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Exploring the relationships and pathways linking education to health, well-being and equity

Literature review

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Summary

For this literature review we aimed to answer the following questions:

- How does education impact on health, well-being and equity outcomes?
- What are the different mechanisms and pathways in which education and attainment have an effect on health, well-being and equity/inequality outcomes?
- What is the nature of the evidence for the pathways?

To address the research questions, we undertook a literature review of existing literature. We undertook a systematic search of literature on Google Scholar, grey literature websites and selected databases of peer reviewed journals. Subsequently, we reviewed the literature for eligibility and extracted data into a data extraction table. We did not critically appraise the quality of the literature. The review aims to give an overview of the literature but does not claim to be exhaustive.

It is clear that education has an effect on health outcomes but the way in which this happens is complex. The papers identified in this review investigate the mechanisms through which education affects health. These mechanisms can be grouped into three broad pathways:

- Work and income
- Health knowledge and behaviours
- Psychosocial environment

Due to the varied nature of the evidence included it is impossible to conclude which mechanism or pathway is the most important. The papers look at different health outcomes, include different measures and control for different variables. Much of the literature came from the US, and there is a suggestion that the importance of education for health may be stronger in the United States than in Europe.

It will be important to consider the broader political and social context of education and health as the need for less focus on individual-level factors has been suggested by some researchers. It will also be important to remember that while education is considered a major 'driver of opportunity', it can also perpetuate cycles of intergenerational and socioeconomic disadvantage. This has implications for future education interventions in terms of which pupils to target and how.

1. Background

Education is a building block to health and well-being throughout the life course and along with the other UK nations, Wales' educational attainment gap, in terms of grades achieved at specific stages, has remained persistent in recent decades. Influencing the wider determinants of health is a Public Health Wales priority. We seek to work with national, regional and local partners to positively influence how education, as a determinant, can improve health and equity.

WHO's HESRI framework (1) sets out five essential conditions for healthy prosperous lives for all. One of the five conditions is 'Health and social and human capital'. Education falls under this category and is considered an essential condition for a healthy and prosperous life.

Similarly, both the 2010 and 2020 Marmot reviews (2)(3) set out how education is an essential condition for health, well-being and equity. "Inequalities experienced during school years have lifelong impacts – in terms of income, quality of work and a range of other social and economic outcomes including physical and mental health" (p.50) (3).

In Wales, the Well-being of Future Generations (Wales) Act 2015 (4) sets out seven well-being goals, including 'a prosperous Wales' and 'a healthier Wales'. A component of a prosperous Wales is 'a society…which develops a skilled and well-educated population'. To help demonstrate progress towards the seven well-being goals, Welsh ministers have set 50 national well-being indicators.

Indicator 8 relates to adults with qualifications, with a specific milestone of 75% of working age adults qualified to level 3 or higher by 2050, and percentage in each local authority with no qualifications being 5% or below. An additional indicator (number 7) relates to attainment at year 11, this is the average capped 9 point score of pupils and includes a measure of the attainment gap (comparing those eligible for free school meals with those not eligible).

This literature review explores the relationship between education and health to inform our work to influence the educational attainment gap as a determinant of health.

2. Research questions

- How does education impact on health, well-being and equity outcomes?
- What are the different mechanisms and pathways through which education and attainment influence health, well-being and equity/inequality outcomes?
- What is the nature of the evidence for the pathways?

2.1 Objectives

The objectives of the literature review are to:

a) Identify relevant literature through a rapid review of literature
b) Examine evidence on how education affects health, well-being and equity outcomes (the pathways and mechanisms)
c) Summarise findings and discuss their applicability to the Welsh context, including any areas of uncertainty
d) Develop a data extraction table

3. Approach to literature review

A rapid, systematic search of the literature was undertaken on Google Scholar, grey literature websites and selected databases of peer reviewed journals in May and June 2022. Subsequently the literature was reviewed for eligibility and data were extracted into a data extraction table.

This review describes both literature which has developed models and frameworks and literature which provides evidence of a relationship between education and health (direct or indirect).

