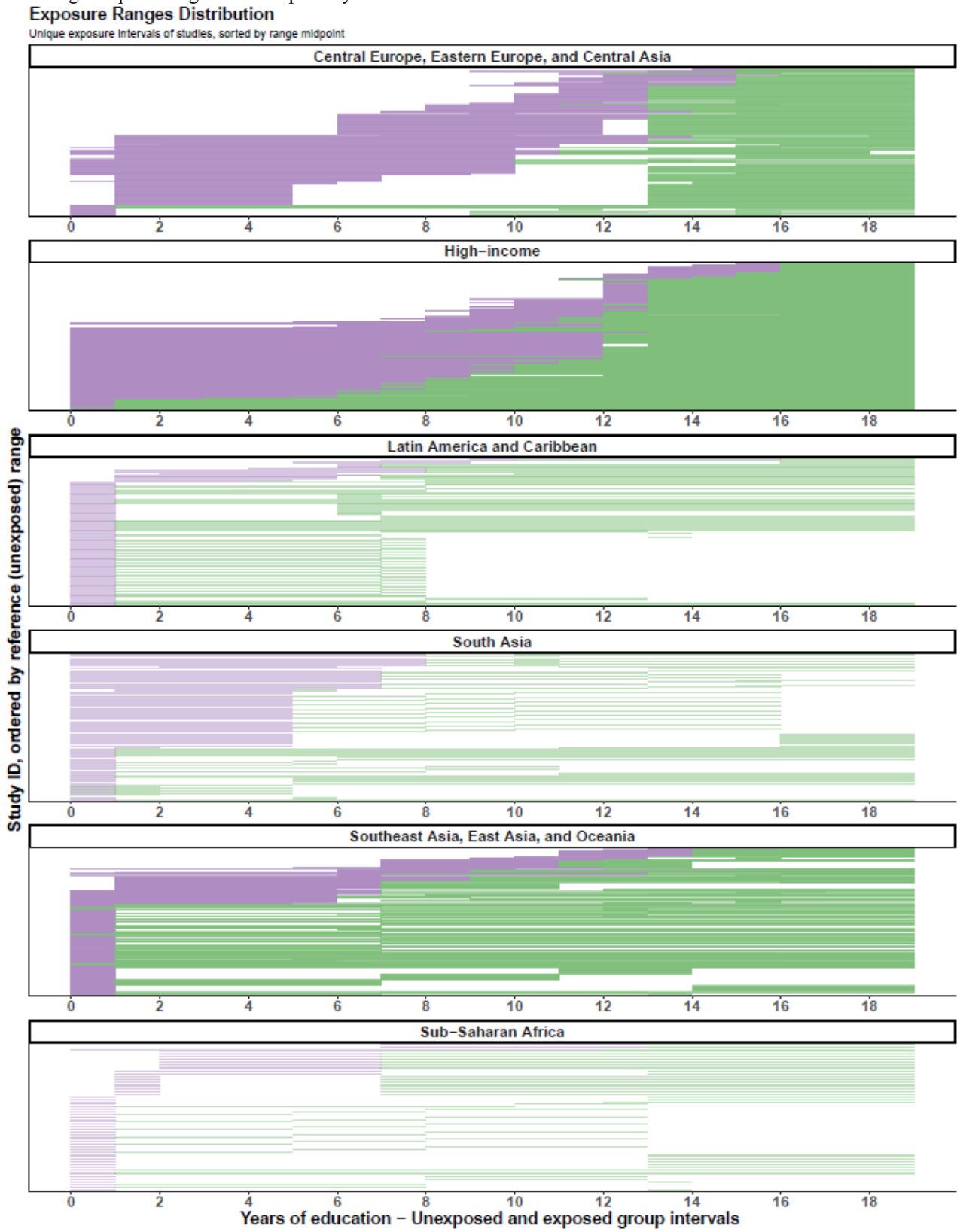
# References


1. Biggerstaff BJ, Tweedie RL. Incorporating variability in estimates of heterogeneity in the random effects model in meta-analysis. Stat Med. 1997 Apr 15;16(7):753–68.

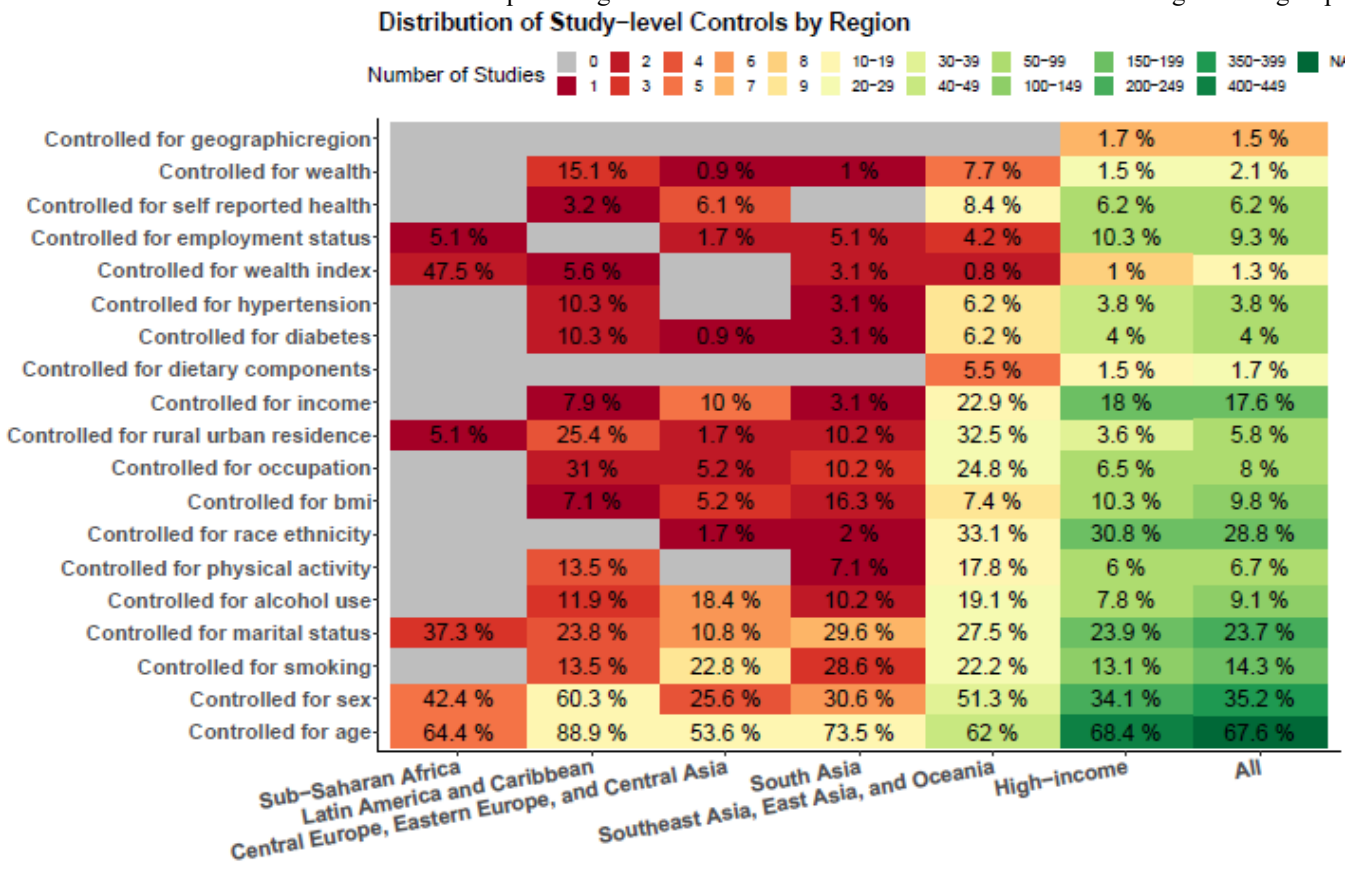
2. Robards J, Evandrou M, Falkingham J, Vlachantoni A. Marital status, health and mortality. Maturitas. 2012 Dec;73(4):295–9.

