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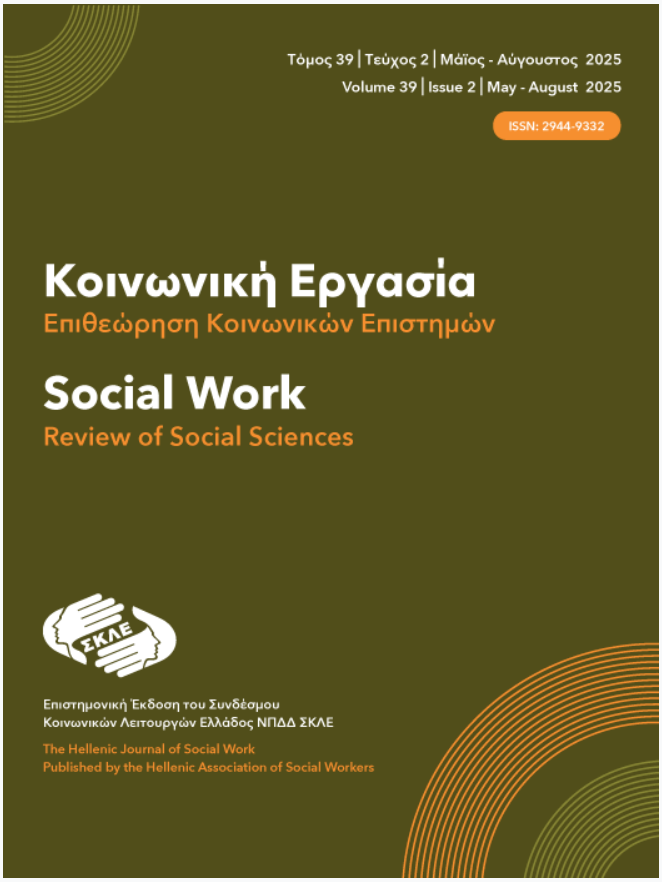

Εκπαίδευση και ευδόκιμη γήρανση: Μια συστηματική ανασκόπηση και μετά-ανάλυση μελετών κοόρτης

Ευαγγελία Τσιλώνη, Έλενα Δραγκιώτη, Μαίρη Γκούβα, Στέφανος Βασιλόπουλος, Μανόλης Μέντης

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Education and successful Aging: A systematic review and meta-analysis of cohort studies

Tsiloni Evangelia[1], Dragioti Elena[2], Gouva Mary[3], Vassilopoulos P. Stephanos[4], Mentis Manolis[5]

[1] Phd Student, Department of Educational Sciences and Social Work, University of Patras, Greece.
[2] Associate Professor, Research Laboratory Psychology of Patients, Families & Health Professionals, Department of Nursing, School of Health Sciences, University of Ioannina, Greece.
[3] Professor, Research Laboratory Psychology of Patients, Families & Health Professionals, Department of Nursing, School of Health Sciences, University of Ioannina, Greece.
[4] Professor, Department of Educational Sciences and Social Work, University of Patras, Greece.
[5] Assistant Professor, Department of Educational Sciences and Social Work, University of Patras, Greece.

ABSTRACT

Successful aging refers to a multifaceted concept that includes the physical, cognitive, emotional, and social health of older adults. In recent years, growing research interest has focused on the various factors that contribute to positive aging outcomes. This study examines the relationship between educational level and successful aging in individuals aged 65 and over, using a systematic review and meta-analysis of cohort studies. Electronic databases (PubMed, Scopus, ERIC, and PsycINFO) were searched to identify eligible papers following the PRISMA guidelines. Additionally, reference lists of relevant systematic reviews, meta-analyses, and included studies were reviewed. The methodological quality of the selected studies was appraised through the application of the Newcastle-Ottawa Scale (NOS). Combined estimates were calculated using random-effects models with the REML method in R version 4.4.0. Twenty-eight articles met the eligibility criteria and were included in the review and meta-analysis. Statistical analysis showed that upper secondary education (OR = 1.17, 95% CI = 1.09–1.26), tertiary education (OR = 1.27, 95% CI = 1.03 –1.56), and varied educational levels (OR = 1.11, 95% CI = 1.05–1.18) were significantly associated with successful aging of older adults. Based on the current data, higher educational levels are significantly associated with successful aging in later life.

Key-words: Successful aging; Healthy aging; Education; Lifelong education; Older adults

Correspondence: Evangelia Tsiloni, evangeliatsiloni@gmail.com

Introduction

The continuous increase in global life expectancy has led to a significant rise in both the absolute and relative numbers of older adults within national populations (World Health Organization, 2022). The demographic landscape of the European Union is undergoing a profound transformation, with the proportion of the population aged 65 and over expanding steadily. Projections indicate that, within the next few decades, this age group will represent nearly one-third of the total population, marking a major shift in the region's age structure (Eurostat, 2020). This demographic shift poses significant challenges for healthcare systems and societies, as advancing age often correlates with an increased vulnerability to various diseases and disabilities, including chronic conditions such as diabetes and cardiovascular diseases, as well as mental health disorders such as dementia and depression (Almeida et al., 2006). In this direction, the United Nations General Assembly defined 2021-2030 as the Decade of Healthy Ageing to improve older adults' lives, their family environment, as well as the communities (World Health Organization, 2021).

In response to the increasing aging population, there is a growing need to understand how to age well (Abud et al., 2022). Successful aging (SA) is a complex concept that has been described in the literature through various related terms, including "healthy aging," "active aging," "productive aging," "positive aging," and "aging well," reflecting the broad range of its interpretations (Belachew et al., 2024). In 1997, Rowe and Kahn introduced the biomedical model of successful aging, which emphasized the absence of major diseases and the maintenance of high physical, cognitive, and social functioning (Rowe & Kahn, 1997). Although this model set the stage for subsequent definitions, it was often criticized for its narrow focus on health aspects without considering the broader experiences of older adults (Wagg et al., 2021).

In recent years, the World Health Organization (WHO) has provided a broader framework for understanding healthy aging, defining it as the ability to maintain and develop functional capacity that supports wellbeing in later life (World Health Organization, 2015). This definition highlights the importance of maintaining not only physical and cognitive functions but also the capacity to engage in meaningful social and emotional activities (Wagg et al., 2021). Current research supports this multidimensional view of successful aging, suggesting that a thorough understanding should encompass both objective and subjective measures across physical, cognitive, mental, and social domains (Urtamo et al., 2019). Despite these advancements, reaching a consensus on a standardized definition of successful aging remains challenging due to considerable variability in conceptualizations across different studies (Behr et al., 2023).

Recent research has increasingly examined the factors associated with successful aging through a multidimensional lens. Daskalopoulou et al. (2018) focused on behavioral influences, identifying clear links between smoking, alcohol consumption, and healthy aging. Lin et al. (2020) emphasized physical activity as a key factor contributing to the successful aging process in both middle-aged and older populations. In addition, Rodrigues et al. (2023) provided a broader synthesis of determinants and indicators, highlighting the complexity of successful aging as an outcome influenced by biological, psychological, and social dimensions. Within this multidisciplinary exploration, education has emerged as a significant area of interest, often considered part of an individual's socioeconomic position (SEP) (Kok et al., 2016). Studies have suggested that education may be correlated with various aspects of well-being in older adults, including physical health, cognitive function, mental health, and social engagement (Lövdén et al., 2020; Sirven & Debrand, 2008). Despite the extensive research conducted, the precise impact of education on the process of successful aging remains inconclusive (Cosco et al.,

2017; Curcio et al., 2018; Gureje et al., 2014; Jang, 2020; Nie et al., 2021; Strawbridge et al., 1996).

Several systematic reviews have examined the relationship between socioeconomic factors and successful aging. For example, Depp and Jeste (2006) explored general demographic influences, while Wagg et al. (2021) and Zhang et al. (2022) focused on income and social participation. However, none of these studies specifically investigated the role of educational attainment in individuals aged 65 and above. Rodrigues et al. (2023) emphasized the need to consider education as a distinct determinant of successful aging. To address this gap, this study aims to conduct the first systematic review and meta-analysis of longitudinal studies examining the relationship between education and successful aging in older populations, providing deeper insights into how education influences the multifaceted nature of aging well.

Materials and methods

Search Strategy

This review and meta-analysis followed the reporting standards outlined in the PRISMA guidelines for systematic reviews and meta-analyses (Lee & Koo, 2022). The protocol is available online at: https://osf.io/vbta6.

The electronic databases of PubMed, Scopus, ERIC, and PsycINFO were searched from their inception dates to March 31, 2024. The search strategy utilized a combination of keywords and controlled vocabulary terms (MeSH terms) to identify relevant studies on "education," "successful aging," "older adults," and "cohort." Synonyms were also incorporated to broaden the search. The search strategy was adapted to align with the unique features of each database. Furthermore, reference lists from the selected studies, as well as from pertinent systematic reviews and meta-analyses, were also reviewed.

Inclusion and Exclusion Criteria

Studies were included if they: a) mentioned successful aging (SA) or its synonyms (e.g., healthy aging) in the title or abstract, b) provided a definition of successful aging, c) were cohort studies discussing any kind of longitudinal association between education and successful aging, and d) were peer-reviewed articles written in the English language. The authors specifically focused on studies involving participants over 65 years old at follow-up to explore the connection between education and successful aging. This age group provided insights into the long-term impact of education on cognitive function, physical health, and overall well-being in later life. Case reports, reviews, meta-analyses, research protocols, conference abstracts, and commentaries were excluded.

