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Educational Inequalities in Adult Mortality: A Systematic Review and Meta-Analysis of the Asia Pacific Region

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Complete List of Authors:	<p>Beck, Kathryn; Norwegian University of Science and Technology Faculty of Medicine and Health Sciences, Department of Public Health and Nursing</p> <p>Balaj, Mirza; Norwegian University of Science and Technology, Department of Sociology and Political Science</p> <p>Donadello, Lorena; Norwegian University of Science and Technology, Department of Sociology and Political Science</p> <p>Mohammad, Talal; Norwegian University of Science and Technology, Department of Sociology and Political Science</p> <p>Vonen, Hanne; Norwegian University of Science and Technology, Department of Sociology and Political Science</p> <p>Degail, Claire; Norwegian University of Science and Technology, Department of Sociology and Political Science</p> <p>Eikemo, Kristoffer; Norwegian University of Science and Technology, Department of Sociology and Political Science</p> <p>Giouleka, Anna; Norwegian University of Science and Technology, Department of Sociology and Political Science</p> <p>Gradeci, Indrit; Norwegian University of Science and Technology, Department of Sociology and Political Science</p> <p>Westby, Celine; Norwegian University of Science and Technology, Department of Sociology and Political Science</p> <p>Sripada, Kam; Norwegian University of Science and Technology, Department of Sociology and Political Science</p> <p>Jensen, Magnus Rom; Norwegian University of Science and Technology, Library Section for Humanities, Education and Social Sciences, University Library</p> <p>Solhaug, Solvor; Norwegian University of Science and Technology, Library Section for Humanities, Education and Social Sciences, University Library</p> <p>Gakidou, Emmanuela; Institute for Health Metrics and Evaluation, University of Washington; University of Washington Seattle Campus, Department of Health Metrics Sciences, School of Medicine</p> <p>Eikemo, Terje; Norwegian University of Science and Technology, Department of Sociology and Political Science</p>
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Title: Educational Inequalities in Adult Mortality: A Systematic Review and Meta-Analysis of the Asia Pacific Region

Corresponding Author: Kathryn Beck, Haakon Odd Christiansens Veg 3B, Trondheim Norway 7048, Kathryb@stud.ntnu.no

Co-Authors:

Kathryn Beck, Department of Public Health and Nursing, Norwegian University of Science and Technology, Trondheim, Norway

Mirza Balaj, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Lorena Donadello, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Talal Mohammad, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Hanne Dahl Vonen, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Claire Degail, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Kristoffer Eikemo, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Anna Giouleka, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Indrit Gradeci, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Celine Westby, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Kam Sripada, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Magnus Rom Jensen, Library Section for Humanities, Education and Social Sciences, University Library, Norwegian University of Science & Technology, Trondheim, Norway

Solvor Solhaug, Library Section for Humanities, Education and Social Sciences, University Library, Norwegian University of Science & Technology, Trondheim, Norway

Emmanuela Gakidou, Institute for Health Metrics and Evaluation, University of Washington, Seattle, WA, USA, Department of Health Metrics Sciences, School of Medicine, University of Washington, Seattle, WA, USA

Terje Andreas Eikemo, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

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Abstract

Objectives: In this study we aim to analyze the relationship between educational attainment and all-cause mortality of adults in the High-Income Asia Pacific region.

Design: This study is a comprehensive systematic review and meta-analysis with no language restrictions on searches. A random-effects meta-analysis was conducted to evaluate the overall effect of individual level educational attainment on all-cause mortality.

Setting: The High-Income Asia Pacific Region consisting of Japan, South Korea, Singapore and Brunei Darussalam.

Participants: Articles reporting adult all-cause mortality by individual level education were obtained through searches of the following databases: Pub-Med, Web of Science, Scopus, EMBASE, Global Health (CAB), EconLit, and Sociology Source Ultimate.

Primary and Secondary Outcome Measures: Adult all-cause mortality was the primary outcome of interest.

Results: Literature searches resulted in 15,345 sources screened for inclusion. A total of 30 articles meeting inclusion criteria with data from the region were included for this review. Individual-level data from 7 studies covering 222,241 individuals were included in the meta-analyses. Results from the meta-analyses showed an overall risk ratio of 2.40 (95% CI 1.74-3.31) for primary education and an estimate of 1.29 (95% CI 1.08-1.54) for secondary education compared to tertiary education.

Conclusion: The results indicate that lower educational attainment is associated with an increase in the risk of all-cause mortality for adults in the High-Income Asia Pacific region. This study offers empirical support for the development of policies to reduce health disparities across the educational gradient and universal access to all levels of education.

Trial Registration: PROSPERO registration for global systematic review CRD42020183923.

Article Summary

Strengths and Limitations of this Study

- The present study provides the most up-to-date collection of evidence regarding educational inequalities in adult all-cause mortality for the High-Income Asia Pacific Region.
- The present systematic review utilized a global, language-unrestricted search strategy to gather all available data.
- The present systematic review and meta-analysis is the first to our knowledge to utilize harmonized education groups for this region, allowing more comparable effect sizes.
- This study employed a random-effects meta-analysis model, giving a more robust estimate given the high levels of heterogeneity.
- High levels of heterogeneity in the meta-analysis likely are due to the differences between the populations within the studies and differences between methodologies and measurements used.

Introduction

Research in public health often describes the differences in disease and treatment within the general population. However, we often fail to examine how the societal conditions we live in shape our health and life chances. These societal conditions in which we are born and grow include our education, income, employment status, housing, and work conditions, and have great and complex influences on our subsequent health and disease status.[1] While it may seem intuitive that those making a larger income would experience better health than someone living in poverty, the social determinants also act on a gradient, as that with every additional year of education health status improves. As a result, research to explain and measure inequities in health is needed to guide policy changes aimed at not only “closing the gap” between the most and least advantaged groups, but ultimately by reducing the inequalities between groups across the social gradient in health.

Education is often used as a proxy measure for SES in health inequalities research, as it is relatively constant after young adulthood while often having a significant impact on later measures of SES and is influenced through parental characteristics and therefore, to some degree, can act as an indicator of early-life socioeconomic conditions.[2] Though it may be common knowledge that having a good education helps one by increasing prospects of a good job with a decent income, the exact pathways in which education influences health are complex and intertwining. Egerter et al[3] have described the pathways in which educational attainment affects one’s health. Examples of these pathways include through health knowledge and behaviors, healthcare access, working conditions, income, social network, and social standing.[3]

Despite the growing focus on health inequalities, this field has been dominated by research describing trends in North American and European countries, with others falling behind. In the Asia Pacific region, specifically Japan, South Korea, Singapore, and Brunei Darussalam, health inequalities began gaining increased attention in the early 2000s, with most research conducted in Japan and South Korea. Despite this, the amount of research done is lagging by decades compared to Europe and the United States. While comparative studies are rare, one study comparing educational inequalities in mortality between Japan and the U.S. found that the magnitude of the inequalities was similar.[4] This suggests that the intensity of such inequalities may be similar to those in Europe and the United States. Traditionally, this region has had the longest life expectancies, relatively little inequality, and tight supportive social networks.[5] When comparing life expectancies (LE) by welfare regime, the East Asian regime had higher average LE than even the Scandinavian welfare regimes, suggesting that other social and cultural factors may be of importance in this region.[6] However, as rapid economic growth driven by drastic technological innovation and growing globalization contribute to the high LE and improved population health, inequalities also rise. If we want to reduce inequalities, prevent the widening of the health gap, and diminish disparities across the social gradient, we first need to quantify the level of inequality so we can monitor these trends over time and enact policies that reduce these unjust inequities.

Therefore, the aim of this study is to analyze the relationship between educational attainment and all-cause mortality of adults in the High-Income Asia Pacific region, consisting of Japan, South Korea, Singapore, and Brunei Darussalam. This region has been

classified by the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) led by the Institute for Health Metrics and Evaluation (IHME) by epidemiological similarity and geographic closeness.

Methods

Search Strategy and Selection Criteria

A literature search was conducted using the databases Pub-Med, Web of Science, Scopus, EMBASE, Global Health (CAB), EconLit, and Sociology Source Ultimate in November and December 2019 by librarians. The search was limited to records published since 1980 without any language limitations. The search was constructed using key terms: education, socioeconomic status, health inequalities, adult, mortality, all-cause mortality, and death. The specific search string contains commonly related terms and synonyms to the key terms above. Rather than using the Boolean term “AND” for the search string, we used proximity searching. Setting the proximity to 10 ensures the two words or blocks must occur within ten words of each other, yielding a more relevant and manageable result through a higher bar for inclusion in the search results. A hand-search for relevant articles not found through database searching was conducted by searching the reference lists of obtained articles such as literature reviews and narrative reviews.

Abstracts of articles found through the literature search were screened by two independent reviewers. In the case of disagreement, a third independent reviewer determined the final decision. During the abstract screening, all articles that mentioned social group analysis were included. This was done as many studies may not explicitly state educational attainment as a measure examined, but rather simply state “socioeconomic variables”. During full article reading, two reviewers screened each article for inclusion, with a third review used in case of disagreement. The inclusion and exclusion criteria are summarized in Table 1 according to the SPIDER framework. Articles were examined for quality from two reviewers using checklists from the Joanna Briggs Institute (JBI).

Table 1. SPIDER Framework for Inclusion and Exclusion Criteria

SPIDER Framework	Inclusion Criteria	Exclusion Criteria
Sample	Sample size and characteristics were not a criterion for inclusion in this review Age 18 years or older	Sample size and characteristics were not a criterion for exclusion in this review Age less than 18 years
Phenomenon of Interest	Adult mortality according to educational attainment All-cause mortality	Indices using education aggregated with other indicators Cause-specific mortality
Design	All study designs other than the two listed in exclusion criteria	Case-crossover and ecological studies
Evaluation	Individual-level measures	Aggregate-level measures

	Relative inequality measures: RR (relative risk), HR, OR, RR (rate ratio), Logistic coefficients	Measures: Standardized incidence ratio, standardized mortality ratio, time-to-event ratio, incidence, rate and risk difference
Publication Type	Publication type is not an inclusion criterion	Comment, editorials, or letters

All relevant data was extracted using a standardized extraction template. The template includes information such as location (country or region), date(s), sample sizes, method of measuring exposure (education) and outcome (mortality), confounders adjusted for in the multivariate analysis, effect measure estimates, educational groups definition according to study, corresponding years of education, and others. Extractors used ISCED mappings[7] to determine corresponding numerical years of education for articles that reported only education categories. Illiterate was considered 0 years of education, while literate was considered \geq one year. Following data extraction, articles which contained data for the High-Income Asia Pacific region were selected for inclusion into this study.