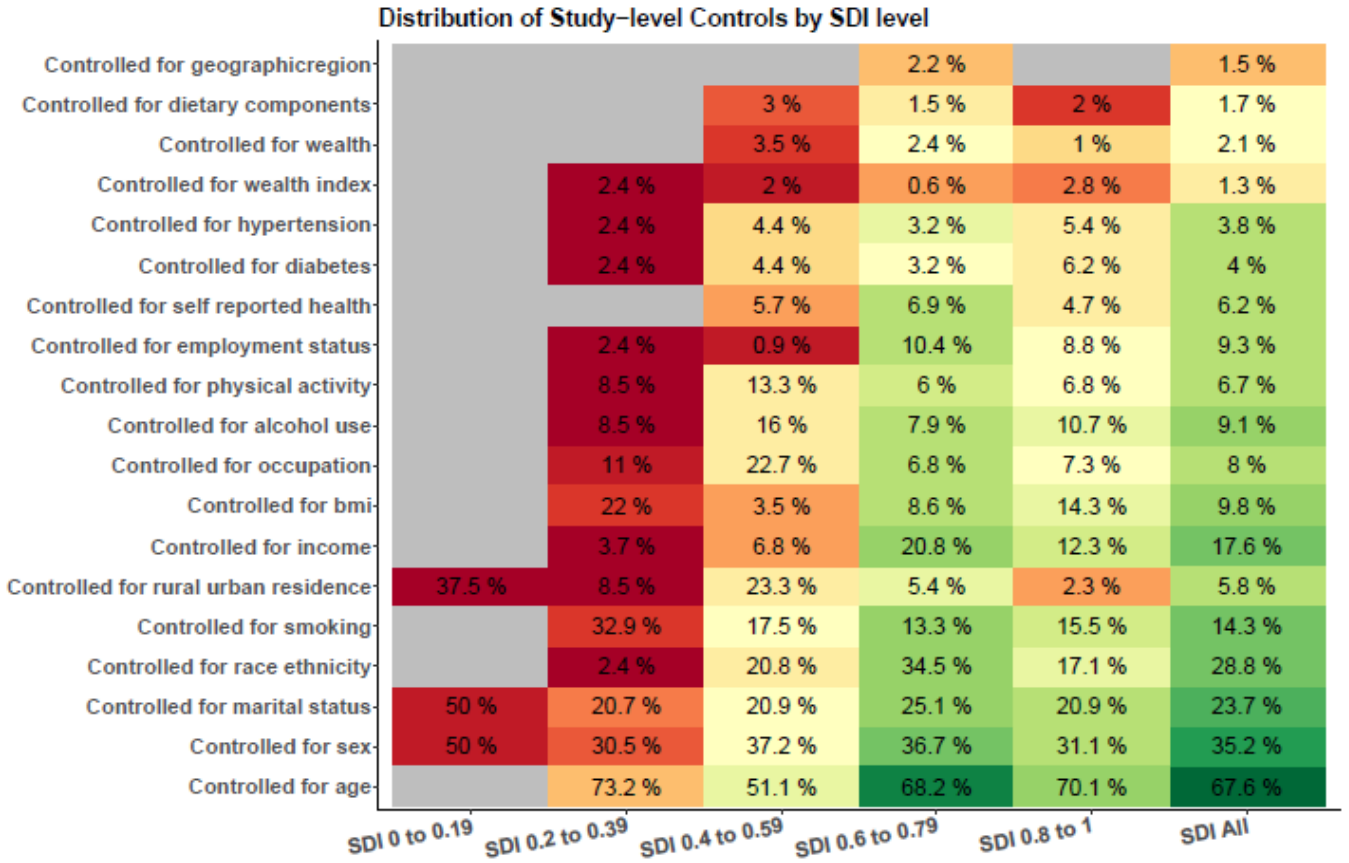

# Figures

**Supplementary Figure 1. Distribution of study-level education and reference categories by region**. Distribution of study-level education reference (purple) and exposure (green) categories, paired for each observation, by super-region. High-income and European/Asian regions typically studied the effect of education on mortality risk at higher exposure levels, eg, secondary compared to tertiary education, while other regions tended to study effect of lower exposure levels, eg, less than primary schooling compared to greater than primary-level attainment.