Data Extraction

All citations were retrieved, imported into a citation management software, EndNote, and then independently screened by two review members (ET and ED) according to the inclusion and exclusion criteria. In cases where discrepancies arose, a third reviewer (MG) was consulted to reach consensus. Upon confirming the eligibility of the studies, data extracted included: first author, publication year, country, study, sample size, baseline age, follow-up age, education measurement, definition of successful aging, measurement of successful aging, length of follow-up, as well as odds ratios (OR) or any other relevant metrics (HR, β) and their corresponding 95% confidence intervals (CIs). Additionally, the type of successful aging definition was recorded. Studies with definitions that covered at least three

basic domains of successful aging —physical, cognitive, psychological, and social —were considered multidimensional, while others were categorized as non-multidimensional.

Quality Assessment

The adapted Newcastle-Ottawa Scale for cohort studies was utilized to evaluate the methodological quality of the included studies, assessing them across three main domains: selection, comparability, and outcome (Wells et al., 2000). Consistent with previous reviews (Lin et al., 2020; Wagg et al., 2021), a tailored version of this scale was employed to align with the specific purposes of this study (Table 1). The studies were then categorized into three quality levels: good (seven to ten stars), fair (five to six stars), and poor quality (four stars or fewer). Two reviewers (ET and ED) independently assessed the quality of the eligible studies, and any discrepancies in their ratings were resolved through consultation with a third reviewer (MG).

Table 1.
Description of Newcastle-Ottawa quality assessment scale for cohort studies

Criteria	Description	Scoring
A. Selection	Representativeness of the exposure cohort	From community of general population (+1) ≥70% Response rate (+1)
	Ascertainment of exposure	Hierarchical, graded education or years of education (+1)
B. Comparability	Comparability of cohorts based on the design or analysis	Control for age and sex (+1) Control for any additional factor (+1)
C. Exposure	Assessment of outcome	Successful Aging was adequately measured if at least three of four basic domains of successful aging were assessed (physical, cognitive, psychological, and social) (+1) Objective measurements of Successful Aging (+1) Subjective measures of Successful Aging (+1)
	Was follow up long enough for outcomes to occur?	At least 24 months (+1)
	Adequacy of follow up of cohorts	Follow up rate more than 80%, or subjects lost to follow up unlikely to introduce bias (+1)

Data Synthesis

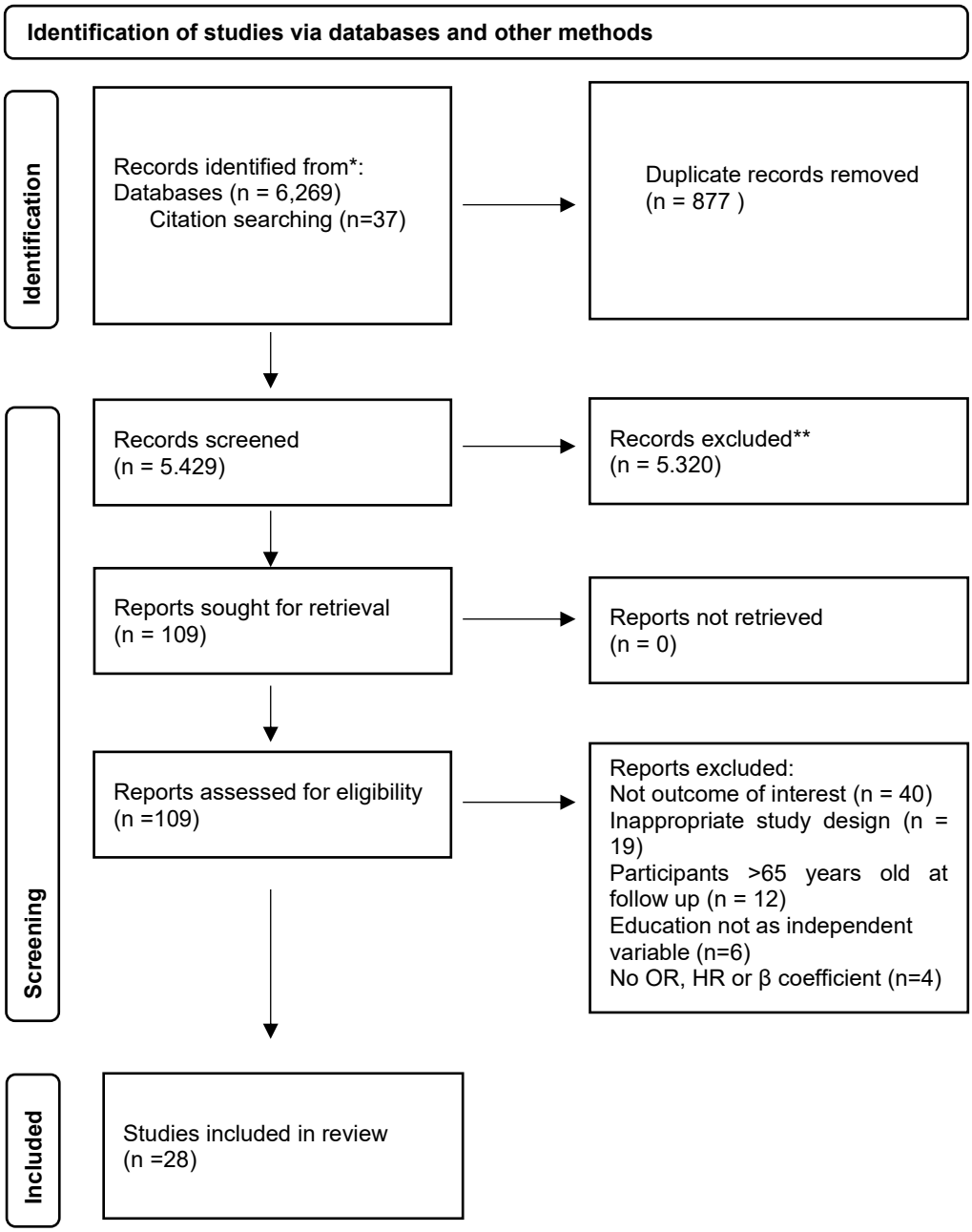
We first categorized the education levels as follows: No Formal Education was defined as "*0 years of education, Illiterate."* Primary Education was categorized as "*Primary and below, 1-6 years of education."* Lower Secondary Education included *"7-12 years of education, ≤8 years, 9-12 years, < Higher school certificate, <12 years of education, Low education: <12 years of education, Middle school or above*." Upper Secondary Education encompassed "*Secondary education, Secondary graduation or more, ≥High school, Years of education (5-18), Years of education (6-19), High school or university education, ≥12 years of education*." Tertiary Education was described as "*Tertiary education, College graduate, >College graduate*." Varied Educational Levels were defined as "*Educational level, Educational level (10 levels), Education, Schooling, Years of education, Education (one category increase)."* These categories were used to ensure consistency in analysis, given the diverse range of education levels reported in the studies. Additionally, we transformed the regression coefficient (b) to log Odds Ratios (log OR) to harmonize the reported effect sizes for the analysis (Dimou et al., 2023; Dragioti et al., 2015). The binary effects sizes were also transformed to log OR, and all log ORs were then analyzed converting them to ORs.

For each education category, we synthesized the combined estimates using random-effects models with the Restricted Maximum Likelihood (REML) method. This approach allowed us to account for variability both within and between studies, providing a more comprehensive and reliable estimate of the effect of education on successful aging. We also examined heterogeneity and publication bias. Heterogeneity across studies was quantified using the I^2 statistic, reflecting the extent to which observed variation stems from true differences rather than chance (Higgins et al., 2003). Publication bias was evaluated using Egger's test for funnel plot asymmetry (Egger et al., 1997), and illustrated by funnel plots (Light & Pillemer, 1984). Two additional sensitivity analyses were performed to assess the variation in odds ratios associated with successful aging. One analysis was stratified by sex (Both, Men, Women), and the other by whether the definition of successful aging was multidimensional or not. Statistical analyses for the meta-analysis were carried out using R software (version 4.4.0), with the metafor package employed to perform all effect size estimations and model computations (R Core Team, 2023; Viechtbauer, 2010).

Results

The search identified 6,269 papers from the databases and 37 additional papers were obtained from citation searching. After the removal of duplicates (n=877), a total of 5,429 papers were screened for eligibility based on title and abstract. Of these, 109 papers were considered for full-text review, and finally, 28 cohort studies met the inclusion criteria and were included in the systematic review and meta-analysis. The PRISMA flowchart detailing the study selection process is shown in Figure 1.

Figure 1.
PRISMA flowchart



Characteristics of Included Studies

The characteristics and main outcomes of the included studies are summarized in Table 2, while Table 3 presents the results of associations between education and successful aging in these studies. The studies were published between 1996 (Strawbridge et al., 1996) and 2024 (Wang et al., 2024). Regarding the geographical setting, the majority of studies were conducted in American countries, including the USA (Ford et al., 2000; LaCroix et al., 2016; Leveille et al., 1999; McLaughlin et al., 2020; Strawbridge et al., 1996; Terry et al., 2005; Vaillant & Western, 2001; Willcox et al., 2006; Xu et al., 2015), Canada (Kaplan et al., 2008; Shields & Martel, 2006; White et al., 2015), Mexico (Arroyo-Quiroz et al., 2020), and Hawaii (Bell et al., 2014). Five studies were conducted in Asia, comprising two from China (Chang et al., 2023; Wang et al., 2024), two from Taiwan (Hsu & Jones, 2012; Liu & Su, 2017), and one from Indonesia (Oktaviani et al., 2022). Additionally, four studies were carried out in Australia (Almeida et al., 2006; Byles et al., 2019; Hodge et al., 2013, 2014), three in Europe (Cosco et al., 2017; Kok et al., 2016; Whitley et al., 2018), and one study in Africa (Gureje et al., 2014). Furthermore, one study included data from four countries: the USA, England, China, and Japan (Lu et al., 2021).