Effect Size Computation

Risk ratios were calculated for an overall effect size for each study, using the raw population numbers for each educational group with the tertiary educational group used as the reference category. The primary factors for effect size calculation and therefore inclusion into the meta-analysis were: (1) the design of the study and (2) availability of data needed for effect size calculation, and (3) the study's educational attainment grouping. A random-effects model with inverse variance weighting was utilized to complete the meta-analysis. Statistical analyses were completed using RStudio with R version 4.0.3.[8]

Assessing Heterogeneity

As heterogeneity is expected between included studies due to the variation between participants' characteristics and settings, a test for heterogeneity was conducted. This was first done by using Cochrane's Q test to assess heterogeneity, and the heterogeneity was then quantified by using an I^2 statistic. As recommended by Cochrane, a p-value of less than 0.1 will be considered statistically significant heterogeneity [9]. The degree of heterogeneity in the I^2 statistic was determined as being low (0-25%), medium (25-75%), or high (75-100%).[9] A random-effects model was chosen *a priori* for the meta-analysis to account for the expected high levels of heterogeneity and give a more robust estimate.

Patient and Public Involvement

Due to the global nature of the systematic review strategy, it was not feasible to involve the public in the design or conduct of this study.

Results

The literature search yielded 15,017 records after the first-degree removal of duplicates from the different databases. The hand-searching of reference lists of relevant records yielded an additional 384 records, and after duplicate removal, 15,345 records

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continued to the abstract screening phase. Of these, 1,799 articles were assessed for eligibility in the full-text screening, and 579 articles met the criteria for data extraction for the global review. In total, 30 articles were conducted in one or more countries within the High-Income Asia Pacific region as shown in the PRISMA flow diagram in Figure 1. Of the 30 studies included in this synthesis, 24 are longitudinal cohort studies, five are cross-sectional studies utilizing unlinked death certificate data, and one is a prospective pooled cohort analysis.

Figure 1 about here

Study Characteristics

Table 2 gives an overview of the descriptive characteristics of the included studies. One study is a prospective pooled cohort study that uses data from both Japan, South Korea, and Singapore. Aside from the pooled cohort study, 14 studies each (48.3%) were completed in both Japan and South Korea, one study (3.45%) was completed in Singapore, and no studies were completed in Brunei Darussalam. A majority (19) of the studies were representative of the entire population (63.3%), while many were representative of specific cities, municipalities, or population groups. Leaving 11 studies that were not representative of the entire population (36.6%). In total, only two studies utilized data from as early as 1963 and 1970, while four studies included earliest data from the late 1980's, and 26 studies included data from the 1990's and onwards. Eight of the articles (26.6%) were of "good" quality, while 22 (73.3%) were of "excellent" quality and zero articles were of "fair" quality.

Table 2. Descriptive Characteristics of Included Studies.

Author	Data Source	Years of Study	Sample Size	Ages	Male Population	Number of Deaths	Representative of population?	Max Years Follow-up
Japan								
Chiu et al., [4]	NUJLSOA	1999-2009	6,171	65+	43 %	n.d.	Yes	11
Fujino et al., [10]	JACC Study	1988-1998	39,999	40-79	42 %	6,628	Yes	11
Minagawa et al., [11]	NUJLSOA	1999-2009	13,225	65+	n.d.	1,434	Yes	10
Tani et al., [12]	JAGES	2010-2013	15,449	65+	46 %	754	No	3.8
Sugisawa et al., [13]	N/A	1987-1990	1,943	60+	46 %	161	Yes	3
Ishizaki et al., [14]	Saku Longitudinal Study on Aging	1992-1998	8,090	65+	43 %	n.d.	No	6
Iwasaki et al., [15]	Komo-Ise Study	1993-2000	5,629	40-69	100 %	338	No	7
Nishi et al., [16]	AGES 2003 Cohort Study	2003-2007	14,668	65+	48 %	1,218	No	4
Ito et al., [17]	JPHC Study Cohort I	1990-2003	39,228	40-59	48 %	2,430	No	13
Honjo et al., [18]	JACC Study	1988-2009	16,692	40-60	0 %	1,019	No	20
Hirokawa et al., [19]	Jichi Medical School Cohort Study	1992-2002	11,081	18+	39 %	588	No	10
Honjo et al., [20]	JACC Study	1990-2006	57,109	40-65	43 %	6,054	Yes	16
Liang et al., [21]	N/A	1987-1999	7,174	60+	45 %	724	Yes	12
Iwasa et al., [22]	Longitudinal Interdisciplinary Study on Aging	1991-2000	2,447	52-77	42 %	264	No	7
South Korea								
Jung-Choi et al., [23]†	N/A	1990-2004	70,167,890	25-64	50 %	1,415,287	Yes	N/A
Khang & Kim [24]	The 1998 & 2001 KNHANES	1998-2012	10,137	30+	46 %	1,219	Yes	12
Kim & Khang [25]	The 1998 NHANES	1998-2003	5,607	30+	47 %	264	Yes	6

Khang et al., [26]	The 1998 & 2001 NHANES	1998-2005	8,366	30+	n.d.	310	Yes	8
SUH, G. H. [27]	N/A	1999-2002	1,245	65+	43 %	158	No	3.5
Lim et al., [28]†	N/A	1995-2010	81,354,834	30-59	50 %	348,200	Yes	N/A
Kim et al., [29]	KLIPS	2003-2008	19,305	19+	50 %	424	Yes	6
Son et al., [30]†	N/A	1993-1997	16,923,772	20-64	n.d.	287,000	No	N/A
Bahk et al., [31]†	N/A	1970-2010	152,101,958	25-64	50 %	614,910	Yes	N/A
Khang & Kim [32]	NHANES	1998-2003	5,437	30+	n.d.	242	Yes	6
Khang & Kim [33]	The 1998 NHANES	1998-2002	5,607	30+	n.d.	197	Yes	4
Khang et al., [34]†	N/A	1995-2000	15,177,375	35-64	50 %	462,770	Yes	N/A
Khang [35]	KLIPS	1998-2003	1,574	50+	100 %	176	Yes	5
Kim et al., [36]	KMSMS	1994-2014	70,713	40+	61 %	5,618	Yes	20
Singapore								
Ma et al., [37]	1992 Singapore National Health Survey	1992-2001	3,492	18+	48 %	108	Yes	9
Pooled Cohort Analysis								
Yang et al., [38]	Asia Cohort Consortium ¹ Japan	1963-1993	280,192	19+	45 %	59,822	Yes	15.8
Yang et al., [38]	Asia Cohort Consortium ² South Korea	1992-1993	13,697	25+	100 %	894	No	15.6
Yang et al., [38]	Asia Cohort Consortium ³ Singapore	1993-1999	63,247	19+	44 %	10,682	Yes	11.5

†Cross-sectional

¹Japan Collaborative Cohort Study (JACC), Japan Public Health Center-Based Prospective Study (JPHC), Life Span Study Cohort (LSS), Miyagi Cohort (Miyagi) Ohsaki National Health Insurance Cohort Study (Ohsaki), Takayama Study (Takayama)

²Seoul Male Cancer Cohort (SeoulM)

³Singapore Chinese Health Study (SCHS)

Analysis of the Association between Educational Attainment and Mortality

Seven studies covering 222,241 individuals and 17,551 deaths allowed for analysis of all-cause mortality by predetermined educational categories. Figure 2 shows the risk of mortality by primary educational status with the tertiary educational category used as the reference category. The individual studies with the calculated (unadjusted) risk ratios (RR) and 95% confidence intervals, and the overall random-effects estimate are listed along with a forest plot visualization of the studies' estimates.

In this analysis, risk ratios ranged from 1.21 to 6.13, with only one estimate including the null value[16]. The overall estimate calculated through the random effects model indicated an RR of 2.40 with a corresponding 95% CI of 1.74 to 3.31, indicating a statistically significant effect of primary education on the increased risk for all-cause mortality ($z=5.33$, $p<0.01$). The Q statistic was statistically significant ($Q=236.98$, $p<0.01$), and the I^2 value estimates that about 97% of the variation across studies is due to heterogeneity, rather than chance, both of which suggest significant heterogeneity.

Figure 2 about here.

Figure 3 illustrates the meta-analysis and forest plot using secondary education compared to tertiary education (ref) in mortality risk. In this analysis, multiple studies did not show as clear of an increase in risk as in previous analyses. Three of the seven studies' effect sizes or 95% CI included the null value of 1, indicating a non-statistically significant or null effect of secondary education on the risk of mortality in these estimates. However, the overall effect estimate shows a statistically significant increase in the risk of mortality by secondary education, with a 29% increase in risk ($z=2.87$, $p<0.01$). Meaning those with 10 to 12 years of schooling had 1.29 times the risk of mortality compared to those with 13 or more years of schooling. The Q statistic was statistically significant ($Q=57.50$, $p<0.01$), and the I^2 value estimates that about 90% of the variation across studies is due to heterogeneity, both of which suggest significant heterogeneity.

Figure 3 about here.

Discussion

This study is the most comprehensive systematic review and meta-analysis to date describing the influence of educational attainment on adult all-cause mortality in the High-Income Asia Pacific region. The results reveal that lower educational attainment is associated with a significant increase in the risk of mortality for adults in the High-Income Asia Pacific region. Despite impressive improvements in health and living conditions in the region in the past 50 years[5,39], the inequalities in educational attainment and mortality have persisted.