A full outline of the approach to selecting literature and the inclusion/exclusion criteria can be found in the methods document.

4. Findings

4.1 Introduction

There is a well-known and well-documented relationship between education and health (5)(6)(7). Education is central to individual and population health and well-being (8) as well as higher life satisfaction (9). According to the OECD, "better-educated individuals are more likely to report better health than less-educated individuals, even after controlling for a variety of individual background characteristics" (p.3)(10). An alternate explanation for this association is 'spuriousness' (11) and third variables like family background, parental investments into their children or differences in non-cognitive traits and time preferences (12).

An extensive body of literature has aimed to investigate and document this generally positive association, whether there is evidence of a causal relationship and potential mediating variables. A total of 31 papers were included in this literature review. Some research focuses on specific health and well-being outcomes or

conditions like diabetes, obesity, cardiovascular disease, depression or pain, while others take a broader approach examining self-reported general health through surveys. The review initially set out to define the different terminology used in the papers (conceptual framework, conceptual model, theoretical framework and so on), however, it proved difficult to find reliable sources of universal definitions of these concepts and a glossary was therefore not added.

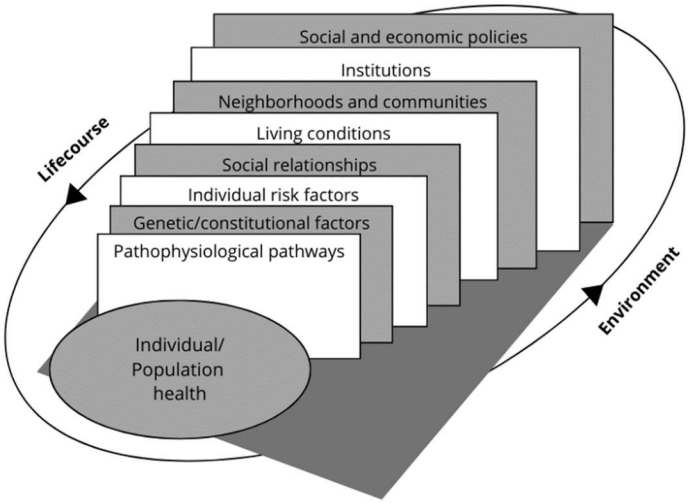
4.2 Frameworks and models

Many models and conceptual frameworks have been mapped out and developed to understand the relationship between education and health. Zimmerman and Woolf (13), in their discussion paper of existing literature, use an overarching theoretical framework, the socioecological model, to explore the impact of social determinants of health, specifically education, on health (see Fig. 1). The model situates the individual and their characteristics within and affected by the family and household, the community and its institutions (e.g., school, workplace, and civil institutions), and broader political context. The different levels of the model interact with each other.

They argue that "education is one of the key filtering mechanisms that situate individuals within particular ecological contexts" (p.2). The model can therefore provide a context for the numerous ways in which education is linked to our life experiences, including health outcomes. Moreover, the model provides a framework for better understanding how educational outcomes themselves are conditioned on the many social and environmental contexts in which we live. The authors go on to explore the mechanisms by which education impacts health. They argue that the connections between education and health are essential to setting policy priorities as education affects health not only at the individual level but also at community and population level through, for example, "health-related community (or place-based) characteristics that often surround people with high or low education" (p.3). Addressing social inequity is imperative to reduce health inequities and the authors argue that an increased awareness of the importance of education might help drive investment in education and improvements in educational policy.

Lastly, the authors argue that educational *attainment* (the number of years of schooling completed) is an important measure but it is "far from the whole story" (p.3). Quality of education along with other dimensions of education (for example cognitive development, character development, knowledge, critical thinking and problem solving) are critical for the broader socioecological context individuals find themselves in.

Figure 1.