Sample sizes ranged from 356 (Strawbridge et al., 1996) to 73,579 (LaCroix et al., 2016). Except for four studies that investigated only men (Almeida et al., 2006; Bell et al., 2014; Vaillant & Western, 2001; Willcox et al., 2006) and two studies that examined only women (Byles et al., 2019; LaCroix et al., 2016), the rest of the studies included both men and women. The follow-up time varied from two (Ford et al., 2000; Xu et al., 2015) to 45 years (Terry et al., 2005). Finally, a multidimensional definition for successful aging was applied in 12 studies (Chang et al., 2023; Cosco et al., 2017; Hsu & Jones, 2012; Kok et al., 2016; Liu & Su, 2017; Lu et al., 2021; Oktaviani et al., 2022; Vaillant & Western, 2001; Wang et al., 2024; White et al., 2015; Whitley et al., 2018; Xu et al., 2015), while the remaining studies employed more limited definitions that considered fewer domains.

Methodological Quality of the Included Studies

The majority of studies (22 studies) had good quality, while six studies had fair quality (Table 2).

Table 2.
Characteristics of included studies

Authors (Year)	Country	Study	Sample size	Gender (%)	Baseline Age	Follow Up Age	Follow up (mean years)	Term used for SA	Main Outcome	Quality
Almeida et al. (2006)	Australia	A longitudinal Study of Older Australian Men	601	100% men	≥65	≥80	4.8	Successful mental health aging	Higher education was positively associated with successful mental health aging (HR=1.92, 95% CI: 1.34 - 2.75, p<0.001).	Fair
Arroyo-Quiroz et al. (2020)	Mexico	MHAS	5142	52.7% women	>50 (M=63)	≥77	14	Healthy Aging	Schooling was significantly associated with healthy aging at 77 (OR=1.05, CI: 1.03-1.08, p<0.01).	Good
Bell et al. (2014)	Hawaii	Hawaii Lifespan Study	1292	100% men	71-82 (M=75.7)	85-95 (M=85)	21	Healthy Aging	Less years of education were associated with increased odds of poor health (OR=1.69, 95% CI: 1.29-2.20, p<.001).	Good
Byles et al. (2019)	Australia	ALSWH	10062	100% women	70-75	90-95	20	Successful Aging	Women classified as successful seniors had better education (OR=0.59, 95% CI: 0.48 - 0.71, p<0).	Fair
Chang et al. (2023)	China	CHARLS	1949	62.7% men	≥60 (60-69)	>67	7	Successful Aging	Higher levels of education were associated with better levels of successful aging (illiterate: OR=0.097, 95% CI: 0.057-0.164, p=<0.001; primary and below: OR=0361, 95% 0.232-0.561, p<0.001).	Good
Cosco et al. (2017)	UK	CFAS	1141	63.4% women	≥65 (M=76)	NR	4	Sustained Independence	Higher education was associated with higher SA trajectories in later life in the total sample (OR=1.44, 95% CI: 1.14-1.82) and women (OR=1.50, 95% CI: 1.11-2.03).	Good
Ford et al. (2000)	USA	A longitudinal Study of persons aged 70 and older	602	70.3% women	≥70 (M=78)	NR	2	Successful Aging	Education was not associated with successful aging (OR=1.08, 95% CI: 0.89-1.30, p=.67).	Good
Gureje et al. (2014)	Nigeria	ISA	930	61.1% men	≥65	≥70 (M=79)	5.3	Successful Aging	Education was not predicted successful aging (OR=1.2, 95%CI: 0.20-7.68).	Good
Hodge et al. (2013)	Australia	MCCS	5512	NR	>60	≥70 (M=70)	11.7	Successful Aging	Education level was not associated with increased odds of ageing successfully (OR=0.99, 95% CI: 0.71-1.39).	Good
Hodge et al. (2014)	Australia	MCCS	5636	63 % women	27-75 (M=65.8)	>70	11	Successful Aging	Higher education was associated with successful aging (OR=1.43, 95% CI: 1.08-1.89).	Good

Hsu & Jones (2012)	Taiwan	Taiwan Longitudinal Survey on Aging	2584	NR	>60	NR	14	Successful Aging	Individuals with lower education were more likely to be in the usual aging, declining health, or care demanding groups than in the successful aging group (OR=0.901, p<.001; OR=0.888, p<.001; OR=0.886, p<.001).	Good
Kaplan et al. (2008)	Canada	CNPHS	2432	56% women	65-85	>70	10	Thriving	Education was not significantly associated with thriving (OR=1.31, 95% CI: 0.76-2.26).	Good
Kok et al. (2016)	Netherlands	LASA	2095	52.6% women	55-85 (M=69)	NR	16	Successful Aging	Higher education was strongly associated with successful aging (β=0.06, 95% CI: 0.02-0.09).	Good
LaCroix et al. (2016)	USA	WHI	73579	100% women	50-79 (M= 68.9)	≥80	16	Aging Well	In female veterans, having less than a college education was not associated with better survival outcomes. However, in non-veteran women, those without a college degree were notably less likely to be categorized as part of the group with healthy survival (OR=0.91, 95% CI: 0.87-0.94, p ≤ 0.05).	Fair
Leveille et al. (1999)	USA	EPESE	1907	55.6% men	≥65	>80 or death	10	Successful Aging	Education was no associated with being nondisabled prior to death in very old age (OR=0.85, 95%CI: 0.53-1.35).	Good
Liu & Su (2017)	Taiwan	TLSA	3118	56% men	≥60 (M=72)	≥65	14	Healthy Aging	Education was found to be robust factor in predicting healthy aging (β=0.29, p<0.001).	Good
Lu et al. (2021)	USA	HRS	10305	58.8% women	>60 (M=72)	NR	10	Healthy Aging	Higher education level was associated with healthy aging in the four countries (β=-0067 (USA); -0.082 (England); -0.139 (China); -0.061 (Japan), p<0.001).	Good
	England	ELSA	6590	55.9% women	>60 (M=71)	NR	13			
	China	CHARLS	5930	51.7% men	>60 (M=68)	NR	4			
	Japan	JSTAR	1935	51% women	>60 (M=67)	NR	4			
McLaughlin et al. (2020)	USA	HRS	17591	NR	≥51	NR	14	Healthy Aging	Higher educational level was associated with healthy aging (β=1.127, p<0.001).	Good
Oktaviani et al. (2022)	Indonesia	IFLS	1289	52.1% women	≥60	≥65	7	Successful Aging	Higher education was associated with successful aging in women (OR=2.24, 95% CI: 1.25-4.01, p<0.01), but not in men (OR=1.27, 96%CI: 0.92-1.75).	Good
Shields & Martel (2006)	Canada	NPHS	1309	NR	≥65	NR	8	Good Health	Higher education was associated with staying healthy (HR=1.3, 95% CI: 1.0-1.2, p<0.05).	Good
Strawbridge et al. (1996)	USA	The Alameda County Study	356	59% women	65-95 (M=72)	NR	6	Successful Aging	Higher education did not significantly predict successful aging (OR = 1.67, 95% CI: 0.98-2.84).	Good

Terry et al. (2005)	USA	Framingham community-based cohort study	2531	56% women	40-50	≥85	45	Healthy survival	Higher education predicted survival to age 85 (OR=1.25, 95% CI: 1.12-1.39, p<.001) and survival free of major morbidity at age 85 and older (OR=1.20, 95%CI: 1.06-1.35, p=0.004).	Fair
Vaillant & Western (2001)	USA	The Study of Adult Development	456	100% men	14	≥ 70 or death	60	Healthy Aging	Years of education was strong predictor of healthy aging in the univariate model (OR=0.79, 95%CI 0.71-0.88, p=0.000), but in the multivariate model the association was weaker or non-significant (OR=0.90, 95% CI: 0.79-1.03, p=0.12).	Good
Wang et al. (2024)	China	CHARLS	4815	51.5% women	≥60 (M=67)	NR	7	Healthy Aging	Higher education was associated with lower odds of being in the fair or poor healthy aging trajectory compared to the healthy aging trajectory (OR = 0.49, 95% CI: 0.37-0.65, p <0.001; OR = 0.35, 95% CI: 0.19-0.66, p <0.001).	Good
White et al. (2015)	Canada	MSHA	946	60.5% women	≥65 (M=76)	≥70 (M=81)	5	Healthy Aging	Higher education was associated with higher HA scores among both women and men (OR = 1.15, 95% CI: 1.05-1.26, p < 0.05), as well as independently in women (OR = 1.20, 95% CI: 1.06-1.37, p < 0.05) and men (OR = 1.14, 95% CI: 1.03-1.28, p < 0.05).	Good
Whitley et al. (2018)	Scotland	The West of Scotland Twenty-07 study	856	NR	≥55 (M=57)	≥75 (M=76)	20	Successful Aging	Higher education was associated with higher HA score (OR=2.19, 95%CI: 1.67-2.71).	Fair
Willcox et al. (2006)	USA	HPP	5820	100% men	45-68 (M=54)	>85 or death	40	Healthy survival	Higher education was associated with exceptional survival (OR=1.56, 95%CI: 1.28-2.00, p<0.001).	Fair
Xu et al. (2015)	USA	HRS	9237	59.7% women	≥65 (M=74.7)	≥67	2	Multidimensional health trajectories	Higher education was significantly associated with lower likelihood of significant and increasing impairments (β=-0.353, p<.001).	Good