Sir Michael Marmot[40] hypothesized the good health of Japan as being a result of high levels of collectivism, social cohesion, and job security. Before the introduction of neo-liberal market reforms, employers in Japan and South Korea relied heavily on long-term workers with seniority-based wage systems. Through this framework, employees enjoyed relatively high levels of job security and low levels of income inequality between workers. However, due to the introduction of these reforms sparked by economic crisis, employers began shifting to non-regular workers and pay-per-performance schemes, resulting in rising insecurity and inequality with fewer social insurance protections for workers and weakening

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social cohesion. This may have increased inequalities in South Korea as the relative risk of mortality for men of low education in 1980 was 3.44, increasing to 6.41 in 2000 after the introduction of these market reforms, when compared to highly educated men.[31]

Perhaps because of this transformation, the educational systems have seen skyrocketing competitiveness and high- and middle- income families are drastically outspending low-income families on education.[41–43] The phenomenon of “shadow education” or private supplemental educational lessons referred to as *juku* in Japan and *hagwon* in South Korea is by no means new or isolated to East Asian countries. The percentage of average monthly household educational expenditure on private supplementary education shows an unequal and rising trend across income quintiles from 2002 to 2013 in Singapore.[44] The wealthiest 20% increased their educational expenditures by 1.49% during this 10-year timespan, while the poorest 20% increased their expenditure by only 0.62%. These expenditure trends and skyrocketing competition may result in the educational system being a reproducer of class status instead of a mechanism for social mobility and may lead to an increase in future inequalities.[45] On the one hand, education can be used as a powerful tool to eliminate inequities and promote social mobility, while on the other hand, when middle- and high-income families drastically outspend low-income families on supplemental schooling, education is used to reproduce and exacerbate inequities in society.

To the best of our knowledge, only one other systematic review and meta-analysis of educational inequalities in all-cause mortality for the Asian context has been completed.[46] This review included, among others, Japan, South Korea, and Singapore, with 11 studies from these countries in their meta-analyses. Researchers compared the highest available education level to the lowest level in each study, finding an overall RR of 1.29 (1.17-1.43) for those with “low education” compared to those with “high education” in their subgroup consisting of Japan, South Korea, and Singapore.[46]

Overall, their results support the results found in our analyses, however, their overall estimate includes the highest adjusted estimate from each study, while ours is based on unadjusted estimates, likely contributing to the lower value compared to ours. All included studies in their meta-analysis except one, which did not meet our inclusion criteria, were included in our review—suggesting that the review process was thorough, and all relevant literature was included. Therefore, this study provides both an updating of the existing literature review and provides new knowledge on the relationship between education and health in this region, through a more detailed analysis.

Implications and Future Research

By demonstrating a gradient effect of education on mortality, we offer empirical support for policies that aim to improve morbidity and mortality across all socioeconomic groups rather than focus on “closing the gap” between the most and least advantaged groups. We also demonstrate strong support for policy aimed at improving access to education for all, from primary through higher education, as we see a significant impact of education on the health and life of all individuals.

Although this review offers valuable empirical evidence, further research is needed on this topic and region. Additional longitudinal data is also needed, especially in South Korea, Singapore, and Brunei Darussalam. This lack of data highlights that although these countries

are classified as high-income, research in health inequalities is dominated by studies conducted in the U.S and Europe. Further research is also needed to examine the mechanisms in which education influences health and mortality, although this requires a rich, comprehensive evidence base, and so far, is not feasible in this region. This review makes an essential step in the identification and monitoring of educational inequalities in mortality in the High-Income Asia Pacific region, and future research is needed to monitor these trends across time and eventually to reduce disparities in health, allowing all individuals the opportunity to live a long healthy life.

The results and interpretations of this review should be taken with consideration to its limitations. We cannot be sure that our conclusions apply to countries with severe data restrictions, namely Singapore and Brunei Darussalam. As all the studies relied on self-reported education levels, we cannot rule out the potential for response bias in some individuals if they could not accurately remember their total years of education or their highest level of educational attainment. Additionally, the high levels of heterogeneity in the analysis should not be ignored. This is most likely due to the differences between the populations within the studies and differences between methodologies and measurements used. While it is not surprising that there are high levels of heterogeneity in the meta-analysis, due to the between country nature of the study and the inability to control for all confounders within the primary studies, the interpretation of this meta-analysis should be taken with caution as we cannot be sure the effect seen from these studies would be the same for the entire population either within or outside of the region studied.

To our knowledge, this is the most up-to-date review of educational attainment and adult mortality conducted in this region. This study benefits from using education as a measure of socioeconomic status, as this is a consistent and early indicator of an individual's SES.[47] This review also utilized a thorough global search without language restriction allowing for near-complete coverage of all relevant articles. Additionally, the meta-analysis utilized harmonized educational categories which, as far as we know, has not previously been done. Lastly, this study employed a random-effects model, giving a more robust estimate given the high levels of heterogeneity.

Conclusion

This study provides empirical evidence to support the association between educational attainment and adult all-cause mortality in the High-Income Asia Pacific region. We see a gradient effect of education on mortality as with every step up the educational ladder, individuals experience a reduced risk of mortality. Overall, these results offer a basis for evidence-based policy decisions to reduce health disparities across the educational gradient and improve access to education from primary to higher education. Further research is needed to expand the limited research base in this region, to allow for consistent monitoring of these trends, and to support further policy changes aimed at reducing health disparities.

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Author Contributions

The study concept and strategy was developed by MB, KS, EG, and TAE. The manuscript was drafted by KB and revised by TAE and MB. The search strategy was developed and executed by MRJ and SS. Study screening and data extraction was completed by KB, LD, TM, HDV, CD, KE, AG, IG, and CW.

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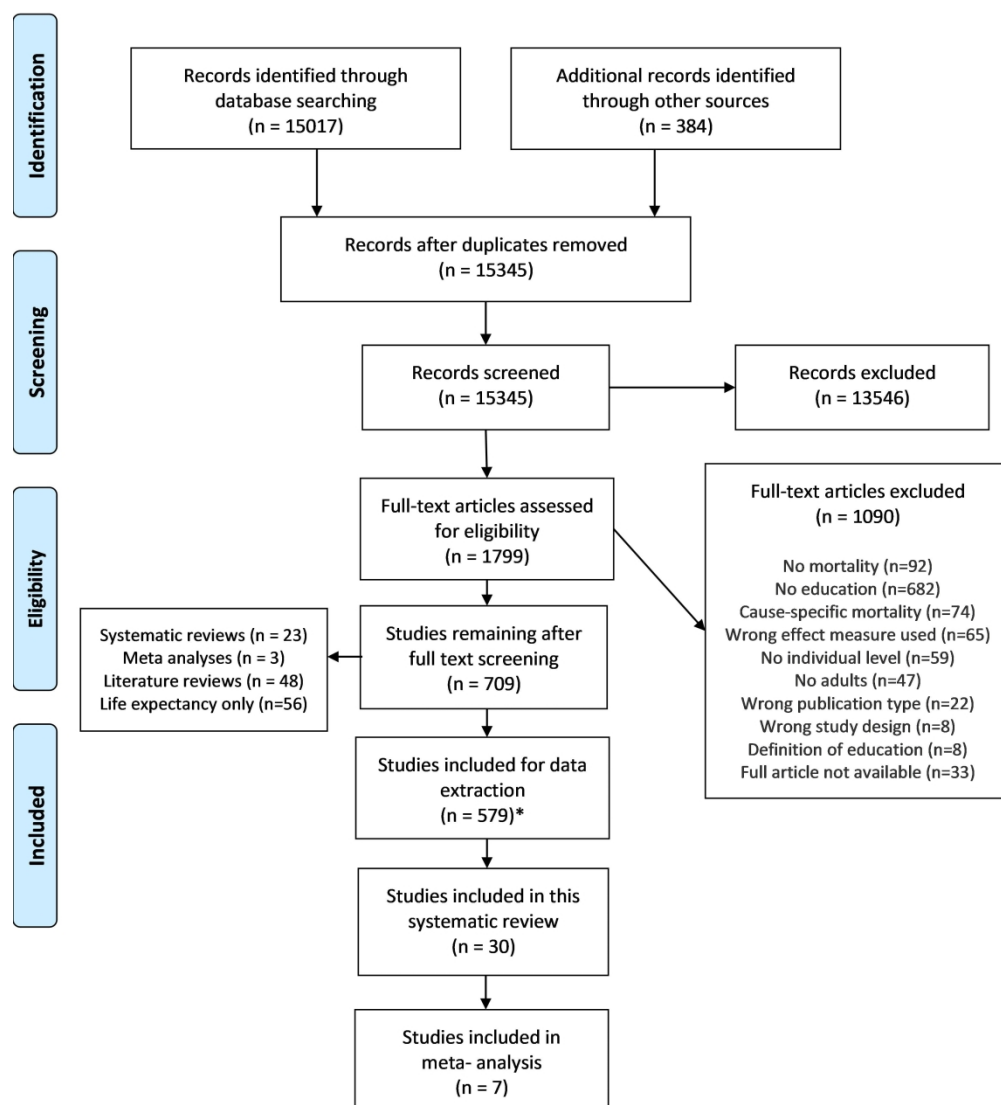


Figure 1. PRISMA Flow Diagram Note. 12 Extractions from one book.

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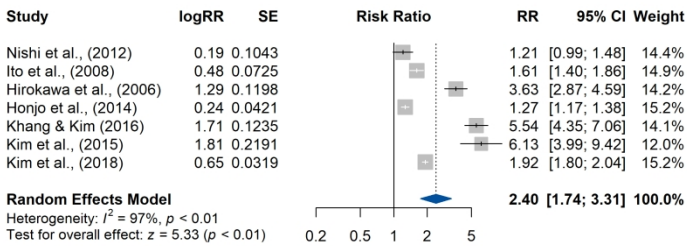


Figure 2. Forest Plot for Primary Education vs. Tertiary Education Note. Primary education equates to middle school or less (0-9 years), while tertiary education equates to college or higher (≥ 13 years). Tertiary education is the reference category.

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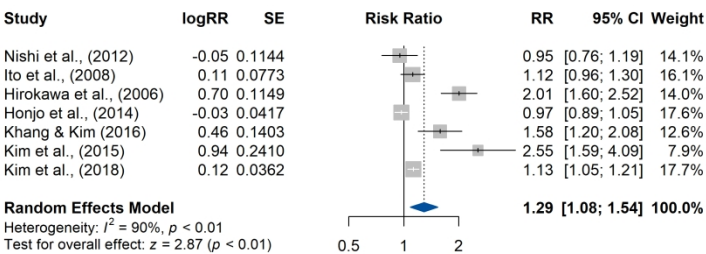


Figure 3. Forest Plot for Secondary Education vs. Tertiary Education. Note. Secondary education equates to high school (10-12 years), while tertiary education equates to college or higher (≥ 13 years). Tertiary education is the reference category.