Source: Zimmerman and Woolf. Understanding the Relationship between Education and Health. 2014

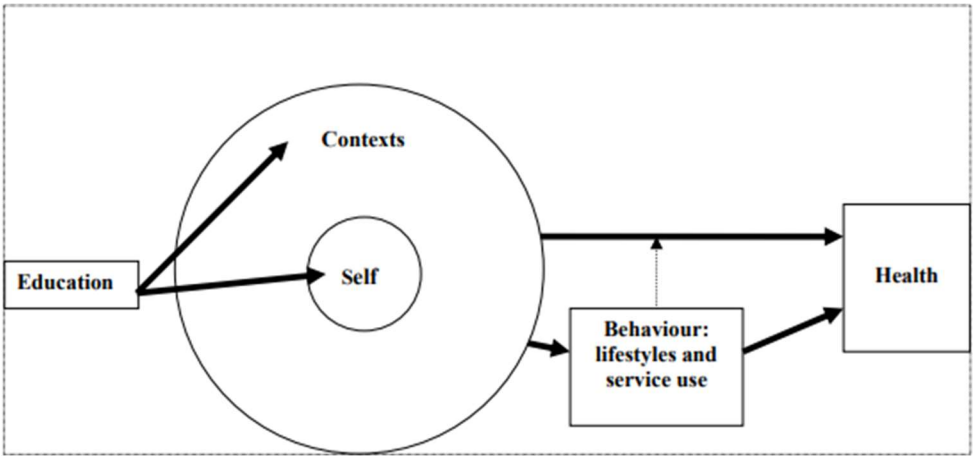
In 2006, Feinstein, Sabates, Anderson et al. (6) carried out an extensive evidence review and mapped out a general conceptual framework that sets out the hypothesised mechanisms for the effect of education on health. Similarly to Zimmerman and Woolf, the authors base their hypothesis on an ecological model and state that education impacts health because:

- individuals exist in multiple, multi-layered and interacting context;
- each of these contexts is a domain of social relations and environmental health;
- education impacts on each factor in each context at each level

The hypothesised mechanisms operate at all levels of society including individual level, household and work contexts, community level and national level. The effect of education on health is dynamic and "through benefits of education for individual and community agency, education may continue to moderate the effect of contexts on the individual, providing protection against the stresses and health impacts of risky environments" (p.188).

The authors found there are substantial and important causal effects of education on health but more research into the exact contributions of the mechanisms is needed to make precise policy recommendations. Figure 2 illustrates their basic conceptual model of the effects of education on health.

Figure 2.



Source: Feinstein, L et al. Chapter 4. What are the effects of education on health. In: Measuring the Effects of Education on Health and Civic Engagement: Proceedings of the Copenhagen Symposium. OECD; 2006

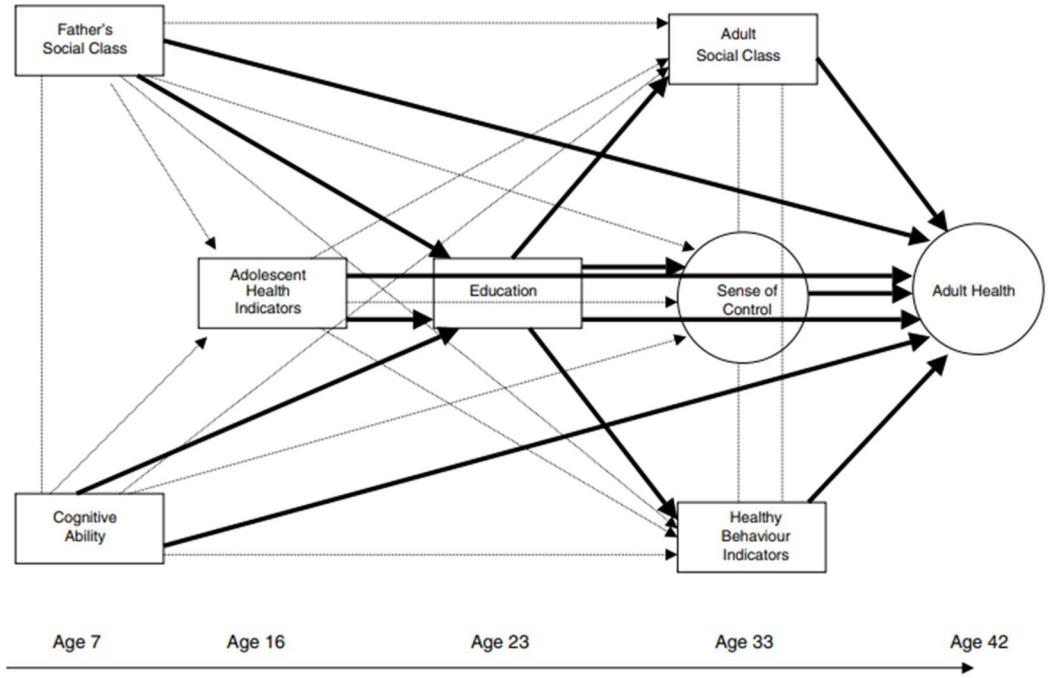
Researchers have studied mediators such as income and health behaviours through which education may affect health. A mediator variable is one that explains the relationship between the dependent and independent variables (predictor and outcome).