Abbreviations: OR=Odds Ratio, HR=Hazard Ratio, β= β coefficient, M=mean, NR=Not Reported, SA=Successful Aging, HA= Healthy Aging

Table 3.
Results of the eligible studies: associations of education and successful aging

Authors (Year)	Education Variable	Odds Ratio(OR), Hazard Ratio (HR) or β coefficient (95% CI)	Confounders
Almeida et al. (2006)	Educational level: High school or university	Preserved Cognitive function: OR=2.44 (1.52-3.95); HR=2.32 (1.53-3.51); Well-Preserved Mood: OR=1.31 (0.71-2.44); HR 1.35 (0.78-2.33), Good Mental Health: OR=1.85 (1.24-2.79); HR=1.74 (1.24-2.45); Successful Mental Health Aging: HR=1.92 (1.34-2.75)	No
Arroyo-Quiroz et al. (2020)		Loosing Healthy Aging Status: HR=0.96 (0.96-0.97), p<0.01 (Crude); HR=0.97 (0.97-0.98), p<0.01 (Adjusted); Healthy Ageing at 77: OR=1.02 (1-1.04), p=0.11 (Crude); OR=1.05 (1.03-1.08), p<0.01 (Adjusted); Healthy Ageing at 90: OR=1.02 (0.99-1.04), p=0.17 (Bivariate); OR=1.00 (0.98-1.03), p<0.74 (Multivariate)	Sociodemographic, smoking, alcohol consumption, physical activity, self-perceived depression, overweight or obesity, follow up time and parental longevity
Bell et al. (2014)		Nonsurvival vs survival: OR=1.03 (0.79-1.34), p=0.838 (age-adjusted); Unhealthy survivors vs healthy survivors: OR=1.69 (1.29-2.20), p<.001 (age-adjusted); Unhealthy survivors vs healthy survivors: OR=1.45 (1.08-1.95), p=0.14 (Stepwise Logistic Regression Model)	Sociodemographic
Byles et al. (2019)	Educational level: - ≥Higher school certificate (Ref) - <Higher school certificate	Successful ager: OR=0.59 (0.48-0.71), p<0; Managed ager, long survivor (ageing with disease): OR=0.58 (0.49-0.69), p<0; Usual agers, long survivors (ageing with disease and/or disability): OR=0.77 (0.67-0.89), p<0; Early mortality: OR=1.01 (0.88-1.15)	Sociodemographic, Smoking, BMI, vigorous exercise, social support
Chang et al. (2023)	Education level: -Illiterate - Primary and below - Junior high school and above (Ref)	Class 1 (high-declining group): Illiterate: OR=0.097 (0.057-0.164); Primary and below: OR=0.361 (0.232-0.561) Class 2 (medium level-declining group): Illiterate: OR=0.338 (0.206-0.555); Primary and below: OR=0.654 (0.422-1.015) Class 3 (low level-steady group (Ref)	Sociodemographic, life styles, self-rated health, life satisfaction, social services
Cosco et al. (2017)	Years of education: - 0-9 - 10-11 - ≥12	*≥12 years of education* Total: Highest functioning class: OR=1.38 (1.13-1.69) (Unadjusted); Highest functioning class: OR=1.44 (1.14-1.82) (Adjusted) *Men:* Highest functioning class: OR=1.54 (1.09-2.18) (Unadjusted); Highest functioning class: OR=1.31 (0.90-1.92) (Adjusted); *Women:* Highest functioning class: OR=1.60 (1.24-2.07) (Unadjusted); Highest functioning class: OR=1.50 (1.11-2.03) (Adjusted)	Age, sex, occupational status, and marital status
Ford et al. (2000)	Years of education (less years)	Sustained independence: OR=1.08 (0.89-1.30), p=.67 (less years of education)	Sociodemographic, health, lifestyle, and attitudes
Gureje et al. (2014)	Years of education - 0 years of education - 1-6 years of education -7-12 years of education - ≥ 13 years of education (ref)	*Predictors of indices of Successful Aging* 7-12 years of education: Absence of Chronic Health Conditions: OR=1.5 (0.43-5.17), p=.51; Functional Independence: OR=2.9 (1.20-6.94), p=.02; Self-reported Satisfaction: OR=1.4 (0.65-3.16), p=.36 1-6 years of education: Absence of Chronic Health Conditions: OR=1.7 (0.60-4.79), p=.31; Functional Independence: OR=2.8 (1.27-6.10), p=.01; Self-reported Satisfaction: OR=1.7 (0.93-3.16), p=.08	Sociodemographic, economic status, smoking, physical activity, self-reported health, social environment

		0 years of education: Absence of Chronic Health Conditions: OR=1.3 (0.42-4.11), p=.62; Functional Independence: OR=3.2 (1.61-6.28), p=.002; Self-reported Satisfaction: OR=1.5 (0.86-2.72), p=.14 *Predictors of Successful Aging* Men: OR=1.1 (0.14-825) (7-12 years of education); OR=0.8 (0.15-4.65) (1-6 years of education); OR=0.8 (0.10-7.07) (0 years of education) Women: OR=9.0 (0.69-117.79) (7-12 years of education); OR=11.1 (1.07-114.81), p<.05 (1-6 years of education); OR=15.1 (1.01-225.19), p<.05 (0 years of education) Total: OR=1.2 (0.20-7.68) (7-12 years of education); OR=1.1 (0.19 -5.92) (1-6 years of education); OR=1.2 (0.22-6.11) (0 years of education)	
Hodge et al. (2013)	Educational level: -Primary (Ref) -Secondary -Tertiary	Prediction of successful aging: OR: 0.94 (0.69-1.28) (Secondary education) Prediction of successful aging: OR: 0.99 (0.71-1.39) (Tertiary education)	Sociodemographic, economic, health behaviour, diseases, and physical measurements, attitude and social environment
Hodge et al. (2014)	Educational level: -Primary (Ref) -Secondary -Tertiary	Secondary education: Prediction of successful aging: OR: 1.07 (0.83-1.37) - Model 1**;** Prediction of successful aging: OR: 1.05 (0.81-1.35) - Model 2 Tertiary education: Prediction of successful aging: OR: 1.43 (1.08-1.89) - Model 1**;** Prediction of successful aging: OR: 1.37 (1.04-1.82) - Model 2	Sociodemographic, physical activity, economic, alcohol intake, smoking, and medical history Model 1: without BMI and WHR**;** Model 2: with BMI and WHR
Hsu & Jones (2012)	Years of education	Successful aging (Ref); Usual aging: OR=0.90 (p<.001); Health declining: OR=0.88 (p<.001); Care demanding: OR=0.88 (p<.001) (Older cohort)	Sociodemographic
Kaplan et al. (2008)	Education level: ≥high school	Thrivers vs Nonthrivers: OR=1.31 (0.76-2.26) Thrivers vs Institutionalized: OR= 1.37 (0.71-2.66) Thrivers vs Deceased: OR=1.70 (0.95-3.06)	Sociodemographic, psychosocial factors, behavioral factors, and health status
Kok et al. (2016)	Years of education	Successful aging: β=0.09 (0.06-0.11) (Model 1a); (0.04-0.10) (Model 2); β=0.06 (0.02-0.09) (Model 3) *Indicators of Successful Aging* Functional limitations: OR=1.05 (1.00-1.09); Self-Rated health: OR=1.02 (0.98-1.06); Cognitive functioning: OR=1.13 (1.08-1.18); Depressive symptoms: OR=1.03 (0.99-1.07); Satisfaction with life: OR=1.01 (0.96-1.07); Social loneliness: OR=0.98 (0.94-1.02); Emotional support given: OR=1.10 (1.05-1.14); Instrumental support: OR=1.04 (1.00-1.09); Social activity: OR=0.97 (0.93-1.02)	Model 1a: Adjusted for age and sex Model 2: Adjusted for age, sex, and occupational status Model 3: Adjusted for age, sex, occupational status, and income Indicators of successful aging: Adjusted for age and sex
LaCroix et al. (2016)	Educational level -< College graduate - College graduate (Ref)	*Predictors of living to age 80 years with no disease and no mobility disability* Veterans: OR=0.98 (0.82-1.16), p ≤.05 (Crude); OR=1.10 (0.91-1.32), p ≤.05 (Adjusted) Non-Veterans: OR=0.78 (0.76-0.81), p ≤.05 (Crude); OR=0.91 (0.87-0.84), p ≤.05 (Adjusted) Veterans only: OR=0.98 (0.82-1.16) (Crude); OR=1.07 (0.88-1.30) (Adjusted)	Crude Model: Adjusted for Age Adjusted Model: Sociodemographic, health behavior and health status, race/ethnicity, depression, physical activity, BMI
Leveille et al. (1999)	Years of education - >12 years (ref) - 9-12 years - ≤ 8 years	*Predictors of being nondisabled prior to death in very old age* 9-12 years: OR=0.99 (0.62-1.59) (Model 1); OR=0.95 (0.58-1.53) (Model 2) ≤ 8 years: OR=0.83 (0.53-1.31) (Model 1); OR=0.85 (0.53-1.35) (Model 2)	Model 1: demographic, health, self-reported medical conditions Model 2: demographic, health, self-reported medical conditions, age at death