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Educational Inequalities in Adult Mortality: A Systematic Review and Meta-Analysis of the Asia Pacific Region

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Complete List of Authors:	<p>Beck, Kathryn; Norwegian University of Science and Technology Faculty of Medicine and Health Sciences, Department of Public Health and Nursing</p> <p>Balaj, Mirza; Norwegian University of Science and Technology, Centre for Global Health Inequalities Research, Department of Sociology and Political Science</p> <p>Donadello, Lorena; Norwegian University of Science and Technology, Centre for Global Health Inequalities Research, Department of Sociology and Political Science</p> <p>Mohammad, Talal; Norwegian University of Science and Technology, Centre for Global Health Inequalities Research, Department of Sociology and Political Science</p> <p>Vonen, Hanne; Norwegian University of Science and Technology, Centre for Global Health Inequalities Research, Department of Sociology and Political Science</p> <p>Degail, Claire; Norwegian University of Science and Technology, Centre for Global Health Inequalities Research, Department of Sociology and Political Science</p> <p>Eikemo, Kristoffer; Norwegian University of Science and Technology, Centre for Global Health Inequalities Research, Department of Sociology and Political Science</p> <p>Giouleka, Anna; Norwegian University of Science and Technology, Centre for Global Health Inequalities Research, Department of Sociology and Political Science</p> <p>Gradeci, Indrit; Norwegian University of Science and Technology, Centre for Global Health Inequalities Research, Department of Sociology and Political Science</p> <p>Westby, Celine; Norwegian University of Science and Technology, Centre for Global Health Inequalities Research, Department of Sociology and Political Science</p> <p>Sripada, Kam; Norwegian University of Science and Technology, Centre for Global Health Inequalities Research, Department of Sociology and Political Science; Norwegian University of Science and Technology, Centre for Digital Life Norway</p> <p>Jensen, Magnus Rom; Norwegian University of Science and Technology, Library Section for Humanities, Education and Social Sciences, University Library</p> <p>Solhaug, Solvor; Norwegian University of Science and Technology, Library Section for Humanities, Education and Social Sciences, University Library</p> <p>Gakidou, Emmanuela; Institute for Health Metrics and Evaluation,</p>

	University of Washington; University of Washington Seattle Campus, Department of Health Metrics Sciences, School of Medicine Eikemo, Terje; Norwegian University of Science and Technology, Centre for Global Health Inequalities Research, Department of Sociology and Political Science
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Title: Educational Inequalities in Adult Mortality:

Corresponding Author: Kathryn Christine Beck, Faculty of Medicine and Health Sciences, Department of Public Health and Nursing, NTNU-Norwegian University of Science and Technology, PO box 8905, 7491 Trondheim, Norway, Kathryb@stud.ntnu.no

Co-Authors:

Kathryn Christine Beck, Faculty of Medicine and Health Sciences, Department of Public Health and Nursing, NTNU-Norwegian University of Science and Technology, Trondheim, Norway

Mirza Balaj, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Lorena Jessica Donadello, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Talal Mohammad, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Hanne Dahl Vonen, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Claire Degail, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Kristoffer Eikemo, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Anna Giouleka, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Indrit Gradeci, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Celine Lossius Westby, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

Kam Sripada, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway. Centre for Digital Life Norway, NTNU, Norway.

Magnus Rom Jensen, Library Section for Humanities, Education and Social Sciences, University Library, Norwegian University of Science & Technology, Trondheim, Norway

Solvor Solhaug, Library Section for Humanities, Education and Social Sciences, University Library, Norwegian University of Science & Technology, Trondheim, Norway

Emmanuela Gakidou, Institute for Health Metrics and Evaluation, University of Washington, Seattle, WA, USA, Department of Health Metrics Sciences, School of Medicine, University of Washington, Seattle, WA, USA

Terje Andreas Eikemo, Centre for Global Health Inequalities Research, Department of Sociology and Political Science, Norwegian University of Science and Technology, Trondheim, Norway

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Abstract

Objectives: In this study we aim to analyze the relationship between educational attainment and all-cause mortality of adults in the High-Income Asia Pacific region.

Design: This study is a comprehensive systematic review and meta-analysis with no language restrictions on searches. Included articles were assessed for study quality and risk of bias using the Joanna Briggs Institute (JBI) critical appraisal checklists. A random-effects meta-analysis was conducted to evaluate the overall effect of individual level educational attainment on all-cause mortality.

Setting: The High-Income Asia Pacific Region consisting of Japan, South Korea, Singapore and Brunei Darussalam.

Participants: Articles reporting adult all-cause mortality by individual level education were obtained through searches conducted from the 25th of November to the 6th of December, 2019 of the following databases: Pub-Med, Web of Science, Scopus, EMBASE, Global Health (CAB), EconLit, and Sociology Source Ultimate.

Primary and Secondary Outcome Measures: Adult all-cause mortality was the primary outcome of interest.

Results: Literature searches resulted in 15,345 sources screened for inclusion. A total of 30 articles meeting inclusion criteria with data from the region were included for this review. Individual-level data from 7 studies covering 222,241 individuals were included in the meta-analyses. Results from the meta-analyses showed an overall risk ratio of 2.40 (95% CI 1.74-3.31) for primary education and an estimate of 1.29 (95% CI 1.08-1.54) for secondary education compared to tertiary education.

Conclusion: The results indicate that lower educational attainment is associated with an increase in the risk of all-cause mortality for adults in the High-Income Asia Pacific region. This study offers empirical support for the development of policies to reduce health disparities across the educational gradient and universal access to all levels of education.

Trial Registration: PROSPERO registration for global systematic review CRD42020183923.

Article Summary

Strengths and Limitations of this Study

- The present study provides the most up-to-date collection of evidence regarding educational inequalities in adult all-cause mortality for the High-Income Asia Pacific Region.
- The present systematic review utilized a global, language-unrestricted search strategy to gather all available data.
- The present systematic review and meta-analysis is the first to our knowledge to utilize harmonized education groups for this region, allowing more comparable effect sizes.
- This study employed a random-effects meta-analysis model, giving a more robust estimate given the high levels of heterogeneity.

- High levels of heterogeneity in the meta-analysis likely are due to the differences between the populations within the studies and differences between methodologies and measurements used.

Introduction

Research in public health often fails to examine how the societal conditions we live in shape our health and life chances. These societal conditions in which we are born and grow include our education, income, employment status, housing, and work conditions, and have great and complex influences on our subsequent health and disease status.[1] While it may seem intuitive that those making a larger income would experience better health than someone living in poverty, the social determinants also act on a gradient, as that with every additional year of education health status improves. As a result, research to explain and measure inequities in health is needed to guide policy changes aimed at not only closing the gap between the most and least advantaged groups, but ultimately by reducing the inequalities between groups across the social gradient in health.

Education is often used as a proxy measure for socioeconomic status (SES) in health inequalities research, as it is relatively constant after young adulthood while often having a significant impact on later measures of SES and is influenced through parental characteristics and therefore, to some degree, can act as an indicator of early-life socioeconomic conditions.[2] Though it may be common knowledge that having a good education helps one by increasing prospects of a good job with a decent income, the exact pathways in which education influences health are complex and intertwining. Egerter et al. [3] described the pathways in which educational attainment affects one's health through health knowledge and behaviors, healthcare access, working conditions, income, social network, and social standing.

Despite the growing focus on health inequalities, this field has been dominated by research describing trends in North American and European countries, leaving other contexts under-researched and often ignored. In the Asia Pacific region, specifically Japan, South Korea, Singapore, and Brunei Darussalam, health inequalities began gaining increased attention in the early 2000s, with most research conducted in Japan and South Korea. While comparative studies are rare, one study comparing educational inequalities in mortality between Japan and the U.S. found that the magnitude of the inequalities was similar.[3] This suggests that the intensity of such inequalities may be similar to those in Europe and the United States. Traditionally, this region has had the longest life expectancies, relatively little inequality, and tight supportive social networks.[4] When comparing life expectancies (LE) by welfare regime, the East Asian regime had higher average LE than the traditionally high LE of Scandinavian welfare regimes, suggesting that other social and cultural factors may be of importance in this region.[5] However, as rapid economic growth driven by drastic technological innovation and growing globalization contribute to the high LE and improved population health, inequalities also rise.[6] If we want to reduce inequalities, prevent the widening of the health gap, and diminish disparities across the social gradient, we first need to quantify the level of inequality so we can monitor these trends over time and enact policies that reduce these unjust inequities.

Therefore, the aim of this study is to analyze the relationship between educational attainment and all-cause mortality of adults in the High-Income Asia Pacific region,

consisting of Japan, South Korea, Singapore, and Brunei Darussalam. This region has been classified by the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) led by the Institute for Health Metrics and Evaluation (IHME) by epidemiological similarity and geographic closeness. This analysis focuses on relative inequalities in mortality, which may paint a dire picture of widening inequalities despite targeted public health interventions. However, in reality, the absolute rates of mortality often have drastically improved, and inequalities in absolute terms are often seen to have actually reduced over time.[7] Therefore, it is important to consider that both reductions in overall mortality rates, and compositional changes in education groups may contribute to rising relative inequalities in mortality, despite improvements in absolute inequalities.[7]

Methods

Search Strategy and Selection Criteria

A literature search was conducted using the databases Pub-Med (NIH/NLM), Web of Science (Clarivate), Scopus (Elsevier), EMBASE (Elsevier), Global Health (CAB-EBSCO), EconLit (EBSCO), and Sociology Source Ultimate (EBSCO) from the 25th of November to the 6th of December 2019 by librarians. The search was limited to records published since 1980 without any language limitations. The search was constructed using key terms: *education, socioeconomic status, health inequalities, adult, mortality, all-cause mortality, and death*. The specific search string contains commonly related terms and synonyms to the key terms above. Rather than using the Boolean term “AND” for the search string, we used proximity searching. Setting the proximity to 10 ensures the two words or blocks must occur within ten words of each other, yielding a more relevant and manageable result through a higher bar for inclusion in the search results. The literature search string used is provided in the Supplemental Appendix A. A hand-search for relevant articles not found through database searching was conducted by searching the reference lists of obtained articles such as literature reviews and narrative reviews.