Chandola, Clarke, Morris et al. (14), using six phases of the National Child Development Study (UK), found the indirect effect of education on adult health (mediated through its effect on adult social class, control and health behaviours) to be positive and significant. The six phases were carried out in 1965 (at age 7 years), 1969 (age 11 years), 1974 (age 16 years), 1981 (age 23 years), 1991 (age 33 years) and 1999 (age 42 years). For both men and women, they found that the direct association between educational qualifications and adult health was not statistically significant ($p>0.05$) when using a causal analysis and full structural equation model. However, it is important to emphasize that "the absence of evidence for a direct effect of education does not imply that education is unimportant for health. The indirect effect of education (through healthy behaviours and sense of control) was found to be positive" (p.355). They found that most of the association (covariance) between education and adult health is mediated through smoking and sense of control as the results show that educated men and women are more likely to be non-smokers and to have a higher sense of control, which in turn, is associated with better adult health.

In their analysis, they also found some gender differences. For example, 'adult social class' (an ordinal measure ranging from 1 - professional occupations to 6 - manual unskilled occupations) had a direct effect on men's health but not women's health. The authors conclude that to improve population health and reduce health inequalities, health policies need to target these specific causal pathways.

To illustrate these indirect effects of education, Chandola and colleagues developed a causal pathway model of the association between education and health (Fig. 3). In addition to the bold arrows representing the six pathways leading to adult health, the authors also allow variables that are measured after childhood to depend on variables which precede them chronologically. These are denoted by arrows with dotted rather than bold lines. Furthermore, the authors allow for associations between variables that are measured at the same time and indicate these by using dotted lines without arrow-heads. "Dotted lines are used to emphasize associations between the variables which are not hypothesized to drive the education–health relationship, where failure to adjust for these associations would lead to biased estimates of each causal pathway" (p.340).