Liu & Su (2017)	Educational level -Illiterate (Ref) -Elementary school -High school	Elementary school: β=0.193 (p<0.001) (Model 2); β=0.18 (p<0.001) (Model 3) High school: β=0.306 (p<0.001) (Model 2); β=0.29 (p<0.001) (Model 3)	Model 1: Age, Sex, Socioeconomic Model 2: Age, Sex, Socioeconomic, health-related and social behavior.
Lu et al. (2021)	Education -First stage of tertiary or more -Post-secondary non-tertiary -Upper secondary education -Lower secondary education -Primary education or less	Education Rank Score β=-0.076 (-0.082, -0.052), p<0.001 (USA) β=-0.082 (-0.104, -0.060), p<0.001 (England) β=-0.139 (-0.163, -0.114), p<0.001 (China) β=-0.061 (-0.082, -0.039), p<0.001 (Japan)	Socio-economic rank scores, age, cohort, gender, ethnicity, self-rated health in childhood, father's occupation, occupation, marital status, smoking and drinking, interactions between gender and the main socio-economic rank scores, age and cohort, age and marital status, and age and smoking
McLaughlin et al. (2020)	Educational level: - Less than HS diploma (Ref) - HS graduate - Some college - College graduate	β=0.588, p<.001 (HS graduate) β=0.781, p<.001 (Some college) β=1.127, p<.001 (College graduate)	Age category, gender, marital status, household wealth percentile, and race/ethnicity
Oktaviani et al. (2022)	Educational level: - College -University and above - Senior high school - Elementary - No formal education	*Men:* No chronic disease: OR=0.75 (0.61-0.91), p<0.01; No physical difficulty: OR=0.93 (0.77-1.13); Intact cognitive function: OR=1.97 (1.57-2.46). p<0.001; No depressive symptoms: OR=1.22 (0.93-1.61); Having social support: OR=0.97 (0.75-1.25); Having social participation: OR=1.44 (1.10-1.89), p<0.01; Overall successful aging: OR=1.27 (0.92-1.75) *Women:* No chronic disease: OR=0.84(0.68-1.04); No physical difficulty: OR=1.05 (0.85-1.30); Intact cognitive function: OR=2.52 (1.94-3.27, p<0.001); No depressive symptom: OR=1.08 (0.83-1.41); Having social support: OR=1.07 (0.86-1.33); Having social participation: OR=1.72 (1.27-2.34); Overall successful aging: OR=2.24 (1.25-4.01), p<0.01	Sociodemographic, health related behaviors at baseline, changes between two waves
Shields & Martel (2006)	Educational level: - Less than secondary graduation (Ref) - Secondary graduation or more	Having good health: OR=1.5 (1.2-1.7), p<0.05 Staying healthy: HR=1.3 (1.0-1.6), p<0.05 Recovery of health in a two years period: OR=1.0 (0.8-1.3)	Sociodemographic, chronic conditions,behavioral risk factors, psychosocial factors
Strawbridge et al. (1996)	Years of education: ≥ 12 years of education	OR=1.67 (0.98-2.84)	Age, sex, and baseline successful aging
Terry et al. (2005)	Education: < High school graduate High school graduate >High school graduate	Education (one category increase) Survival to age 85: OR=1.25 (1.12-1.39), p<.001; Survival to age 85 free of major morbidity: OR=1.20 (1.06-1.35), p=.004	Sociodemographic, economic, health factors, diseases, and physical measurements
Vaillant & Western (2001)	Years of education (6-19 years)	OR=0.79 (0.71-0.88), p=.000 (Univariate model) OR=0.90 (0.79-1.03), p=.12 (Multivariate model)	Univariate model: physical health Multivariate model: Sociodemographic, economic, health behaviour, diseases and physical measurement, attitude and social environment

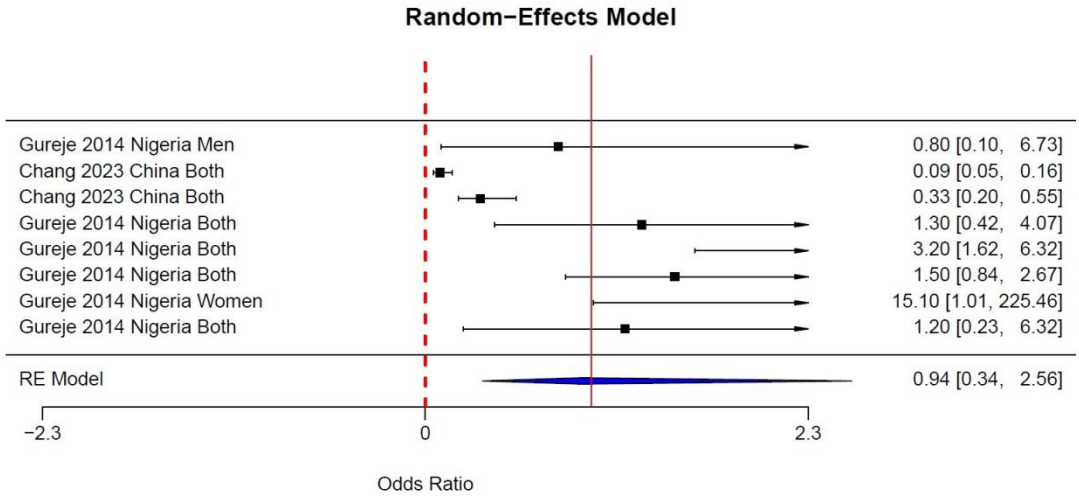
Wang et al. (2024)	Educational level: - Elementary school or below (Ref) - Middle school or above	Good healthy aging trajectory (Ref) Fair healthy aging trajectory: β=-0.71; OR=0.49 (0.37-0.65), p<.001 Poor healthy aging trajectory: β=-1.05; OR=0.35 (0.19-0.66), p<001	Sociodemographics
White et al. (2015)	Educational level : 10-point scale (1=no formal schooling - 10=master's degree or PhD)	*All* OR=1.16 (1.08-1.25), p<0.05 (Model 1); OR=1.16 (1.08-1.25), p<0.05 (Model 3) OR=1.14 (1.05-1.23), p<0.05 (Model 5); OR=1.16 (1.06-1.27), p<0.05 (Model 7); OR=1.15 (1.05-1.26), p<0.05 (Model 9) *Women* OR=1.18 (1.07-1.31), p<0.05 (Model 1); OR=1.17 (1.06-1.30), p<0.05 (Model 3); OR=1.16 (1.04-1.28), p<0.05 (Model 5); OR=1.23 (1.08-1.39), p<0.05 (Model 7); OR=1.20 (1.06-1.37), p<0.05 (Model 9) *Men* OR=1.14 (1.03-1.28), p<0.05 (Model 1); OR=1.16 (1.04-1.30), p<0.05 (Model 3); OR=1.12 (1.01-1.26), p<0.05 (Model 5); OR=1.09 (0.95-1.25) (Model 7); OR=1.09 (0.95-1.26) (Model 9)	Model 1: age, gender Model 3: age, gender, income Model 5: age, gender, life satisfaction Model 7: age, gender, occupation Model 9: age, gender, income, life satisfaction with finances, occupation
Whitley et al. (2018)	Age left school	SII differences: 2.19 (1.67-2.71)	Gender
Willcox et al. (2006)	Educational level: - Low education (<12 years)	Non survival vs Survival: OR=1.17 (1.05-1.30), p=.003; Usual survival vs Exceptional survival: OR=1.62 (1.34-1.96), p<.001 (Age adjusted) Usual survival vs Exceptional survival: OR=1.56 (1.28-1.91), p<.001	Age, Biological factors, Lifestyle factors
Xu et al. (2015)	Years of education	Moderate impairment with increasing cognitive deficit (vs minimal impairment): OR=0.79, p<.001 (Model 1); OR=0.82, p<.001(Model 4) Moderate impairment with increasing cognitive deficit (vs minimal impairment): OR=0.93, p<.001 (Model 1); OR=0.96, p<.01(Model 4) Significant and increasing impairment (vs. minimal impairment): OR=0.69, p<.001 (Model 1); OR=0.74, p<.001 (Model 4) Moderate impairment with increasing cognitive deficit: β=-216, p<.001; Moderate impairment with increasing physical and emotional deficit: β=-0.029; Significant and increasing impairment: β=-0.353, p<.001	Model 1: gender, race/ethnicity, baseline age and health status Model 4: gender, race/ethnicity, baseline age and health status, income, net worth

Meta-analysis Results

No Formal Education and Successful Aging

The random-effects model results of eight estimates from two primary studies demonstrated an overall non-significant effect of no formal education on successful aging (OR = 0.94, 95% CI = 0.34–2.56) (Figure 2). The regression test for funnel plot asymmetry indicated no significant publication bias (p = .458) among the included studies. However, the high level of heterogeneity, with an I^2 value of 90.75% (p < .0001), should be considered when interpreting these results, as it indicates considerable variability in effect sizes across studies, potentially due to differences in study contexts or populations.