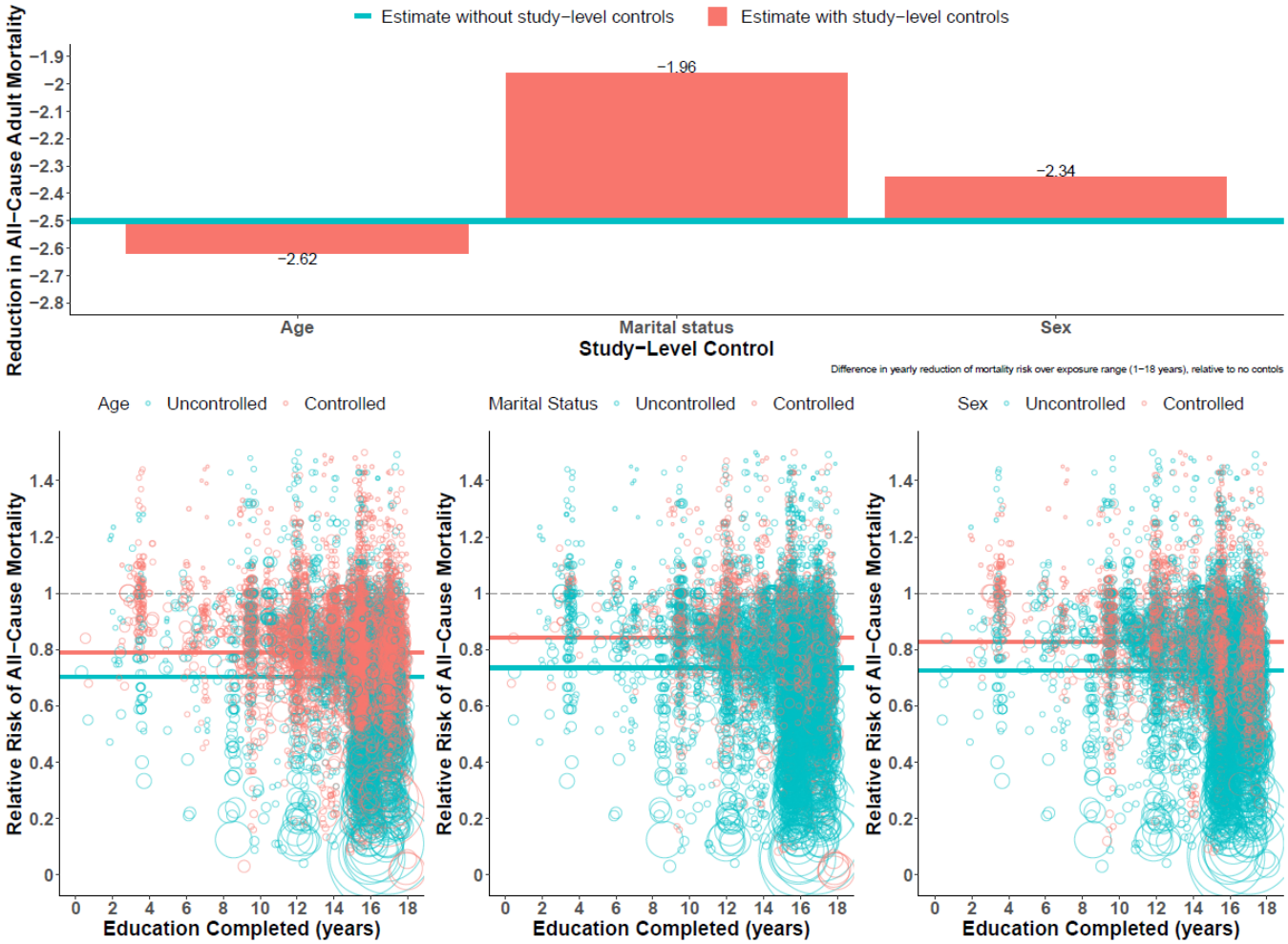


**Supplementary Figure 2. Distribution of study-level confounders.** Colour indicates the number of studies in region/SDI level that have confounder. Value indicates the percentage of observations that controlled for confounder in region/SDI group.