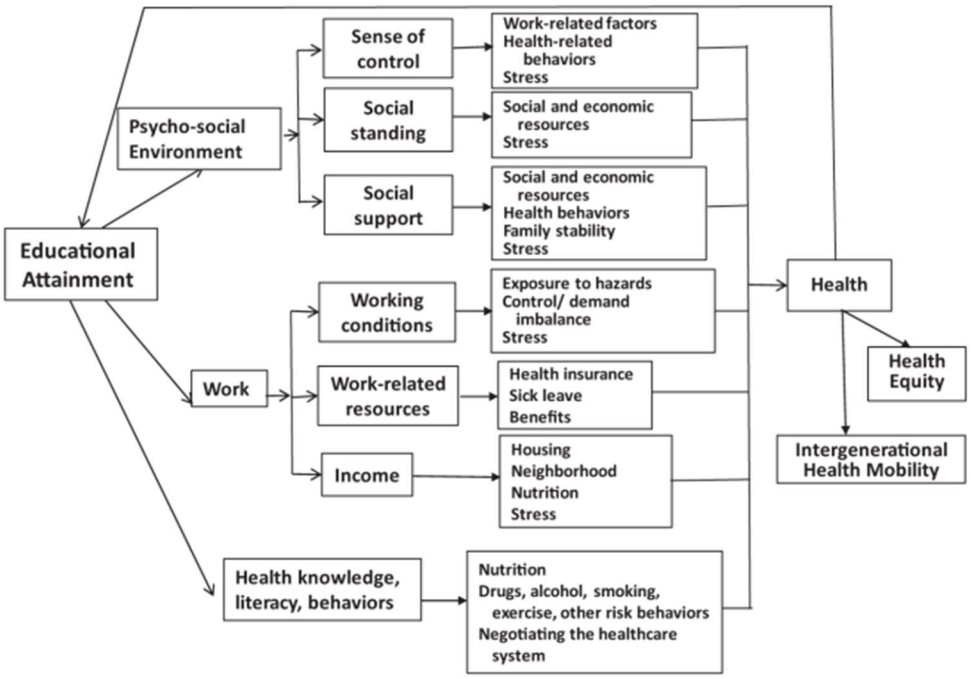
Figure 3.



Source: Chandola et al. Pathways between education and health: a causal modelling approach. 2006

Hahn and Truman (15) have reviewed a wide range of evidence, including mainly primary studies and three systematic reviews, in order to understand the pathways linking education, health and health equity as well as to support the argument that education and education policies are crucial to public health interventions. Building on the work of others, the authors constructed a model to visually present the framework they developed. The model illustrates the three major pathways linking education and health outcomes in adulthood (Fig. 4). The pathways are psychosocial environment (sense of control, social standing and support), work (income, working conditions and resources), and health knowledge, literacy and behaviours (nutrition, risk behaviours, use of healthcare services). The model also illustrates how health has an impact on education, as they argue that education "is at once an element of health and a cause of health" (p.661).

Figure 4.

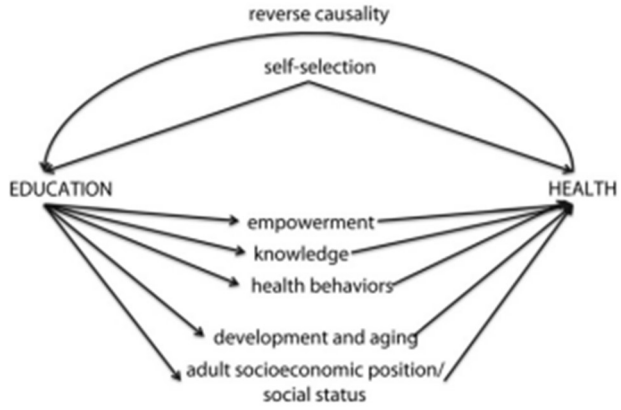


Source: Hahn and Truman. Education Improves Public Health and Promotes Health Equity. 2015

Similarly to Hahn and Truman, Egerter and colleagues (16) argue that education can influence health through various pathways. In this issue brief, which explores existing literature, the authors develop a model which maps out three major interrelated pathways; health knowledge and behaviours, employment and income, and social and psychological factors. The model they developed looks very similar to Figure 4.

Cohen and Syme (17), reviewing evidence from early childhood, kindergarten through 12th grade, and higher education studies, have also mapped out potential pathways and mechanisms in which education affects health. They argue that, as a well-established social determinant of health, education affects health through many mechanisms such as neural development, health literacy and health behaviours, sense of control and empowerment, and life chances (see Fig. 5). The authors point out that each of these mechanisms may have implications that differ for individual health versus population health as well as the importance of contextualising the study population. Figure 5 also indicates an element of reverse causality of the relationship, which highlights the importance that health has on education and the ability to perform in school. The authors recommend that future research should "identify innovative ways to measure the quality of the educational experience when assessing education as a social determinant of health" (p.999) rather than be limited to academic qualifications.