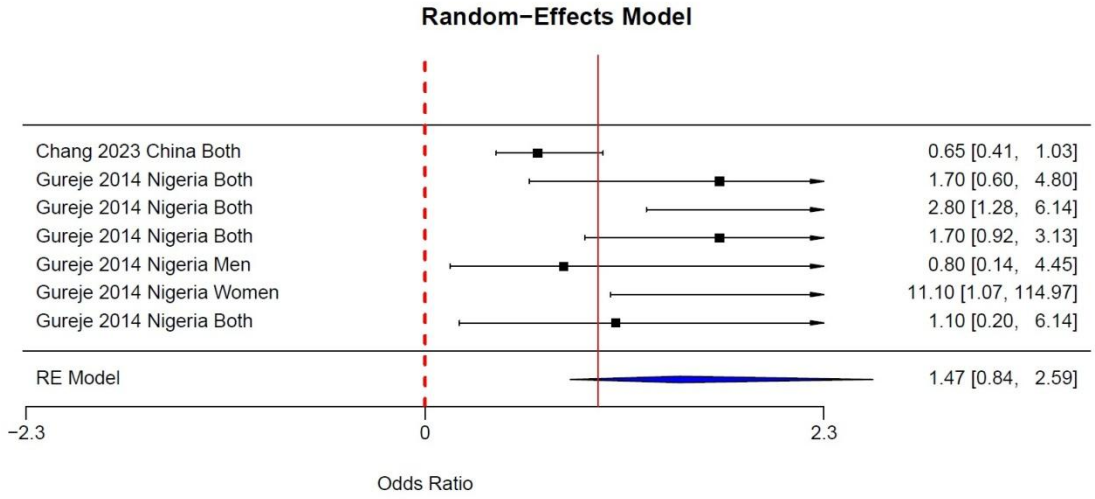
Figure 2.
Forest plot of the association between no formal education and successful aging



Primary Education and Successful Aging

The random-effects model results of seven estimates from two primary studies demonstrated also an overall non-significant effect of primary education on the outcome of successful aging (OR = 1.47, 95% CI = 0.84–2.59) (Figure 3). There was a moderate degree of heterogeneity among the studies, with an I^2 value of 58.51% (p = .01). The regression test for funnel plot asymmetry indicated no significant publication bias (p = .338) among the included studies

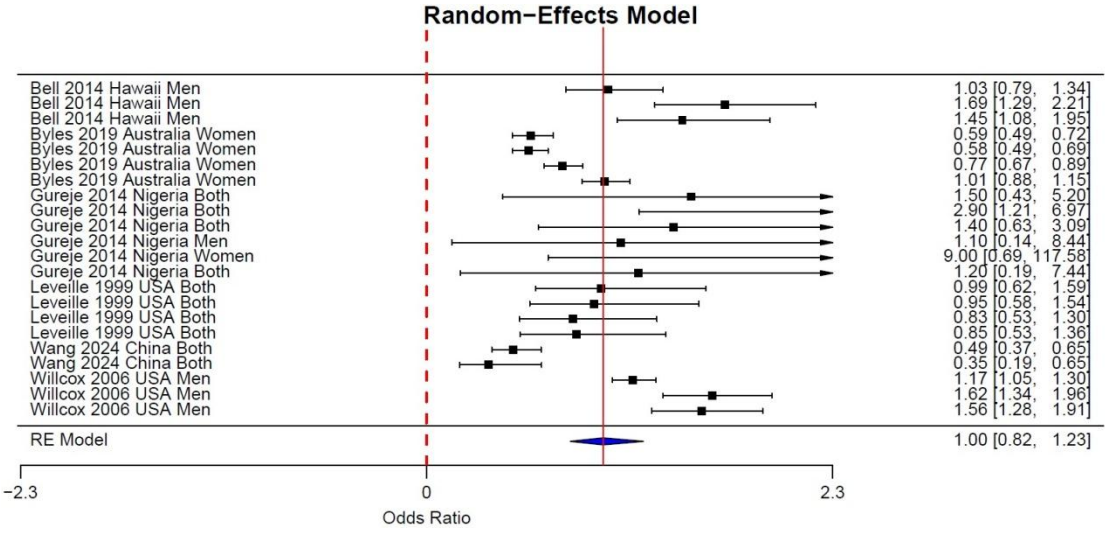
Figure 3.
Forest plot of the association between primary education and successful aging



Lower Secondary Education and both Healthy and Successful Aging

The random-effects model results of 22 estimates from six primary studies demonstrated also an overall non-significant effect of lower secondary education on the outcome of both healthy and successful aging (OR = 1.00, 95% CI = 0.82–1.23) (Figure 4). The regression test for funnel plot asymmetry indicated no significant publication bias (p = .647) among the included studies. However, again the high level of heterogeneity, with an I^2 value of 91.39% (p < .0001), should be considered when interpreting these results.

Figure 4.
Forest plot of the association between lower secondary education and both healthy and successful aging



We also conducted a mixed-effects meta-analysis to assess the impact of sex on the odds ratios across the studies included in our dataset (Table 4). The test of moderators was significant (QM (df = 3) = 14.0535, p = .0028), suggesting that the subgroups (Men, Women, and Both) significantly explained the variability in effect sizes across studies. Specifically, being a man was associated with a significantly higher odds ratio (OR = 1.39, 95% CI = 1.19–1.62), while being a woman was associated with a significantly lower odds ratio (OR = 0.74, 95% CI = 0.57–0.96). The subgroup including both sexes did not show a significant effect. The high level of residual heterogeneity (I^2 = 80.46%) suggested that other factors may also contribute to the variability in effect sizes, warranting further investigation. Considering both the multidimensional and non-multidimensional definitions of successful aging, studies using multidimensional definition of successful aging showed a significant negative effect of lower secondary education, while studies using a non-multidimensional did not show a significant effect of lower secondary education.

Table 4.
Sensitivity analysis by sex and type of definition of SA

	No of studies/ estimates	Sample size	OR (95 % CI) random effects	I^2 (%)	P	Group differences
Lower Secondary Education and Both Healthy Aging and Successful Aging						
Sex						**0.001**
Both	10	7652	0.88 (0.62-1.26)	72.78	0.495	
Men	7	8042	1.39 (1.19-1.62)	67.92	0.0001	
Women	5	10992	0.74 (0.57-0.96)	88.37	0.025	
Type of definition of SA						
Multidimensional	2	4815	0.46 (0.36-0.60)	0.00	0.0001	
Non-multidimensional	20	20011	1.09 (0.90-1.31)	88.63	0.385	
Upper Secondary Education and Successful Aging						
Sex						**0.001**
Both	24	18357	1.11 (1.05-1.17)	93.78	0.0001	
Men	11	2554	1.46 (1.15-1.85)	86.79	0.006	
Women	8	74720	1.06 (0.90-1.24)	96.18	0.505	
Type of definition of SA						**0.001**
Multidimensional	20	3692	1.08 (1.02-1.15)	96.40	0.014	
Non-multidimensional	23	89301	1.28 (1.12-1.46)	94.13	0.000	
Varied Educational Levels and Both Healthy Aging and Successful Aging						**0.001**
Sex						
Both	18	33981	1.04 (0.99-1.09)	99.25	0.106	
Men	12	2235	1.14 (1.00-1.29)	85.52	0.046	
Women	12	3524	1.26 (1.07-1.48)	90.96	0.004	
Type of definition of SA						**0.001**
Multidimensional	33	28284	1.14 (1.06-1.23)	97.38	0.000	
Non-multidimensional	9	8275	1.04 (0.99-1.09)	99.18	0.142	

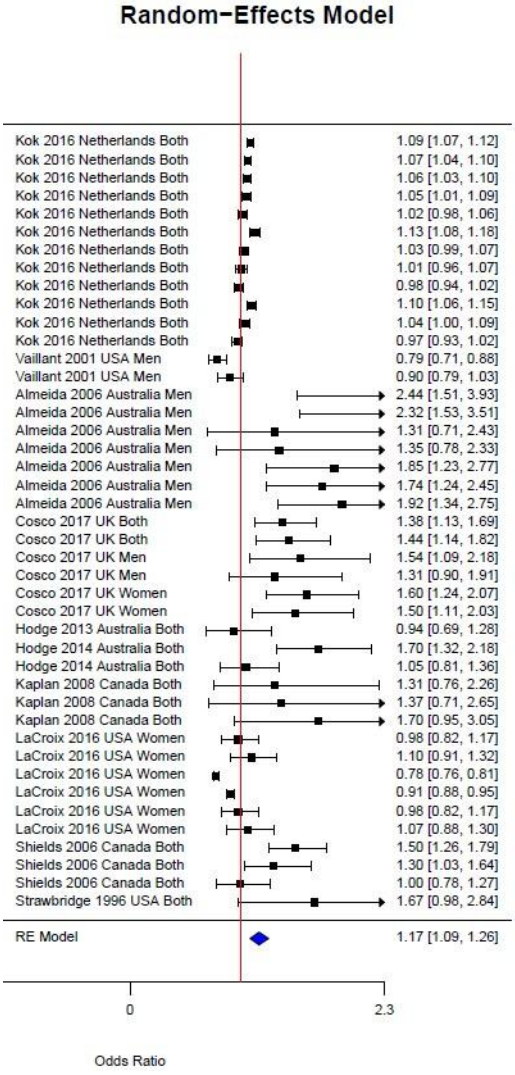
Upper Secondary Education and Successful Aging

The random-effects model results of 43 estimates from 10 primary studies demonstrated an overall significant effect of upper secondary education on the outcome of successful aging (OR = 1.17, 95% CI = 1.09–1.26) (Figure 5). There was a high degree of heterogeneity among the studies, with an I^2 value

of 97.69% ($p < .0001$). The regression test for funnel plot asymmetry indicated significant publication bias ($p = .022$) among the included studies. Table 4 shows the mixed-effects meta-analysis to assess the impact of sex on the odds ratios across the studies in this association. The test of moderators was significant (QM (df = 3) = 24.0616, $p < .0001$), implying that also in this analysis the subgroups (Men, Women, and Both) significantly explained the variability in effect sizes across studies. In this analysis, the men subgroup and the subgroup including both sexes showed a significantly higher odds ratio (OR = 1.46, 95% CI = 1.15–1.85 for men; OR = 1.11, 95% CI = 1.05–1.17 for both sexes). In contrast, the women subgroup did not show a significant effect. The high residual heterogeneity ($I^2 = 97.50\%$) indicated considerable variability across the included studies. Considering both the multidimensional and non-multidimensional definitions of successful aging, the non-multidimensional definition shows a significantly higher odds ratio compared to the multidimensional definition (Table 4). Considering both the multidimensional and non-multidimensional definitions of successful aging, studies using the non-multidimensional definition of successful aging showed a significantly higher odds ratio compared to the multidimensional definition.