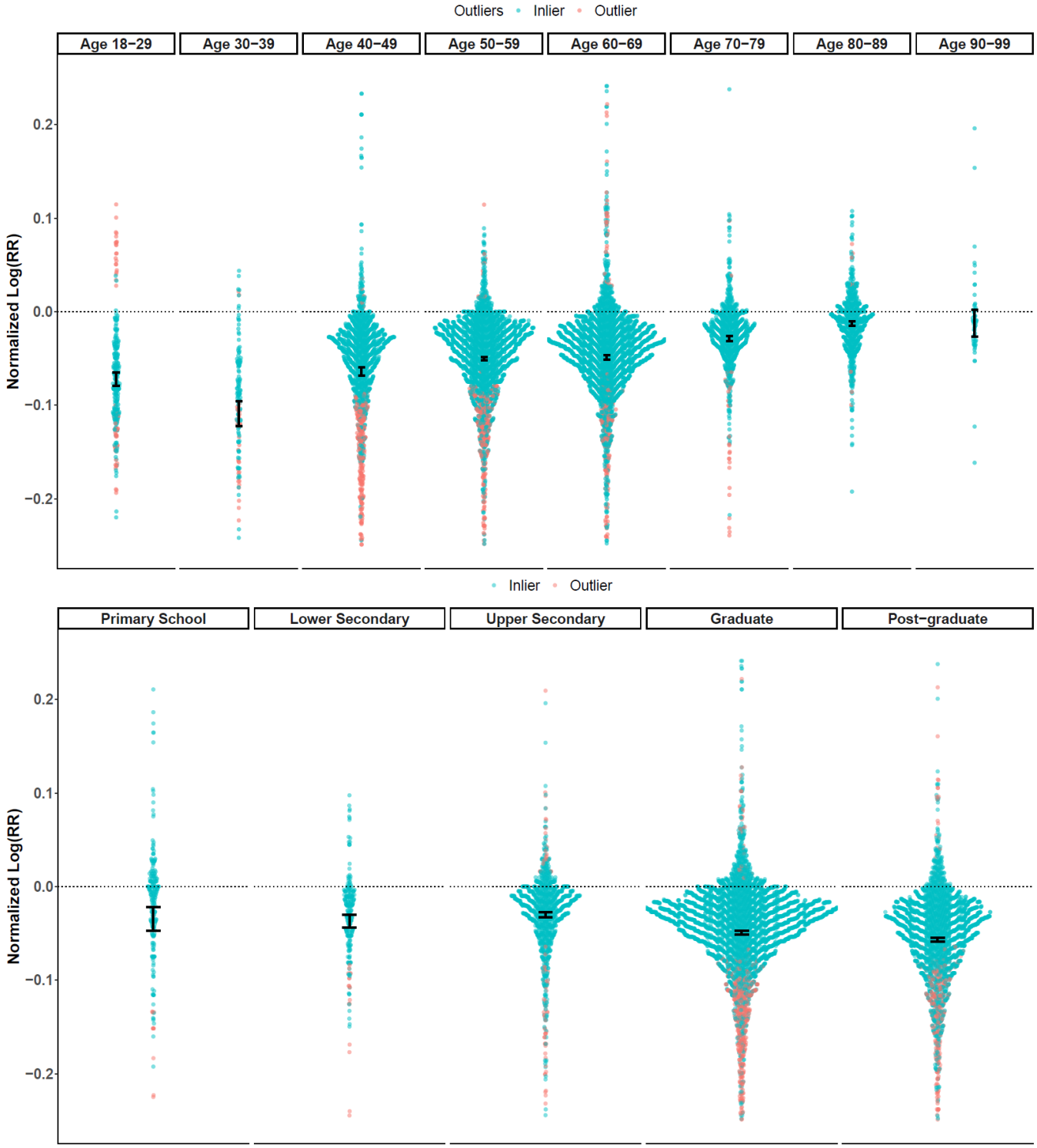


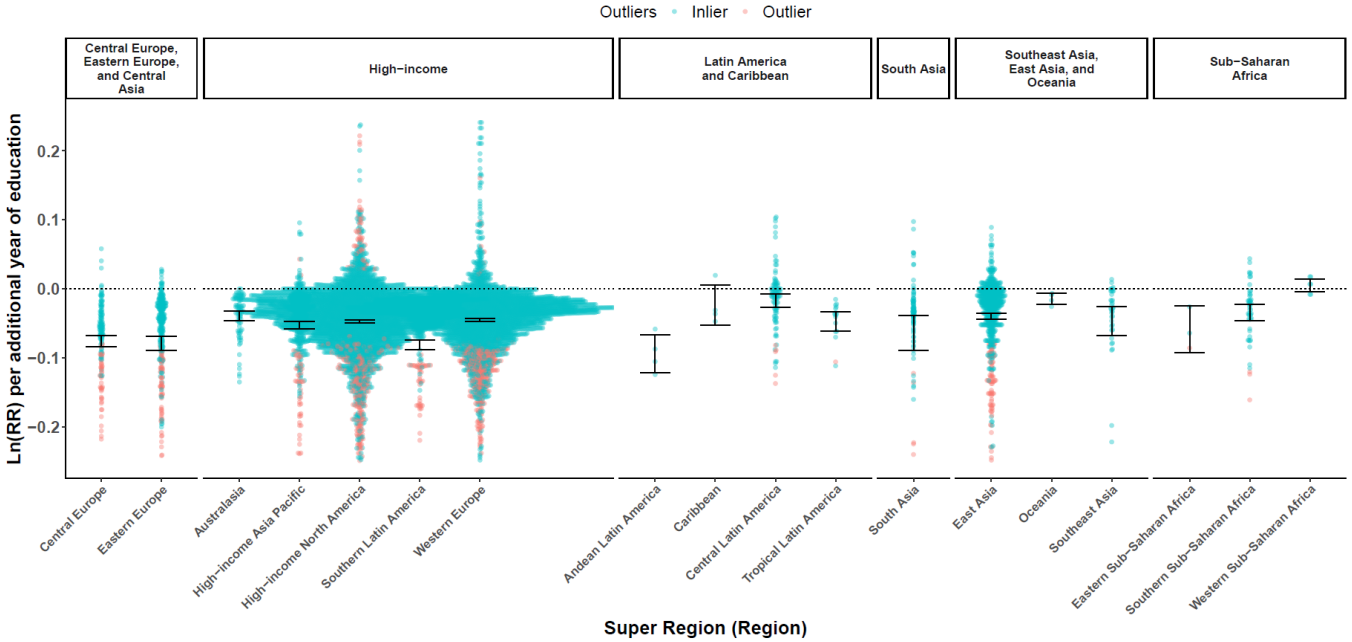
**Supplementary Figure 3. Impact of study-level controls.** Top) The average RR change over 1−18 years of education when controlling for each of three study-level controls, relative to predictions without adjusting for any study-level controls. Bottom) Scatter of effect measures across exposure range, coloured by study-level control presence with mean effect size.



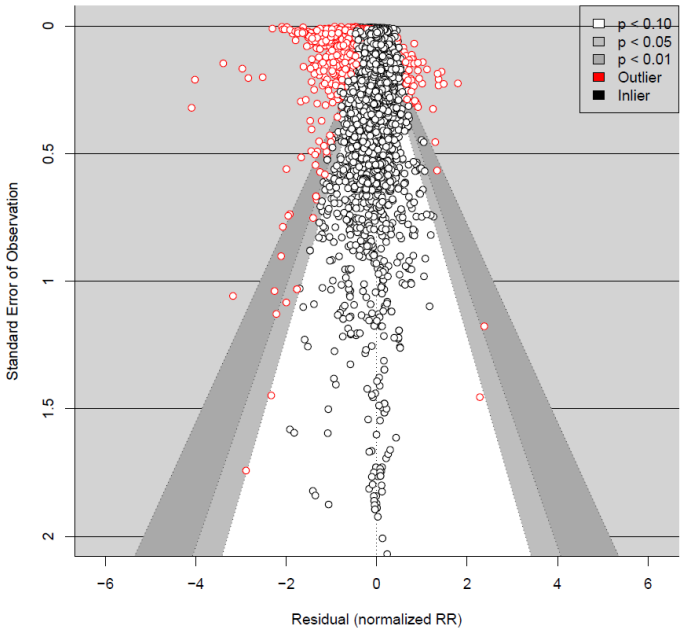
**Supplementary Figure 4. Log-space relative risk of adult all-cause mortality per year of education by age and educational group**. Effect sizes extracted from the systematic review and the midpoints of the exposure and referent categories for each were used to approximate the instantaneous slope of the relative risk curve implied by each extracted effect size, shown here in log space by top) 10-year age interval, and bottom) approximate level of schooling. Normalised ln(RR) can be interpreted as the instantaneous slope of the RR curve implied by each study; data are superimposed with a synthesised average effect size (shown in black).



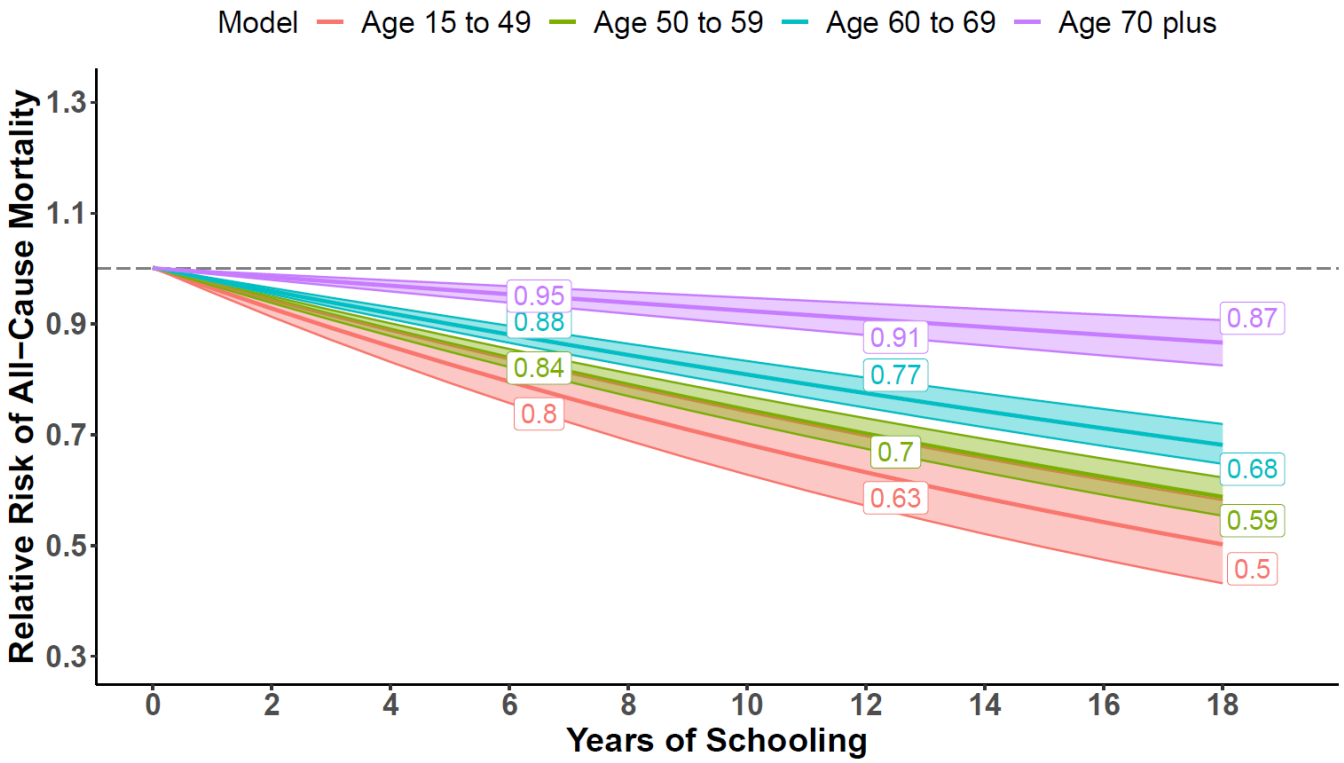
**Supplementary Figure 5. Log-space relative risk of adult all-cause mortality per year of education by region and super region.** Effect sizes extracted from the systematic review and the midpoints of the exposure and referent categories for each were used to approximate the instantaneous slope of the relative risk curve implied by each extracted effect size, shown here in log space by super-region and region. Normalised ln(RR) can be interpreted as the instantaneous slope of the RR curve implied by each study; data are superimposed with a synthesised average effect size (shown in black).