Abstracts of articles found through the literature search were screened by two independent reviewers. In the case of disagreement, a third independent reviewer determined the final decision. During the abstract screening, all articles that mentioned social group analysis were included. This was done as many studies may not explicitly state educational attainment as a measure examined, but rather simply state “socioeconomic variables”. During full article reading, two reviewers independently screened each article for inclusion, with a third review used in case of disagreement. The inclusion and exclusion criteria are summarized in Table 1 according to the SPIDER framework. Articles were assessed for risk of bias and quality by one reviewer independently using the Joanna Briggs Institute (JBI) Critical Appraisal checklists for the study’s design (cohort or cross-sectional).[8, 9] Studies received a score of 1 if the criterion was met and 0 if not, or if it was unclear. The scores were added together and classified into equal quality categories based on the maximum score possible. For cohort studies, the fair category included scores from 0-3, good quality was scores from 4-7, and excellent was scores 8-11. For cross-sectional studies, the categories for fair, good, and excellent were determined from scores ranging from 0-2, 3-5, and 6-8, respectively.

Table 1. SPIDER Framework for Inclusion and Exclusion Criteria

SPIDER Framework	Inclusion Criteria	Exclusion Criteria
Sample	Sample size and characteristics were not a criterion for inclusion in this review Age 18 years or older	Sample size and characteristics were not a criterion for exclusion in this review Age less than 18 years
Phenomenon of Interest	Adult mortality according to educational attainment All-cause mortality	Indices using education aggregated with other indicators Cause-specific mortality
Design	All study designs other than the two listed in exclusion criteria	Case-crossover and ecological studies
Evaluation	Individual-level measures Relative inequality measures: relative risk, hazard ratio, odds ratio, rate ratio, logistic coefficients	Aggregate-level measures Measures: Standardized incidence ratio, standardized mortality ratio, time-to-event ratio, incidence, rate and risk difference
Publication Type	Publication type is not an inclusion criterion	Comment, editorials, or letters

All relevant data was extracted using a standardized extraction template. The template includes information such as location (country or region), date(s), sample sizes, method of measuring exposure (education) and outcome (mortality), confounders adjusted for in the multivariate analysis, effect measure estimates, educational groups definition according to study, corresponding years of education, and others. Extractors used ISCED mappings[10] to determine corresponding numerical years of education for articles that reported only education categories. Illiterate was considered 0 years of education, while literate was considered \geq one year. Articles were extracted independently by reviewers due to the large number of records. A quality control random sample of 10% of the extractions from each reviewer were extracted in duplicate by experienced reviewers. Following data extraction, articles which contained data for the High-Income Asia Pacific region were selected for inclusion into this study.

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Primary education was classified as middle school education or less, equal to 0-9 years of schooling. Secondary education was classified as high school, equal to 10-12 years of schooling, and tertiary education was classified as a college education or higher, equal to 13 years of schooling or more. Risk ratios and 95% confidence intervals were calculated for an overall effect size for each study, using the raw population numbers for each educational group with the tertiary educational group used as the reference category. The primary factors for effect size calculation and therefore inclusion into the meta-analysis were: (1) the design of the study and (2) availability of data needed for effect size calculation, and (3) the study's educational attainment grouping. Three articles met the requirements to be included in the meta-analysis but used the same underlying dataset. Due to this, we excluded two [11, 12] of the articles which used only one wave of the NHANES survey and therefore had a smaller sample size and less follow-up time than the article from Khang and Kim which remained in the analysis.[13] A random-effects model with inverse variance weighting was utilized to complete the meta-analysis. To assess for the presence of publication bias, where smaller studies with only highly significant effect sizes are more likely to be published, funnel plots are usually created and examined for asymmetry. However, funnel plots are only appropriate for detecting publication bias when studies included in the meta-analysis come from one underlying population.[14] As the number of studies included in our meta-analysis is below the threshold for statistical tests for funnel plot asymmetry to be reliable, and our population does not come from one single underlying population and rather is a heterogeneous population, a funnel plot would not be appropriate for this meta-analysis.[14] Statistical analyses were completed using RStudio with R version 4.0.3 and the "meta" R package.[15, 16]

Assessing Heterogeneity and Sensitivity Analyses

As heterogeneity is expected between included studies due to the variation between participants' characteristics and settings, a test for heterogeneity was conducted. This was first done by using Cochran's Q test to assess heterogeneity, and the heterogeneity was then quantified by using an I² statistic. As recommended by Cochran, a p-value of less than 0.1 will be considered statistically significant heterogeneity[17]. The degree of heterogeneity in the I² statistic was determined as being low (0-25%), medium (25-75%), or high (75-100%).[17] A random-effects model was chosen *a priori* for the meta-analysis to account for the expected high levels of heterogeneity and give a more robust estimate. To assess whether the choice of tertiary education as the reference group in the meta-analysis influenced the results, we conducted a sensitivity analysis with secondary education as the reference category. This did not alter the main findings and the results from the sensitivity analysis are available in Supplementary Appendix B, Figures B1 and B2.

Patient and Public Involvement

Due to the global nature of the systematic review strategy, it was not feasible to involve the public in the design or conduct of this study.

Results

The literature search yielded 15,017 records after the first-degree removal of duplicates from the different databases. The hand-searching of reference lists of relevant records yielded an additional 384 records, and after duplicate removal, 15,345 records

continued to the abstract screening phase. Of these, 1,799 articles were assessed for eligibility in the full-text screening, and 579 articles met the criteria for data extraction for the global review. In total, 30 articles were conducted in one or more countries within the High-Income Asia Pacific region as shown in the PRISMA flow diagram in Figure 1. Of the 30 studies included in this synthesis, 24 are longitudinal cohort studies, five are cross-sectional studies utilizing unlinked death certificate data, and one is a prospective pooled cohort analysis.

Figure 1 about here

Study Characteristics

Table 2 gives an overview of the descriptive characteristics of the included studies. One study is a prospective pooled cohort study that uses data from both Japan, South Korea, and Singapore. Aside from the pooled cohort study, 14 studies each (48.3%) were completed in both Japan and South Korea, one study (3.45%) was completed in Singapore, and no studies were completed in Brunei Darussalam. A majority (19) of the studies were representative of the entire population (63.3%), while many were representative of specific cities, municipalities, or population groups. Leaving 11 studies that were not representative of the entire population (36.6%). In total, only two studies utilized data from as early as 1963 and 1970, while four studies included earliest data from the late 1980's, and 26 studies included data from the 1990's and onwards. Among the cohort studies, five studies (20%) were classified as "good" quality through the JBI risk of bias and quality critical appraisal checklists, while 20 (80%) were of "excellent" quality, and 0 studies were of "fair" quality. For cross-sectional studies, all five (100%) scored in the "good" quality category. The risk of bias and study quality scores and categories are presented for each included study in Table 2 and individual scores for each quality assessment criterion are presented in Supplemental Appendix C, Tables C1 and C2.

Table 2. Descriptive Characteristics of Included Studies

Author	Data Source	Years of Study	Sample Size	Ages	Male Population	Number of Deaths	Representative of population?	Max Years Follow-up	JBIScore	Quality Category
Japan										
Chiu et al., [3]	NUJLSOA	1999-2009	6,171	65+	43 %	n.d.	Yes	11	6	Good
Fujino et al., [18]	JACC Study	1988-1998	39,999	40-79	42 %	6,628	Yes	11	9	Excellent
Minagawa et al., [19]	NUJLSOA	1999-2009	13,225	65+	n.d.	1,434	Yes	10	10	Excellent
Tani et al., [20]	JAGES	2010-2013	15,449	65+	46 %	754	No	3.8	8	Excellent
Sugisawa et al., [21]	N/A	1987-1990	1,943	60+	46 %	161	Yes	3	7	Good
Ishizaki et al., [22]	Saku Longitudinal Study on Aging	1992-1998	8,090	65+	43 %	n.d.	No	6	10	Excellent
Iwasaki et al., [23]	Komo-Ise Study	1993-2000	5,629	40-69	100 %	338	No	7	11	Excellent
Nishi et al., [24]	AGES 2003 Cohort Study	2003-2007	14,668	65+	48 %	1,218	No	4	9	Excellent
Ito et al., [25]	JPHC Study Cohort I	1990-2003	39,228	40-59	48 %	2,430	No	13	10	Excellent
Honjo et al., [26]	JACC Study	1988-2009	16,692	40-60	0 %	1,019	No	20	9	Excellent
Hirokawa et al., [27]	Jichi Medical School Cohort Study	1992-2002	11,081	18+	39 %	588	No	10	9	Excellent
Honjo et al., [28]	JACC Study	1990-2006	57,109	40-65	43 %	6,054	Yes	16	7	Good
Liang et al., [29]	N/A	1987-1999	7,174	60+	45 %	724	Yes	12	11	Excellent
Iwasa et al., [30]	Longitudinal Interdisciplinary Study on Aging	1991-2000	2,447	52-77	42 %	264	No	7	11	Excellent
South Korea										
Jung-Choi et al., [31]†	N/A	1990-2004	70,167,890	25-64	50 %	1,415,287	Yes	N/A	5	Good
Khang & Kim [13]	The 1998 & 2001 KNHANES	1998-2012	10,137	30+	46 %	1,219	Yes	12	10	Excellent
Kim & Khang [12]	The 1998 NHANES	1998-2003	5,607	30+	47 %	264	Yes	6	9	Excellent