Figure 5.

Forest plot of the association between upper secondary education and successful aging

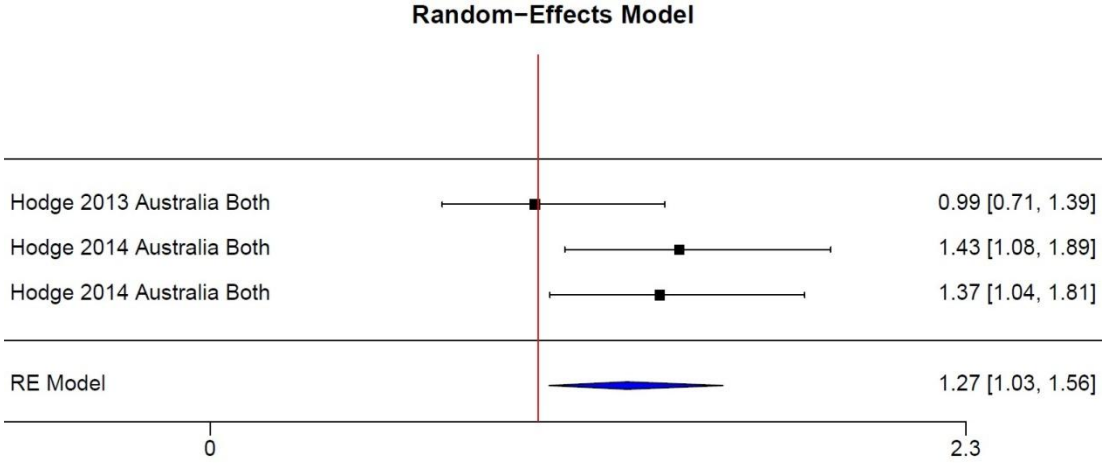


Tertiary Education and Successful Aging

The random-effects model results of three estimates from two primary studies demonstrated an overall significant effect of tertiary education on the outcome of successful aging (OR = 1.27, 95% CI = 1.03 – 1.56) (Figure 6). There was a moderate degree of heterogeneity among the studies, with an I^2 value of 31.72% (p = .214). The regression test for funnel plot asymmetry indicated no significant publication bias (p = 0.338) among the included studies.

Figure 6.

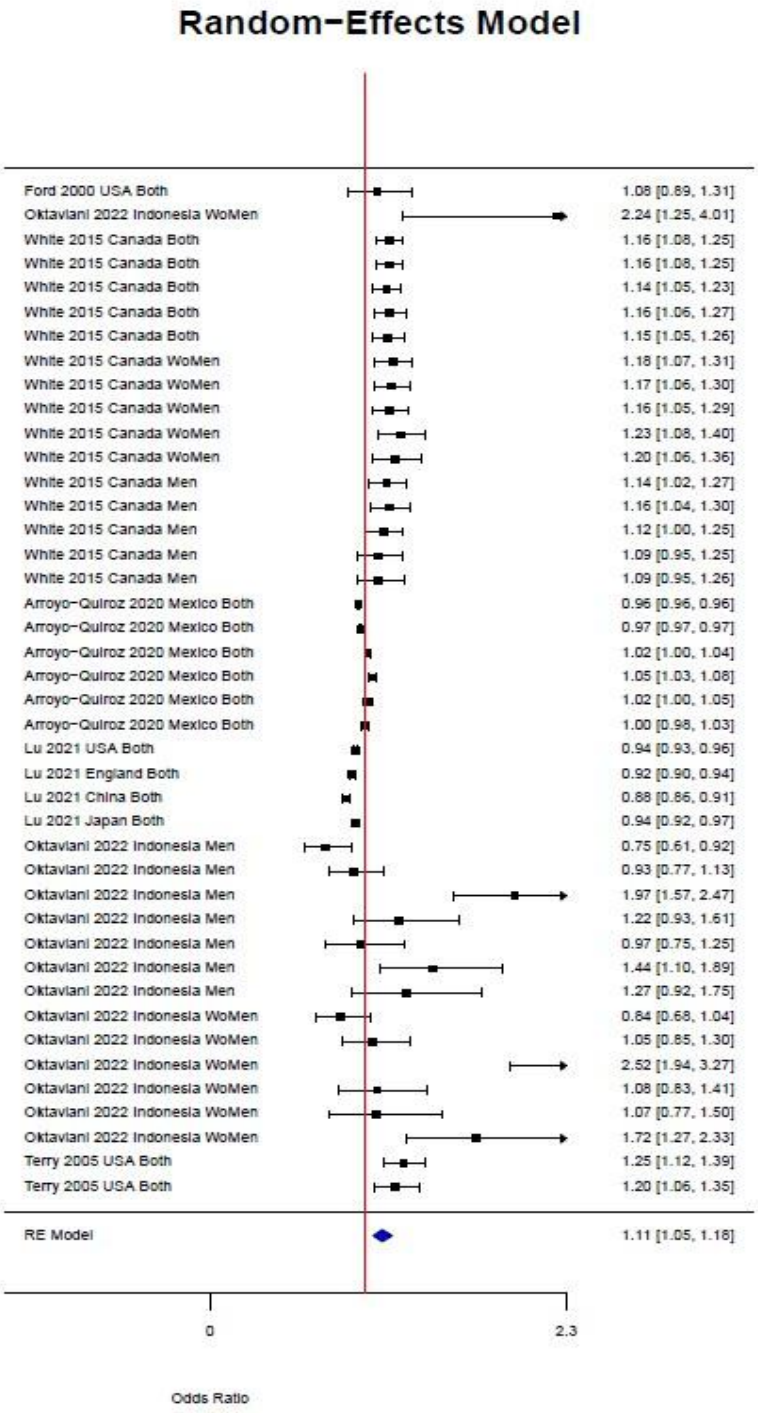
Forest plot of the association between tertiary education and successful Aging



Varied Educational Levels and both Healthy and Successful Aging

The random-effects model results of 42 estimates from seven primary studies demonstrated an overall significant effect of varied educational levels on the outcome of both healthy and successful aging (OR = 1.11, 95% CI = 1.05–1.18) (Figure 7). There was a high degree of heterogeneity among the studies, with an I^2 value of 99.38% (p < .0001). The regression test for funnel plot asymmetry indicated significant publication bias (p = .001) among the included studies. Table 4 shows the mixed-effects meta-analysis to assess the impact of sex on the odds ratios across the studies in this association. The test of moderators was significant (QM (df = 3) = 22.7768, p < .0001), implying that also in this analysis the subgroups (Men, Women, and Both) significantly explained the variability in effect sizes across studies. In this analysis, the men and women subgroup showed a significantly higher odds ratio (OR = 1.14, 95% CI = 1.00–1.29 for men; OR = 1.26, 95% CI = 1.07–1.48 for women). In contrast, the subgroup including both sexes did not show a significant effect. The high residual heterogeneity (I^2 = 99.31%) indicated considerable variability across the included studies. Considering both the multidimensional and non-multidimensional definitions of successful aging, the multidimensional definition showed a significantly higher odds ratio compared to the non-multidimensional definition, which did not show a significant effect (Table 4).

Figure 7.
Forest plot of the association between varied educational levels and both healthy and successful aging



Discussion

This systematic review and meta-analysis of longitudinal studies is the first to comprehensively examine the relationship between educational attainment and successful aging in older adults. Evidence from this study suggests a significant link between higher education levels and improved outcomes in the context of successful aging. Specifically, the findings indicated that educational level significantly impacts successful aging, with notable effects observed in individuals with upper secondary and tertiary education. Conversely, no significant effects were found for those with no formal education, primary education, or lower secondary education. Additionally, sensitivity analyses revealed gender differences in successful aging and a profound heterogeneity in the definitions of successful aging across the included studies.

Education and Successful Aging

Our findings aligned with previous systematic reviews and meta-analyses that provided evidence about the relationship between educational attainment and successful aging. Specifically, Wagg et al. (2021) reviewed forty cross-sectional and longitudinal studies, finding that higher education, income, and occupational status contributed to healthy aging. Similarly, Zhang et al. (2022) found that higher education levels correlated with successful aging in developing countries, while Rodriguesf et al. (2023) and Belachew et al. (2024) reported a positive association, though with more limited data. Only Depp and Jeste (2006) did not find a significant association between education and successful aging, which, according to the authors, may be attributed to sampling bias or the use of composite outcomes, which could lessen the effect of demographic and socioeconomic indicators compared to individual variables.

Research on individual factors has consistently demonstrated that higher educational attainment contributes to successful aging through multiple pathways. Firstly, higher education was associated with a more comprehensive knowledge of health and wellness, enabling individuals to make informed decisions regarding nutrition, exercise, and medical care, thus promoting healthier lifestyles and reducing the prevalence of chronic diseases (Cutler & Lleras-Muney, 2010). Additionally, educational attainment was correlated with higher income levels and improved employment prospects, facilitating access to superior healthcare services and better living conditions (Ma et al., 2016). Furthermore, educational activities seemed to foster cognitive reserve, potentially mitigating the risk of dementia and cognitive decline later in life, as these activities provided cognitive challenges and stimulation that contribute to cognitive resilience (Meng & D'Arcy, 2012; Stern, 2012). Lastly, education was linked with robust social networks and engagement, crucial for emotional support and mental well-being in the later stages of life (Hertzog et al., 2008).