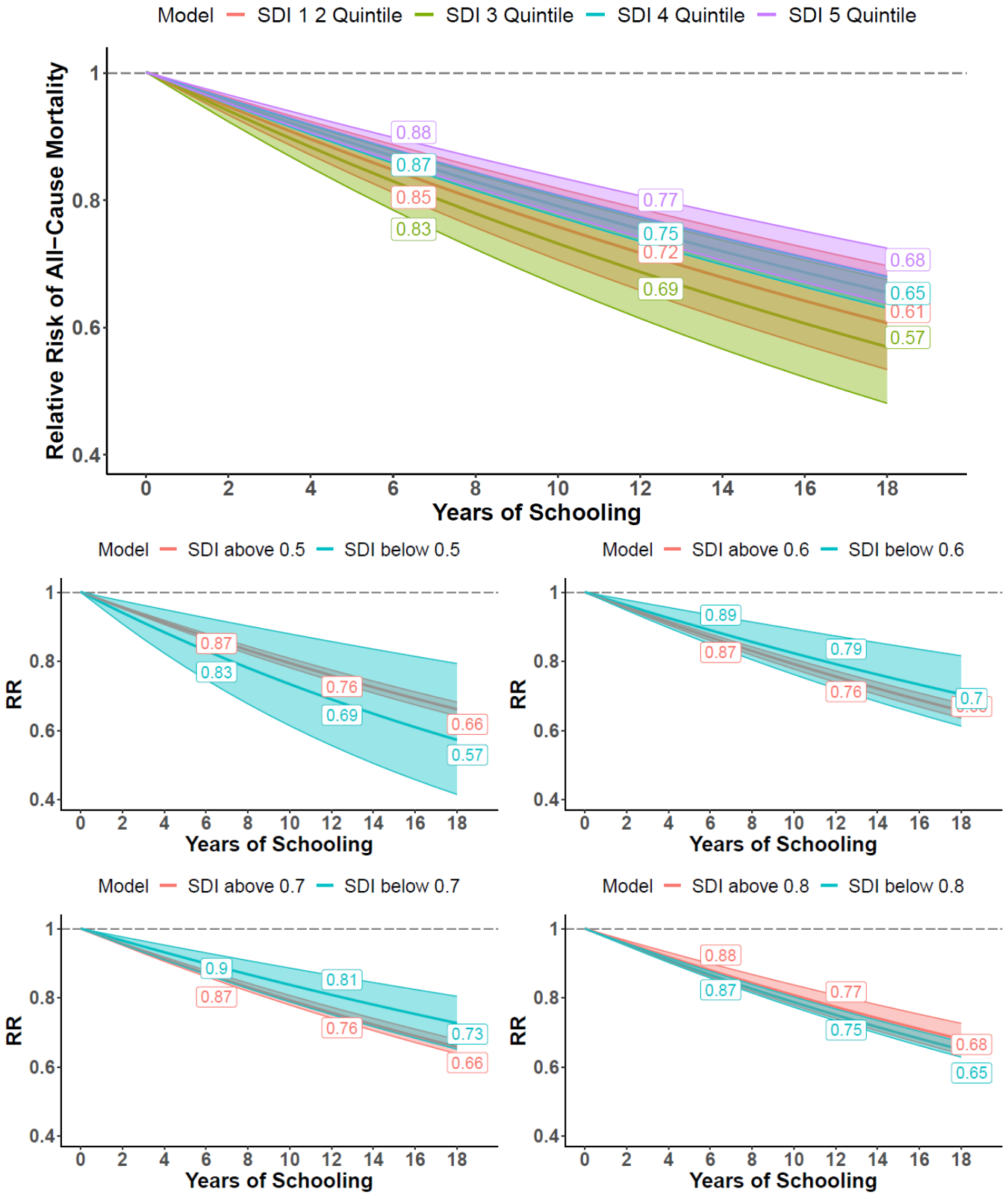

**Supplementary Figure 6. Funnel plots of effect sizes extracted in systematic review.** Funnel plots show how the effect sizes of RRs from individual studies systematically vary according to the SE of their observations. The residuals are defined as the normalised RR of the study minus the global model fit. Many studies outside of the funnel would indicate study-level heterogeneity and indicate more deviation from the average effect size than would be expected from chance alone. RR=relative risk.