Khang et al., [32]	The 1998 & 2001 NHANES	1998-2005	8,366	30+	n.d.	310	Yes	8	8	Excellent
SUH, G. H. [33]	N/A	1999-2002	1,245	65+	43 %	158	No	3.5	7	Good
Lim et al., [34]†	N/A	1995-2010	81,354,834	30-59	50 %	348,208	Yes	N/A	5	Good
Kim et al., [35]	KLIPS	2003-2008	19,305	19+	50 %	424	Yes	6	8	Excellent
Son et al., [36]†	N/A	1993-1997	16,923,772	20-64	n.d.	287,001	No	N/A	5	Good
Bahk et al., [37]†	N/A	1970-2010	152,101,958	25-64	50 %	614,910	Yes	N/A	4	Good
Khang & Kim [11]	NHANES	1998-2003	5,437	30+	n.d.	242	Yes	6	9	Excellent
Khang & Kim [38]	The 1998 NHANES	1998-2002	5,607	30+	n.d.	197	Yes	4	8	Excellent
Khang et al., [39]†	N/A	1995-2000	15,177,375	35-64	50 %	462,776	Yes	N/A	5	Good
Khang [40]	KLIPS	1998-2003	1,574	50+	100 %	176	Yes	5	7	Good
Kim et al., [41]	KMSMS	1994-2014	70,713	40+	61 %	5,618	Yes	20	8	Excellent
Singapore										
Ma et al., [42]	1992 Singapore National Health Survey	1992-2001	3,492	18+	48 %	108	Yes	9	10	Excellent
Pooled Cohort Analysis										
Yang et al., [43]	Asia Cohort Consortium ¹ Japan	1963-1993	280,192	19+	45 %	59,822	Yes	15.8	8	Excellent
Yang et al., [43]	Asia Cohort Consortium ² South Korea	1992-1993	13,697	25+	100 %	894	No	15.6		
Yang et al., [43]	Asia Cohort Consortium ³ Singapore	1993-1999	63,247	19+	44 %	10,682	Yes	11.5		

†Cross-sectional

¹Japan Collaborative Cohort Study (JACC), Japan Public Health Center-Based Prospective Study (JPHC), Life Span Study Cohort (LSS), Miyagi Cohort (Miyagi) Ohsaki National Health Insurance Cohort Study (Ohsaki), Takayama Study (Takayama)²Seoul Male Cancer Cohort (SeoulM)³Singapore Chinese Health Study (SCHS)

Analysis of the Association between Educational Attainment and Mortality

Seven studies covering 222,241 individuals and 17,551 deaths allowed for analysis of all-cause mortality by harmonized educational categories. Figure 2 shows the risk of mortality by primary educational status with the tertiary educational category used as the reference category. The individual studies with the calculated (unadjusted) risk ratios (RR) and 95% confidence intervals, and the overall random-effects estimate are listed along with a forest plot visualization of the studies' estimates. For the studies included in the meta-analysis, six studies (86%) were categorized as "excellent" quality [13, 24, 25, 27, 35, 41] through the risk of bias and quality assessment, while one study (14%) was of "good" quality [28], and no studies were of "fair" quality.

The overall estimate indicated that individuals with primary education had 2.40 times the risk for all-cause mortality compared to tertiary educated individuals (95% CI: 1.74 to 3.31, $z=5.33$, $p<0.01$). In this analysis, risk ratios ranged from 1.21 to 6.13, with only one estimate including the null value.[16] The Q statistic was statistically significant ($Q=236.98$, $p<0.01$), and the I^2 value estimates that about 97% of the variation across studies is due to heterogeneity, rather than chance, both of which suggest significant heterogeneity.

Figure 2 about here.

Figure 3 illustrates the meta-analysis and forest plot using secondary education compared to tertiary education (reference) in mortality risk. In this analysis, the overall effect estimate shows a statistically significant increase in the risk of mortality by secondary education, with a 29% increase in risk ($z=2.87$, $p<0.01$). Meaning those with 10 to 12 years of schooling had 1.29 times the risk of mortality compared to those with 13 or more years of schooling. However, multiple studies did not show as clear of an increase in risk as in previous analyses. Three of the seven studies' effect sizes or 95% CI included the null value of 1, indicating a non-statistically significant or null effect of secondary education on the risk of mortality in these estimates. The Q statistic was statistically significant ($Q=57.50$, $p<0.01$), and the I^2 value estimates that about 90% of the variation across studies is due to heterogeneity, both of which suggest significant heterogeneity.

Figure 3 about here.

Discussion

This study is the most comprehensive systematic review with meta-analysis to date describing the influence of educational attainment on adult all-cause mortality in the High-Income Asia Pacific region. The results reveal that lower educational attainment is associated with a significant increase in the risk of mortality for adults in the High-Income Asia Pacific region. Despite impressive improvements in health and living conditions in the region in the past 50 years[4, 44], the inequalities in educational attainment and mortality have persisted. Though overall mortality rates in the population have declined, trends in relative inequalities show a persistence and widening in the region.[37, 45] A study by Kasajima and Hashimoto [45] examined absolute and relative educational disparities in mortality in Japan and found relative educational inequalities in all-cause mortality persisted despite improvement in average mortality rates. Interestingly, the researchers found that absolute inequalities also widened for causes of mortality linked to lifestyle and behavioral factors, as well as an overall worsening of average mortality for vulnerable populations such as youth and

women.[45] In South Korea, Bahk, Lynch, and Khang [37] found compositional changes in educational groups as a likely cause of the increase in absolute inequalities in mortality and mortality decline, which may have contributed to the increase of relative inequalities. When using measures more robust to such compositional changes, researchers found stable trends for both relative and absolute inequalities in recent years.[37] The pathways in which these trends in all-cause mortality have developed may also be different when examining relative or absolute inequalities. Khang et al. [32] found that when looking at relative educational inequalities in mortality, material factors explained 29% of the excess mortality risk compared to 78.6% of the absolute risk.[32] This shows how relative and absolute inequalities may develop differently, and while we may see worsening inequalities when measured on a relative scale, absolute inequalities may have remained stable, or even improved.

Similar multi-national studies of high-income countries in Europe have found large relative educational inequalities in all-cause mortality, as found in our study. Our estimates suggest a great relative disparity in total mortality for the lowest educated individuals compared to those with a college education or higher. Similarly, when estimating relative inequalities in Western European countries, Mackenbach et al. [46] find an increase in risk of all-cause mortality between 57% and 115% for the lowest educated men compared to the highest educated men, and between 37% and 105% for the lowest educated women, in the years 2005-2009.[46] The researchers also examined the trends in absolute and relative inequalities for these high-income countries between 1990-1994 and 2005-2009, finding that while many countries have seen an increase in the relative educational inequalities for both men and women, many countries have also seen an impressive reduction in absolute educational inequalities in mortality.[46] When looking over a longer time period (1979-2014), Mackenbach et al. [47] again find an almost universal widening of relative educational inequalities in mortality in Western Europe, likely resulting from decreasing mortality rates across the population.[47] The trend of declining mortality and stable or declining absolute inequalities remained despite periods of economic crisis and increases in unemployment and poverty.[47] Due to data restrictions, we were not able to examine long-term trends in relative inequalities in this analysis. If we assume the trends in the High-Income Asia Pacific region follow the same pattern seen in other high-income countries such as in Western Europe, we could expect to see rising relative educational inequalities with declining overall mortality and perhaps stable or improving absolute inequalities, as seen in studies by Kasajima and Hashimoto [45] and Bahk, Lynch and Khang [37]. There is still a need however for further analysis into educational inequalities in this region and analyses into the long-term trends in both relative and absolute terms.

To the best of our knowledge, only one other systematic review and meta-analysis of educational inequalities in all-cause mortality for the Asian context has been completed.[48] This review included, among others, Japan, South Korea, and Singapore, with 11 studies from these countries in their meta-analyses. Researchers compared the highest available education level to the lowest level in each study, finding an overall RR of 1.29 (95% CI:1.17-1.43) for those with “low education” compared to those with “high education” in their subgroup consisting of Japan, South Korea, and Singapore.[48] Overall, the results from Vathesatogkit, Batty and Woodward [48] support the results found in our analyses, however, their overall estimate includes the highest adjusted estimate from each study, while ours is

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based on unadjusted estimates, likely contributing to the lower estimate compared to ours. All included studies in the meta-analysis from Vathesatogkit, Batty and Woodward [48] except one, which did not meet our inclusion criteria, were included in our review—suggesting that the review process was thorough, and all relevant literature was included. Therefore, this study provides both an updating of the existing literature review and provides new knowledge on the relationship between education and health in this region, through harmonized educational groups.

Previous research has hypothesized the good health of Japan as being a result of high levels of collectivism, social cohesion, and job security.[49] Before the introduction of neo-liberal market reforms, employers in Japan and South Korea relied heavily on long-term workers with seniority-based wage systems. Through this framework, employees enjoyed relatively high levels of job security and low levels of income inequality between workers. However, due to the introduction of these reforms sparked by economic crisis, employers began shifting to non-regular workers and pay-per-performance schemes, resulting in rising insecurity and inequality with fewer social insurance protections for workers and weakening social cohesion.[50] This may have increased inequalities in South Korea as the relative risk of mortality for men of low education in 1980 was 3.44, increasing to 6.41 in 2000 after the introduction of these market reforms, when compared to highly educated men.[37]

Perhaps because of this transformation, the educational systems have seen skyrocketing competitiveness and high- and middle- income families are drastically outspending low-income families on education.[51-53] The phenomenon of “shadow education” or private supplemental educational lessons referred to as *juku* in Japan and *hagwon* in South Korea is by no means new or isolated to East Asian countries. The percentage of average monthly household educational expenditure on private supplementary education shows an unequal and rising trend across income quintiles from 2002 to 2013 in Singapore.[54] The wealthiest 20% increased their educational expenditures by 1.49% during this 10-year timespan, while the poorest 20% increased their expenditure by only 0.62%. These expenditure trends and skyrocketing competition may result in the educational system being a reproducer of class status instead of a mechanism for social mobility and may lead to an increase in future inequalities.[50] On the one hand, education can be used as a powerful tool to eliminate inequities and promote social mobility, while on the other hand, when middle- and high-income families drastically outspend low-income families on supplemental schooling, education is used to reproduce and exacerbate inequities in society.

Implications and Future Research

By demonstrating a gradient effect of education on mortality, we offer empirical support for policies that aim to improve morbidity and mortality across all socioeconomic groups rather than focus on closing the gap between the most and least advantaged groups. We also demonstrate strong support for policy aimed at improving access to education for all, from primary through higher education, as we see a significant impact of education on the health and life of all individuals.