Sex and Successful Aging

The mixed-effects meta-analysis by sex further highlighted the importance of considering demographic factors, as men and women showed significantly different odds ratios for successful aging. Specifically, being a man with lower secondary education or upper secondary education was associated with a significantly higher odds ratio for successful aging. In contrast, in the "various educational levels" category, both men and women showed significantly higher odds ratios for successful aging compared to the combined-sex subgroup. These findings underscored the complex interplay between gender, education, and successful aging indicating that gender-specific factors play a critical role in successful aging. The results are consistent with international data suggesting that, although women tend to live

longer, men report fewer functional disabilities and chronic conditions and exhibit advantages in overall quality of life and subjective well-being (Carmel, 2019; Newman & Brach, 2001). This gender gap may stem from disparities in education levels and income, as well as negative stereotypical attitudes that lead to discrimination and marginalization of women throughout their lifespan (Carmel, 2019).

Definitions and Successful Aging

Studies have included different domains for defining and measuring successful aging (e.g., physical function, cognitive function, social function). This heterogeneity in the definitions of successful aging has been highlighted by various researchers (Cosco et al., 2014; Estebsari et al., 2020). The statistical analyses investigating the variability in odds ratios related to successful aging, based on the type of definition used, yielded mixed results. Studies using a non-multidimensional definition did not show a significant effect of lower secondary education on successful aging, while a significantly higher odds ratio was observed for upper secondary education. Yet, studies with multidimensional definitions showed a significantly higher odds ratio of successful aging at various educational levels category. These findings aligned with previous research indicating that multidimensional approaches are more effective in capturing the complexity of successful aging (Depp & Jeste, 2006; Rowe & Kahn, 1997).

Policies to support successful aging

With the global population aging and rising healthcare costs, many governments are implementing policies aimed at extending life and enhancing the quality of life for older adults (Hung et al., 2010). Policies designed to support successful aging should prioritize comprehensive care, particularly for individuals with low education levels and low socioeconomic status, ensuring they receive essential support and resources (Zhang et al., 2022). Lifelong education, through various educational activities and programs, appears to be one of the priorities of modern societies, as it plays critical role in promoting cognitive health, fostering active engagement among older adults, and enhancing their overall well-being (Grosso, 2018; Sloane-Seale & Kops, 2008). For instance, intergenerational programs that facilitate interactions between different age groups have demonstrated effectiveness in strengthening social connections, reducing feelings of isolation, and fostering mutual learning and understanding (Tsiloni et al., 2024).

Strengths and Limitations

Our study presented several strengths. First, to our knowledge, this is the first meta-analysis focusing exclusively on the relationship between education and successful aging in older adults over 65 years old. Previous reviews and meta-analyses focused on different age groups (Wagg et al., 2021), different indicators of successful aging (Daskalopoulou et al., 2018), or specific demographic contexts, such as developing countries (Belachew et al., 2024; Zhang et al., 2022). Additionally, we examined heterogeneity and publication bias and conducted two separate sensitivity analyses to investigate the variability in odds ratios related to successful aging: one stratified by sex (Both, Men, Women) and another by the multidimensional versus non-multidimensional definitions of successful aging. These methodologies facilitated a more nuanced comprehension of the diverse factors influencing successful aging and ensured the robustness of our findings.

However, the study has some limitations. Firstly, it primarily included cohort studies, thus potentially restricting the generalizability compared to other study designs (e.g., cross-sectional,

randomized control trials). Secondly, the criteria for educational attainment varied, potentially introducing variability in the categorization and interpretation of education levels. Thirdly, the inclusion of studies published exclusively in English may have omitted relevant literature published in other languages. Additionally, the possibility of publication bias must be considered, as studies reporting significant findings are more likely to be published than those with non-significant or null results, potentially distorting the overall conclusions. Although we assessed publication bias using funnel plots and Egger's test, the presence of bias cannot be entirely ruled out. Moreover, the variability in definitions of successful aging among included studies may have contributed to inconsistencies in findings. Finally, the categorization of education levels varied significantly, and cultural and geographical differences, and variability in follow-up periods further limit the study's conclusions.

Future research should consider the impact of multidimensional versus non-multidimensional definitions of successful aging in the association between education and aging to provide more nuanced insights into this complex relationship. Additionally, further studies are needed to explore the sources of heterogeneity and better understand the factors influencing the relationship between education and successful aging. Finally, future research should investigate the specific mechanisms and interventions that can enhance educational opportunities throughout the lifespan, particularly for those with lower educational attainment, to further promote healthy aging across diverse populations.

Conclusions

This systematic review and meta-analysis provided robust evidence of the positive impact of educational attainment on successful aging in older adults. Higher levels of education, particularly upper secondary and tertiary education, were consistently associated with improved health and well-being in later life, underscoring the importance of educational attainment in later life. The findings underscored the need for educational policies that support lifelong learning to enhance cognitive function, social engagement, and overall quality of life for aging populations. These insights emphasized the importance of tailored interventions and comprehensive care for older adults with lower education and socioeconomic status. Moving forward, integrating lifelong education into public health strategies will be crucial for promoting successful aging and addressing the varied needs of aging populations globally.

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Εκπαίδευση και ευδόκιμη γήρανση: Μια συστηματική ανασκόπηση και μετά-ανάλυση μελετών κοόρτης

Τσιλώνη Ευαγγελία[1], Δραγκιώτη Έλενα [2], Γκούβα Μαίρη [3], Βασιλόπουλος Στέφανος[4] , Μέντης Μανόλης [5]

[1] Υπ. Διδάκτωρ Τμήματος. Επιστημών της Εκπαίδευσης και Κοινωνικής Εργασίας, Πανεπιστήμιο Πατρών
[2] Αν. Καθηγήτρια, Τμήμα Νοσηλευτικής Πανεπιστημίου Ιωαννίνων
[3] Καθηγήτρια, Τμήμα Νοσηλευτικής Πανεπιστημίου Ιωαννίνων
[4] Καθηγητής, Τμήμα Επιστημών της Εκπαίδευσης και Κοινωνικής Εργασίας, Πανεπιστήμιο Πατρών
[5] Επίκουρος Καθηγητής, Τμήμα Επιστημών της Εκπαίδευσης και Κοινωνικής Εργασίας, Πανεπιστήμιο Πατρών

ΠΕΡΙΛΗΨΗ

Η ευδόκιμη γήρανση περιλαμβάνει ποικίλες διαστάσεις, όπως η σωματική, γνωστική, ψυχική και κοινωνική ευεξία ατόμων μεγαλύτερης ηλικίας. Τα τελευταία χρόνια, παρατηρείται αυξανόμενο ενδιαφέρον για τη διερεύνηση του τρόπου με τον οποίο διάφοροι παράγοντες επηρεάζουν την ευδόκιμη γήρανση. Η παρούσα μελέτη είχε ως στόχο να εξετάσει την επίδραση του μορφωτικού επιπέδου στην ευδόκιμη γήρανση ενηλίκων ηλικίας 65 ετών και άνω, μέσω συστηματικής ανασκόπησης και μετα-ανάλυσης μελετών κοόρτης. Οι ηλεκτρονικές βάσεις δεδομένων PubMed, Scopus, ERIC και PsycINFO ερευνήθηκαν σύμφωνα με τις κατευθυντήριες γραμμές PRISMA. Επιπλέον, εξετάστηκαν οι βιβλιογραφικές αναφορές σχετικών συστηματικών ανασκοπήσεων, μετα-αναλύσεων και των επιλεγμένων μελετών. Η ποιότητα των μελετών αξιολογήθηκε με τη χρήση της Κλίμακας Newcastle-Ottawa (NOS). Οι συνολικές εκτιμήσεις υπολογίστηκαν με μοντέλα τυχαίων επιδράσεων (random-effects) χρησιμοποιώντας τη μέθοδο REML στο R (έκδοση 4.4.0). Συνολικά, 28 μελέτες πληρούσαν τα κριτήρια ένταξης και συμπεριλήφθηκαν στην ανασκόπηση και τη μετα-ανάλυση. Η στατιστική ανάλυση έδειξε ότι η ανώτερη δευτεροβάθμια εκπαίδευση (OR = 1.17, 95% CI = 1.09–1.26), η τριτοβάθμια εκπαίδευση (OR = 1.27, 95% CI = 1.03–1.56), καθώς και ανώτερα ή διαφοροποιημένα μορφωτικά επίπεδα (π.χ. έτη εκπαίδευσης) (OR = 1.11, 95% CI = 1.05–1.18) σχετίζονται σημαντικά με την ευδόκιμη γήρανση. Σύμφωνα με τα διαθέσιμα δεδομένα, τα υψηλότερα επίπεδα εκπαίδευσης συνδέονται σημαντικά με αυξημένες πιθανότητες ευδόκιμης γήρανσης στην τρίτη ηλικία.

Λέξεις-κλειδιά: Ευδόκιμη γήρανση, Υγιής γήρανση, Εκπαίδευση, Δια βίου εκπαίδευση, Άτομα μεγαλύτερης ηλικίας

Στοιχεία Επικοινωνίας: Ευαγγελία Τσιλώνη, evangeliatsiloni@gmail.com