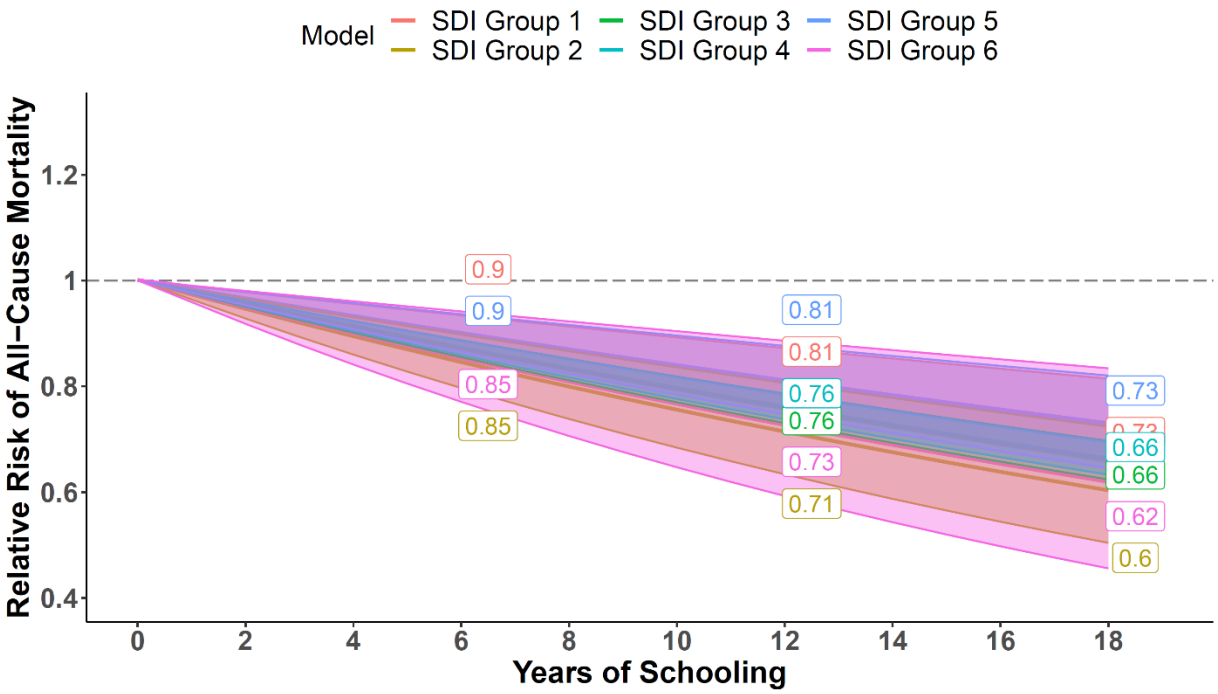


**Supplementary Figure 7. Age-group sensitivity analysis.** Data were subset by age group and a model was fit utilising the same standard covariates (sex, marital status) without age.

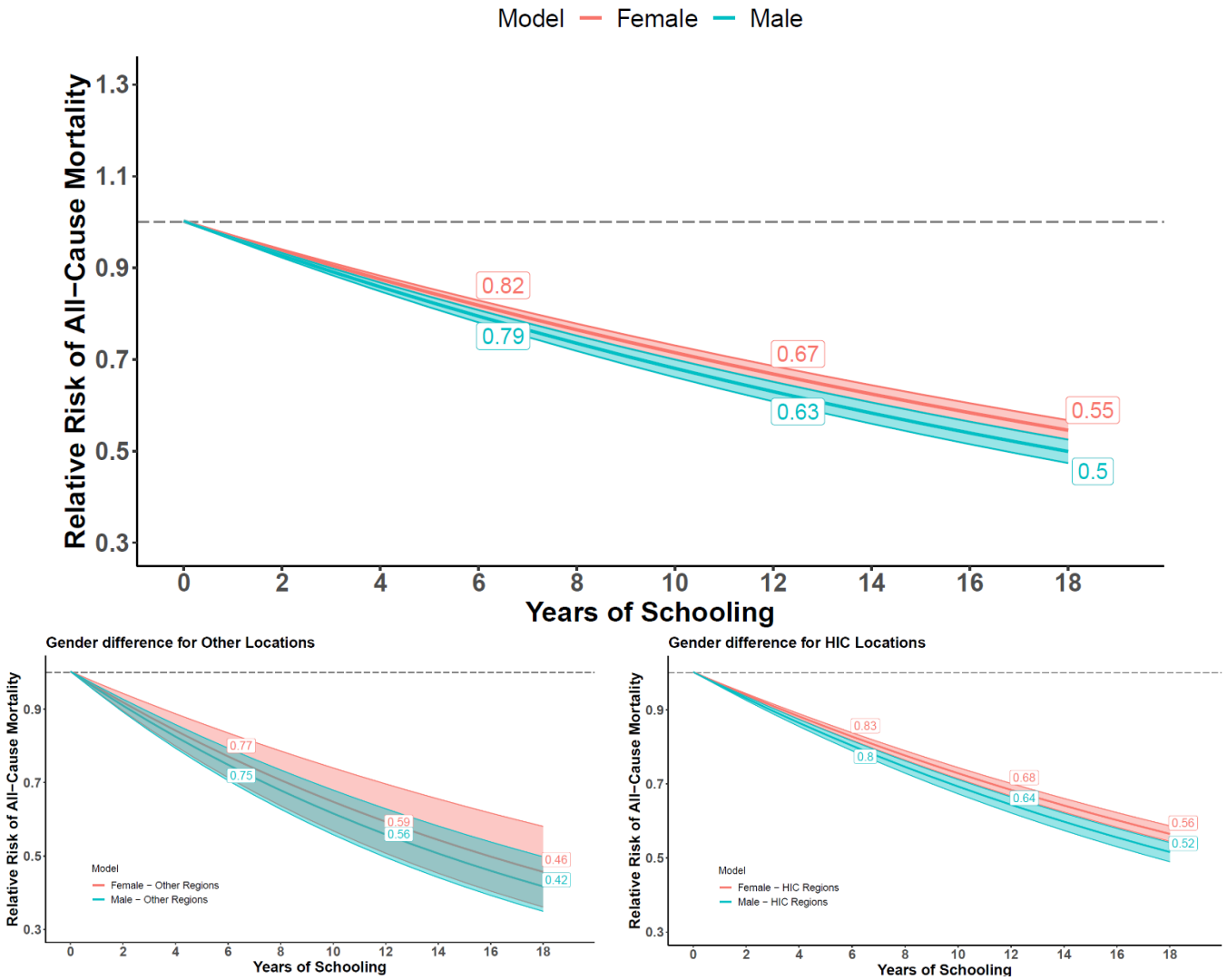


**Supplementary Figure 8. SDI specification sensitivity analysis.** Data were subset by SDI group and a model was fit utilising the same standard covariates (age, sex, marital status). **Top)** results from subsetting into SDI quintiles (with SDI quintile 1 and 2 combined due to data availability). **Middle)** results from subsetting the data into high/low SDI groups utilising different breakpoints. **Bottom)** results from subsetting the data into groups (1) 0 to <0.7, (2) 0.7 to <0.74, (3) 0.74 to <0.78, (4) 0.78 to <0.82, (5) 0.82 to <0.86, (6) 0.86 to <0.895.