Although this review offers valuable empirical evidence, further research is needed on this topic and region. Additional longitudinal data is also needed, especially in South Korea, Singapore, and Brunei Darussalam. This lack of data highlights that although these countries are classified as high-income, research in health inequalities is dominated by studies

conducted in the U.S and Europe. Further research is also needed to examine the mechanisms in which education influences health and mortality, although this requires a rich, comprehensive evidence base, and so far, is not feasible in this region. This review makes an essential step in the identification and monitoring of educational inequalities in mortality in the High-Income Asia Pacific region, and future research is needed to monitor these trends across time and eventually to reduce disparities in health, allowing all individuals the opportunity to live a long healthy life.

The results and interpretations of this review should be taken with consideration to its limitations. We cannot be sure that our conclusions apply to countries with severe data restrictions, namely Singapore and Brunei Darussalam. As all the studies relied on self-reported education levels, we cannot rule out the potential for response bias in some individuals if they could not accurately remember their total years of education or their highest level of educational attainment. Additionally, the high levels of heterogeneity in the analysis should not be ignored. This is most likely due to the differences between the populations within the studies and differences between methodologies and measurements used. While it is not surprising that there are high levels of heterogeneity in the meta-analysis, due to the between country nature of the study and the inability to control for all confounders within the primary studies, the interpretation of this meta-analysis should be taken with caution as we cannot be sure the effect seen from these studies would be the same for the entire population either within or outside of the region studied.

To our knowledge, this is the most up-to-date review of educational attainment and adult mortality conducted in this region. This study benefits from using education as a measure of socioeconomic status, as this is a consistent and early indicator of an individual's SES.[55] This review also utilized a thorough global search without language restriction allowing for near-complete coverage of all relevant articles. Additionally, the meta-analysis utilized harmonized educational categories in estimating the adult all-cause mortality, which, as far as we know, has not previously been done in this region. Lastly, this study employed a random-effects model, giving a more robust estimate given the high levels of heterogeneity.

Conclusion

This study provides empirical evidence to support the association between educational attainment and adult all-cause mortality in the High-Income Asia Pacific region. We see a gradient effect of education on mortality as with every step up the educational ladder, individuals experience a reduced risk of mortality. Overall, these results offer a basis for evidence-based policy decisions to reduce health disparities across the educational gradient and improve access to education from primary to higher education. Further research is needed to expand the limited research base in this region, to allow for consistent monitoring of these trends, and to support further policy changes aimed at reducing health disparities.

Author Contributions

The study concept and strategy was developed by MB, KS, EG, and TAE. The search strategy was developed and executed by MRJ and SS. Study screening and data extraction was completed by KB, LD, TM, HDV, CD, KE, AG, IG, and CW. Statistical analyses were completed by KB. The manuscript was drafted by KB and revised by TAE, MB, and KS.

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Other Information

The protocol for the review was registered in the PROSPERO registration for systematic reviews under number CRD42020183923.

Ethical approval was not acquired as it is not applicable to this research article. As this article uses only published, widely available data from published journal articles, no ethical approval is required. No human participants or animal subjects were used in this research.

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Declaration of Interests

No competing interests to declare for any of the authors.

Data Availability

Researchers interested in using the extracted data from systematic review articles may contact Prof. Terje Eikemo, Department of Sociology and Political Science, NTNU with this request at terje.eikemo@ntnu.no. This data includes information extracted from published journal articles found through the systematic review literature searches.

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Figure 1. PRISMA Flow Diagram

Note. 12 Extractions from one book.

Figure 2. Forest Plot for Primary Education vs. Tertiary Education

Note. Primary education equates to middle school or less (0-9 years), while tertiary education
equates to college or higher (≥ 13 years). Tertiary education is the reference category.

Figure 3. Forest Plot for Secondary Education vs. Tertiary Education

Note. Secondary education equates to high school (10-12 years), while tertiary education
equates to college or higher (≥ 13 years). Tertiary education is the reference category.

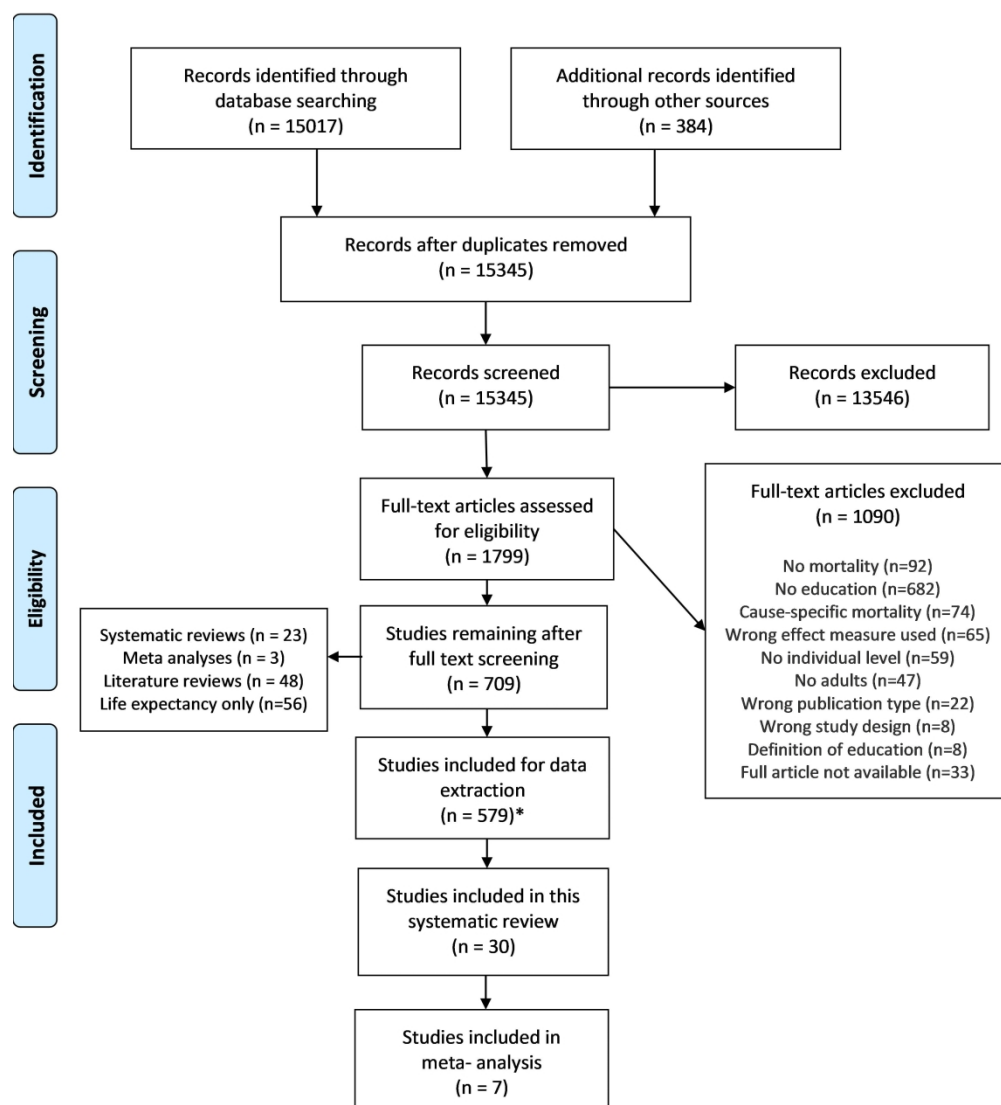


Figure 1. PRISMA Flow Diagram Note. 12 Extractions from one book.

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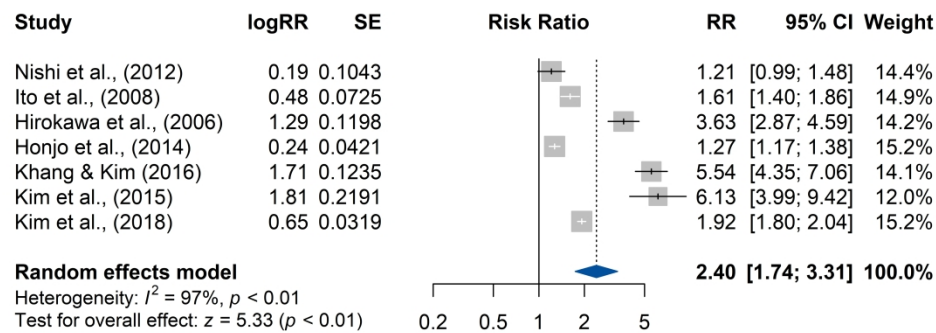


Figure 2. Forest Plot for Primary Education vs. Tertiary Education Note. Primary education equates to middle school or less (0-9 years), while tertiary education equates to college or higher (≥ 13 years). Tertiary education is the reference category.

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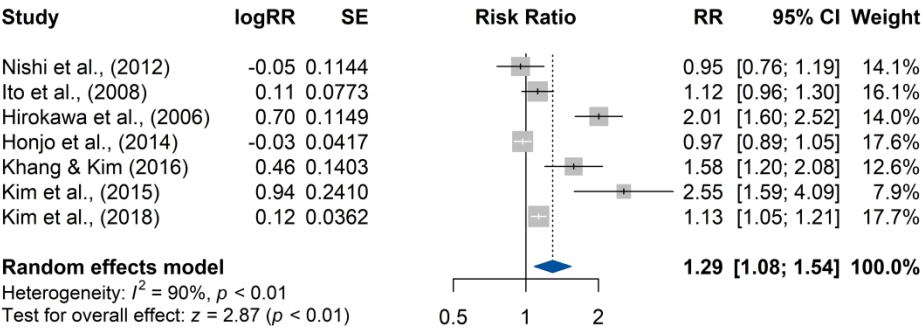


Figure 3. Forest Plot for Secondary Education vs. Tertiary Education. Note. Secondary education equates to high school (10-12 years), while tertiary education equates to college or higher (≥ 13 years). Tertiary education is the reference category.

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Supplemental Information: Appendix A

The literature search string used is provided below:

Search Terms: 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 (*adult**) 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

Supplemental Information: Appendix B

Risk of bias and study quality was assessed using the Joanna Briggs Institute Critical Appraisal checklists for each study design.[1, 2] The critical appraisal criteria and scores for each criterion within the included articles are presented in Supplemental Tables B1 and B2.