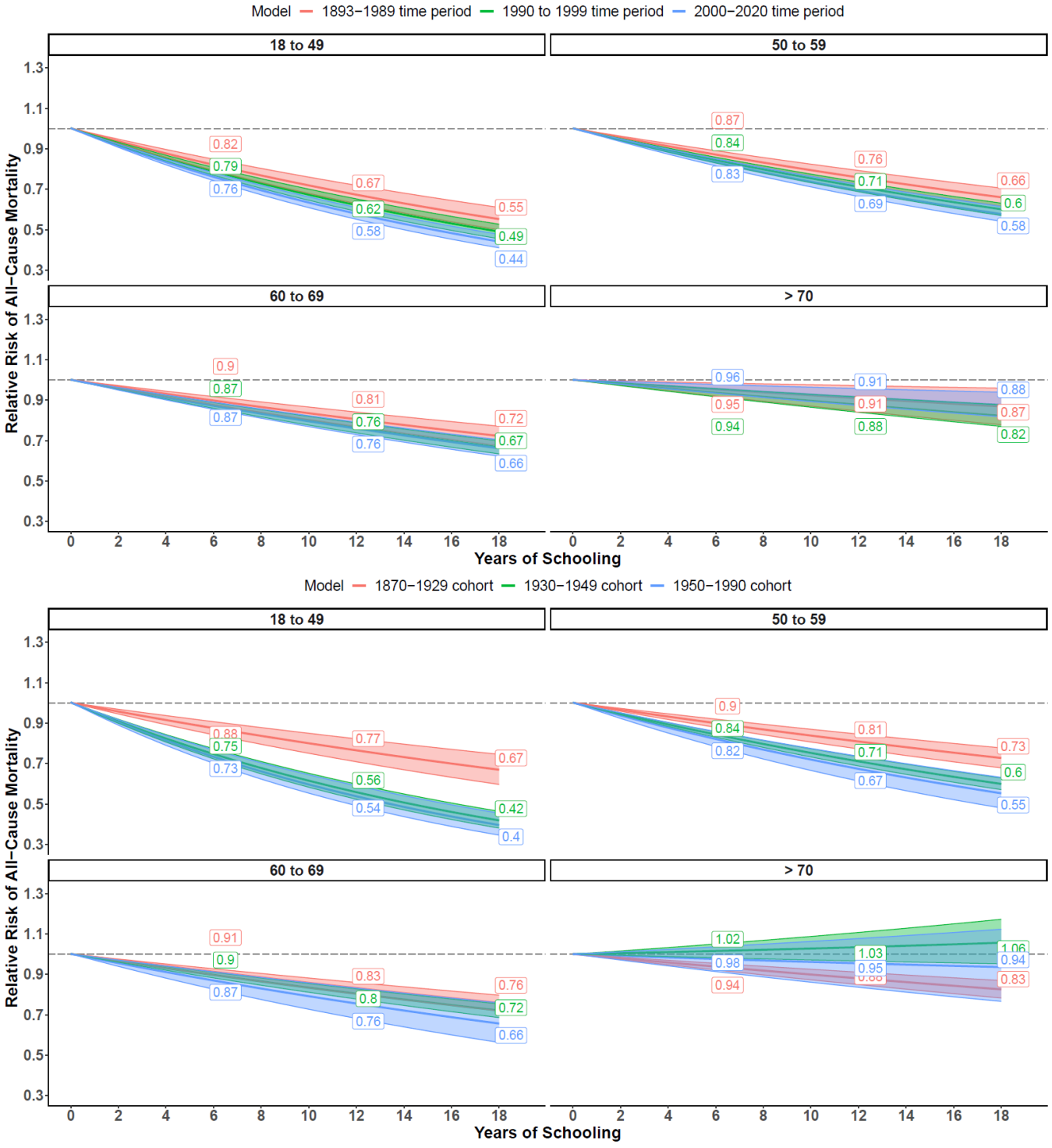



Model
SDI Group 1
SDI Group 2
SDI Group 3
SDI Group 4
SDI Group 5
SDI Group 6
Relative Risk of All−Cause Mortality
1.2
1
0.8
0.6
0.4
0
2
4
6
8
10
12
14
16
18
Years of Schooling
0.9
0.9
0.85
0.85
0.81
0.81
0.76
0.76
0.73
0.71
0.73
0.66
0.66
0.62
0.6

**Supplementary Figure 9. Relationship between education and adult mortality by sex.** Models were run separately by sex and are controlled for by age only (not marital status or sex). Results are shown from fitting models on entire input dataset (top), high income-region only (left) or all other regions combined (right).



**Supplementary Figure 10. Cohort and Period sensitivity analysis.** Relationship between education and adult morality by time period (top) and cohort (bottom), additionally stratified by age-group. Models were run separately by time-period or cohort groups calculated from average age and study year, and are controlled for by marital status and sex.



**Supplementary Figure 11. Normalised relative risks per one year of education, shown for all study data separately by super-region and region.** [End of Document] Normalised relative risks per one year of education, shown for all study data separately by super-region and region. Colour indicates whether the effect measure was automatically trimmed in the global model. Full study titles corresponding with axis label are provided in the supplementary Appendix 3.csv.

# Checklists

**Table 6. Guidelines on Accurate and Transparent Health Estimate Reporting (GATHER) checklist**

| Item # | Checklist item | Reporting location |
|---|---|---|
| Objectives and funding | | |
| 1 | Define the indicator(s), populations (including age, sex, and geographic entities), and time period(s) for which estimates were made. | Main text methods, page 2-3 & appendix pp 4 |
| 2 | List the funding sources for the work. | Abstract and Main text Funding section, page 10 |
| Data Inputs | | |
| For all data inputs from multiple sources that are synthesized as part of the study: | | |
| 3 | Describe how the data were identified and how the data were accessed. | Main text Methods, pages 2-5 |
| 4 | Specify the inclusion and exclusion criteria. Identify all ad-hoc exclusions. | Main text Methods includes overview of criteria on appendix page 4. Supplementary Table 2 incudes detailed inclusion and exclusion criteria. Supplementary Appendix 1 table 3 includes details on exclusions from PRISMA diagram and additional details on criteria. |
| 5 | Provide information on all included data sources and their main characteristics. For each data source used, report reference information or contact name/institution, population represented, data collection method, year(s) of data collection, sex and age range, diagnostic criteria or measurement method, and sample size, as relevant. | Main text results page 5 and 6, Supplementary table 1 pp4, supplementary appendix 2 (all raw data) and supplementary appendix 1 includes all included study citations. |
| 6 | Identify and describe any categories of input data that have potentially important biases (e.g., based on characteristics listed in item 5). | Results section pp 5-7, details in supplementary appendix 1. |
| For data inputs that contribute to the analysis but were not synthesized as part of the study: | | |
| 7 | Describe and give sources for any other data inputs. | Sociodemographic estimates from the Institute for Health Metrics and Evaluation were utilized, citation: Wang H, Abbas KM, Abbasifard M, Abbasi-Kangevari M, Abbastabar H, Abd-Allah F, et al. Global age-sex-specific fertility, mortality, healthy life expectancy (HALE), and population estimates in 204 countries and territories, 1950–2019: a comprehensive demographic analysis for the Global Burden of Disease Study 2019. The Lancet. 2020 Oct 17;396(10258):1160–203. |
| For all data inputs: | | |
| 8 | Provide all data inputs in a file format from which data can be efficiently extracted (e.g., a spreadsheet rather than a PDF), including all relevant meta-data listed in item 5. For any data inputs that cannot be shared because of ethical or legal reasons, such as third-party ownership, provide a contact name or the name of the institution that retains the right to the data. | Data inputs in excel format available in appendices 2-3. |
| Data analysis | | |
| 9 | Provide a conceptual overview of the data analysis method. A diagram may be helpful. | Main text methods overview, PRISMA flow diagram. |
| 10 | Provide a detailed description of all steps of the analysis, including mathematical formulae. This description should cover, as relevant, data cleaning, data pre-processing, data adjustments and weighting of data sources, and mathematical or statistical model(s). | Main text methods, supplementary appendix 1 |

| | | |
|---|---|---|
| 11 | Describe how candidate models were evaluated and how the final model(s) were selected. | Main text methods, 'Meta-regression combining data from systematic review' section, appendix 1 |
| 12 | Provide the results of an evaluation of model performance, if done, as well as the results of any relevant sensitivity analysis. | Main text results section 'disaggregated mortality risk by age group, sex, and Socio-demographic Index', and also appendix 1 supplementary results section. |
| 13 | Describe methods for calculating uncertainty of the estimates. State which sources of uncertainty were, and were not, accounted for in the uncertainty analysis. | Main text methods, 'Meta-regression combining data from systematic review' section, appendix 1 |
| 14 | State how analytic or statistical source code used to generate estimates can be accessed. | GitHub URL provided at resubmission |
| Results and Discussion | | |
| 15 | Provide published estimates in a file format from which data can be efficiently extracted. | Estimates are available in the main text |
| 16 | Report a quantitative measure of the uncertainty of the estimates (e.g. uncertainty intervals). | UIs given for all findings, including in the text and tables in the main text. |
| 17 | Interpret results in light of existing evidence. If updating a previous set of estimates, describe the reasons for changes in estimates. | Main text Discussion |
| 18 | Discuss limitations of the estimates. Include a discussion of any modelling assumptions or data limitations that affect interpretation of the estimates. | Main text Discussion |

1 **Table 7. PRISMA-E 2012 Checklist**

| Checklist of Items for Reporting Equity-Focused Systematic Reviews | | | | |
|---|---|---|---|---|
| **Section** | **Item** | **Standard PRISMA Item** | **Extension for Equity-Focused Reviews** | **Pg #** |
| **Title** | | | | |
| **Title** | 1 | Identify the report as a systematic review, meta-analysis, or both. | Identify equity as a focus of the review, if relevant, using the term equity | 1 |
| **Abstract** | | | | |
| **Structured summary** | 2 | 2. Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number. | State research question(s) related to health equity. | 1 and appendix table 1 and 2 |
| | 2A | | Present results of health equity analyses (e.g. subgroup analyses or meta-regression). | 1 |
| | 2B | | Describe extent and limits of applicability to disadvantaged populations of interest. | 2 (RIC) |
| **Introduction** | | | | |
| **Rationale** | 3 | Describe the rationale for the review in the context of what is already known. | Describe assumptions about mechanism(s) by which the intervention is assumed to have an impact on health equity. | 1-2 (intro), 7-11 (discussion) |
| | 3A | | Provide the logic model/analytical framework, if done, to show the pathways through which the intervention is assumed to affect health equity and how it was developed. | |
| **Objectives** | 4 | Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS). | Describe how disadvantage was defined if used as criterion in the review (e.g. for selecting studies, conducting analyses or judging applicability). | 1 (intro) |
| | 4A | | State the research questions being addressed with reference to health equity | 1 (intro) |
| **Methods** | | | | |
| **Protocol and registration** | 5 | Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number. | | 2 |
| **Eligibility criteria** | 6 | 6. Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale. | Describe the rationale for including particular study designs related to equity research questions. | 2 (Search strategy and selection criteria), table 1, Appendix 1 |
| | 6A | | Describe the rationale for including the outcomes - e.g. how these are relevant to reducing inequity. | |
| **Information sources** | 7 | Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched. | Describe information sources (e.g. health, non-health, and grey literature sources) that were searched that are of specific relevance to address the equity questions of the review. | (Search strategy and selection criteria), Appendix 1 |
| **Search** | 8 | Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated. | Describe the broad search strategy and terms used to address equity questions of the review. | Appendix 1 |
| **Study selection** | 9 | State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis). | | 2(Search strategy and selection criteria) |
| **Data collection process** | 10 | Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators. | | 3 (Data extraction) |
| **Data items** | 11 | List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made. | List and define data items related to equity,where such data were sought (e.g. using PROGRESS-Plus or other criteria, context). | 3 (Data extraction) |

| | | | | |
|---|---|---|---|---|
| **Risk of bias in individual studies** | 12 | Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis. | | 4-5 (Risk of Bias) |
| **Summary measures** | 13 | State the principal summary measures (e.g., risk ratio, difference in means). | | 3-5 (Meta-Regres.) |
| **Synthesis of results** | 14 | Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., $I^2$) for each meta-analysis. | Describe methods of synthesizing findings on health inequities (e.g. presenting both relative and absolute differences between groups). | 3-5 (Meta-Regres.) and appendix 1 |
| **Risk of bias across studies** | 15 | 15. Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies). | | 5 (Risk of Bias) |
| **Additional analyses** | 16 | Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified. | Describe methods of additional synthesis approaches related to equity questions, if done, indicating which were pre-specified | 3-5 (Meta-Regres.) |
| **Results** | | | | |
| **Study selection** | 17 | Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram. | | 4-5 (Results), Appendix 1 Figure 1 Main figure 1 |
| **Study characteristics** | 18 | For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations. | Present the population characteristics that relate to the equity questions across the relevant PROGRESS-Plus or other factors of interest. | 4-5 (Results+ Figure 2 + Appendix |
| **Risk of bias within studies** | 19 | Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12). | | 5 (Study Heterogeneity and Bias) |
| **Results of individual studies** | 20 | For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot. | | Supplementary Figure 8 |
| **Synthesis of results** | 21 | Present results of each meta-analysis done, including confidence intervals and measures of consistency. | Present the results of synthesizing findings on inequities (see 14). | 5 (Disaggregated mortality) |
| **Risk of bias across studies** | 22 | Present results of any assessment of risk of bias across studies (see Item 15). | | 5 (Study Heterogeneity and Bias) |
| **Additional analysis** | 23 | Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]). | Give the results of additional synthesis approaches related to equity objectives, if done, (see 16). | Figures 3-5, Appendix 1 |
| **Discussion** | | | | |
| **Summary of evidence** | 24 | Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers). | | 9-10 (Discussion) |
| **Limitations** | 25 | Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias). | | 9-11 (Discussion) |
| **Conclusions** | 26 | Provide a general interpretation of the results in the context of other evidence, and implications for future research. | Present extent and limits of applicability to disadvantaged populations of interest and describe the evidence and logic underlying those judgments. | 9-11 (Discussion) |
| | 26A | | Provide implications for research, practice or policy related to equity where relevant (e.g. types of research needed to address unanswered questions). | 9-11(Discussion) |
| **Funding** | | | | |
| **Funding** | 27 | Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review. | | 5 (Role of the funding source) |

*From:* Source: Welch V, Petticrew M, Tugwell P, Moher D, O'Neill J, Waters E, White H, and the PRISMA-Equity Bellagio Group. (2012) PRISMA-Equity 2012 Extension: Reporting Guidelines for Systematic Reviews with a Focus on Health Equity. PLoS Med 9(10): e1001333. doi:10.1371/journal.pmed.1001333

## List of articles included in systematic review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**Supplementary Figure 11.** Normalised relative risks per one year of education, shown for all study data separately by super-region and region. Colour indicates whether the effect measure was automatically trimmed in the global model. Full study titles corresponding with axis label are provided in the supplementary Appendix 3.csv.