Cohort Studies Criteria: [1]

1. Were the two groups similar and recruited from the same population?
2. Were the exposures measured similarly to assign people to both exposed and unexposed groups?
3. Was the exposure measured in a valid and reliable way?
4. Were confounding factors identified?
5. Were strategies to deal with confounding factors stated?
6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?
7. Were the outcomes measured in a valid and reliable way?
8. Was the follow up time reported and sufficient to be long enough for outcomes to occur?
9. Was follow up complete, and if not, were the reasons to loss to follow up described and explored?
10. Were strategies to address incomplete follow up utilized?
11. Was appropriate statistical analysis used?

Table B1. Risk of Bias and Study Quality Assessments for Included Cohort Studies

Author	Criterion #1	Criterion #2	Criterion #3	Criterion #4	Criterion #5	Criterion #6	Criterion #7	Criterion #8	Criterion #9	Criterion #10	Criterion #11	JB1 Score	Quality Category
Chiu et al., [3]	Yes	Yes	Yes	No	No	Yes	No	Yes	Unclear	Unclear	Yes	6	Good
Fujino et al.,[4]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	9	Excellent
Minagawa et al., [5]	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	10	Excellent
Tani et al., [6]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	No	No	Yes	8	Excellent
Sugisawa et al., [7]	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Unclear	No	No	Yes	7	Good
Ishizaki et al., [8]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	10	Excellent
Iwasaki et al., [9]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11	Excellent

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Nishi et al., [10]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	9	Excellent
Ito et al., [11]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	10	Excellent
Honjo et al., [12]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	9	Excellent
Hirokawa et al., [13]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	9	Excellent
Honjo et al., [14]	Yes	Unclear	Yes	Yes	Yes	Yes	Unclear	Yes	No	No	No	Yes	7	Good
Liang et al., [15]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11	Excellent
Iwasa et al., [16]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11	Excellent
Khang & Kim [17]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	10	Excellent
Kim & Khang [18]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	No	Yes	9	Excellent
Khang et al., [19]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Unclear	Unclear	Yes	8	Excellent
SUH, G. H. [20]	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	Unclear	Unclear	Yes	7	Good
Kim et al., [21]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Unclear	Unclear	Yes	8	Excellent
Khang & Kim [22]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	9	Excellent
Khang & Kim [23]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Unclear	Unclear	Yes	8	Excellent
Khang [24]	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Unclear	Unclear	Yes	7	Good
Kim et al., [25]	Yes	Yes	Yes	Yes	N/A	Yes	Yes	Yes	Yes	Yes	N/A	N/A	8	Excellent
Ma et al., [26]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	10	Excellent
Yang et al., [27]	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A	Yes	8	Excellent

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Cross-Sectional Studies Criteria: [2]

1. Were the criteria for inclusion in the sample clearly defined?
2. Were the study subjects and the setting described in detail?
3. Was the exposure measured in a valid and reliable way?
4. Were objective, standard criteria used for measurement of the condition?
5. Were confounding factors identified?
6. Were strategies to deal with confounding factors stated?
7. Were the outcomes measured in a valid and reliable way?
8. Was appropriate statistical analysis used?

Table B2. Risk of Bias and Study Quality Assessments for Included Cross-Sectional Studies

Author	Criterion #1	Criterion #2	Criterion #3	Criterion #4	Criterion #5	Criterion #6	Criterion #7	Criterion #8	JB1 Score	Quality Category
Jung-Choi et al., [28]	Yes	No	Yes	Yes	No	No	Yes	Yes	5	Good
Lim et al., [29]	Yes	No	Yes	Yes	No	No	Yes	Yes	5	Good
Son et al., [30]	No	No	No	Yes	Yes	Yes	Yes	Yes	5	Good
Bahk et al., [31]	No	No	Yes	Yes	No	No	Yes	Yes	4	Good
Khang et al., [32]	Yes	No	Yes	Yes	No	No	Yes	Yes	5	Good

References

1 Joanna Briggs Institute. Checklist for Cohort Studies. 2017.

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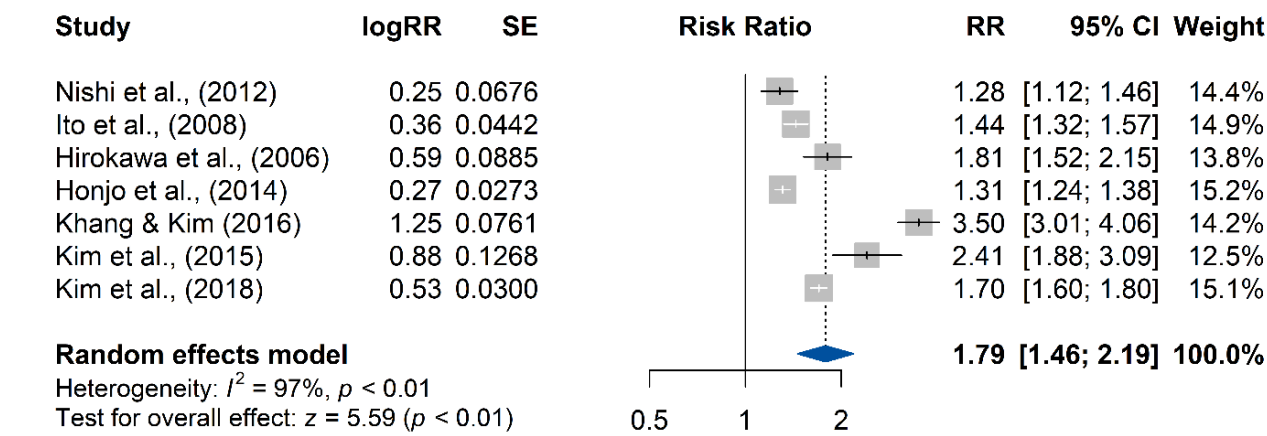
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- 28 Jung-Choi K, Khang Y-H, Cho H-J. Changes in Contribution of Causes of Death to Socioeconomic Mortality Inequalities in Korean Adults. *Journal of Preventive Medicine and Public Health* 2011;**44**:249-59.
- 29 Lim D, Kong KA, Lee HA, *et al.* The population attributable fraction of low education for mortality in South Korea with improvement in educational attainment and no improvement in mortality inequalities. *BMC Public Health* 2015;**15**:313.
- 30 Son M, Armstrong B, Choi JM, *et al.* Relation of occupational class and education with mortality in Korea. 2002:2.
- 31 Bahk J, Lynch JW, Khang Y-H. Forty years of economic growth and plummeting mortality: the mortality experience of the poorly educated in South Korea. *J Epidemiol Community Health* 2017;**71**:282-8.
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Supplemental Information: Appendix C

Supplementary Figure C1

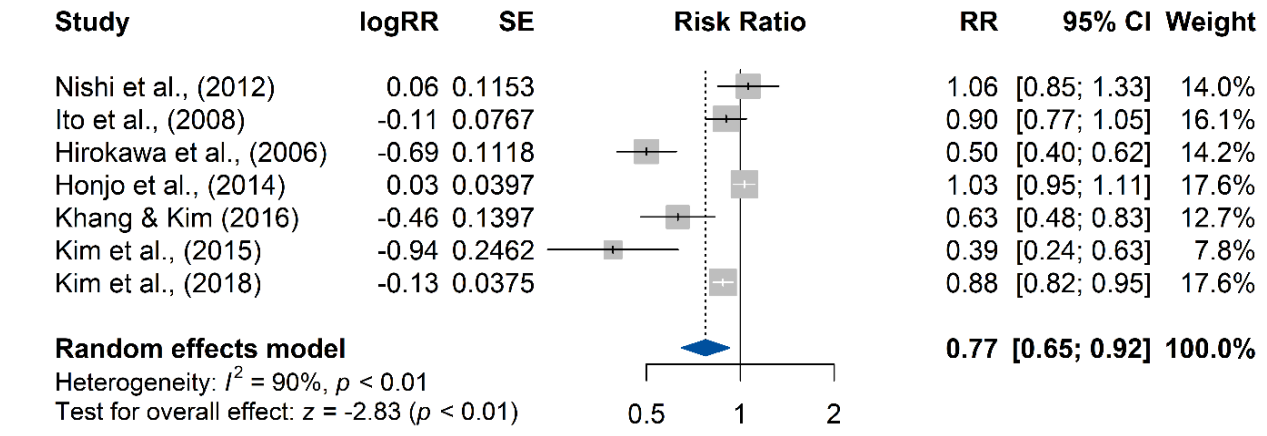
Figure C1. Forest Plot for Primary Education vs. Secondary Education



Note. Primary education equates to middle school or less (0-9 years), while secondary education equates to high school (10-12 years). Secondary education is the reference category.

Supplementary Figure C2

Figure C2. Forest Plot for Tertiary Education vs. Secondary Education



Note. Tertiary education equates to college or higher (≥ 13 years), while secondary education equates to high school (10-12 years). Secondary education is the reference category.



PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	page 1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	page 3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	page 4-5
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	page 4-5
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	page 5-7, table 1
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	page 5
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	page 5, supplemental appendix 1
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	page 5-6
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	page 6
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	page 5-6, table 1
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	page 6
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	page 5
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	page 6-7
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	page 6-7
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	page 6-7
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	page 6-7
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	page 6-7
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	page 7
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	page 7
Reporting bias	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	page 7



PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
assessment			
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	N/A
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	page 7, figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	NA
Study characteristics	17	Cite each included study and present its characteristics.	page 8, table 2
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	page 7-8, table 2, tables S1 & S2
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	page 12, figures 2, 3
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	page 12
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	page 12, figures 2,3
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	NA
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	page 7, supplementary appendix 3
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	NA
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	page 12-14
	23b	Discuss any limitations of the evidence included in the review.	page 15
	23c	Discuss any limitations of the review processes used.	page 15
	23d	Discuss implications of the results for practice, policy, and future research.	page 14-15
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	page 16
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	page 16
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	page 16
Competing interests	26	Declare any competing interests of review authors. For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	page 16

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PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	page 16

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71
For more information, visit: <http://www.prisma-statement.org/>

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