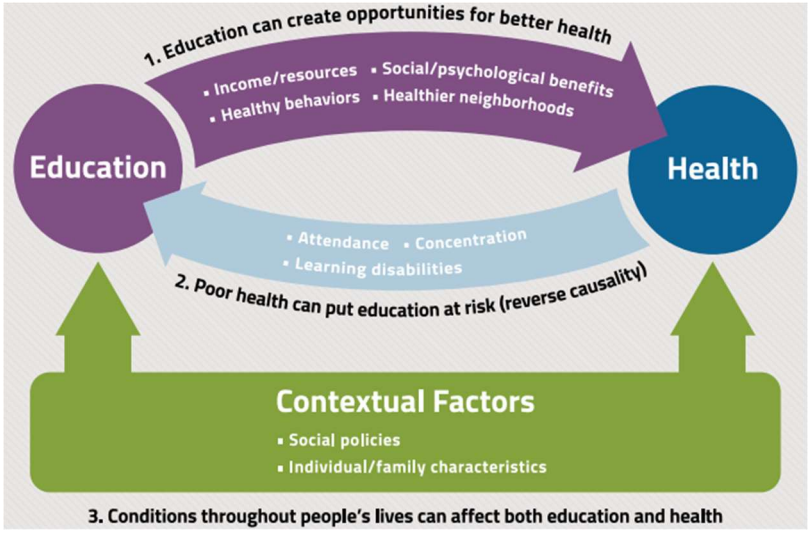
Figure 5.



Source: Cohen and Syme. Education: A Missed Opportunity for Public Health Intervention. 2013

Similarly, the Virginia Commonwealth University in partnership with the Robert Wood Johnson Foundation (18), provide an overview of how education and health are linked as well as the complexity of these links. They argue that there are three main links; 1) education can create opportunities for better health, 2) poor health can put educational attainment at risk (reverse causality) and 3) conditions throughout people's lives can affect both health and education. The diagram below (Fig. 6) maps out these three links. Similar to papers mentioned above, the pathways include income and resources, healthy behaviours, social and psychological benefits and healthier neighbourhoods.

Figure 6.

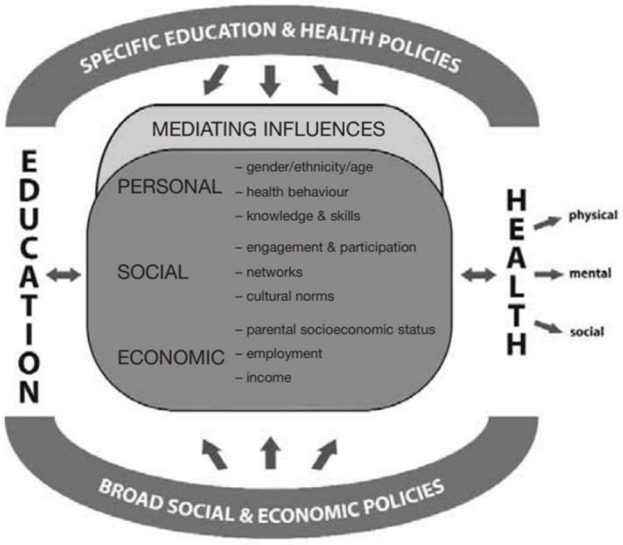


Source: VCU, RWJF. Why Education Matters to Health: Exploring the Causes. 2014

Higgins, Lavin and Metcalfe (19), reviewing existing literature, suggest several routes through which education affects health. These routes are interconnected and include material (employment and income), psychosocial (socialisation and civic

participation) and behavioural factors (psychological resilience, self-efficacy, coping mechanisms, sense of control). They develop a diagram to illustrate the relationship between education and health (see Fig. 7). The diagram illustrates the influence of broad social and economic policies, specific education and health policies and mediating factors such as personal, social and economic factors. The review goes on to highlight the importance of addressing inequality as these benefits of education do not necessarily accrue equally to all population groups in society. Education can also contribute to increased health inequalities by perpetuating cycles of intergenerational and socioeconomic disadvantage.

Figure 7.



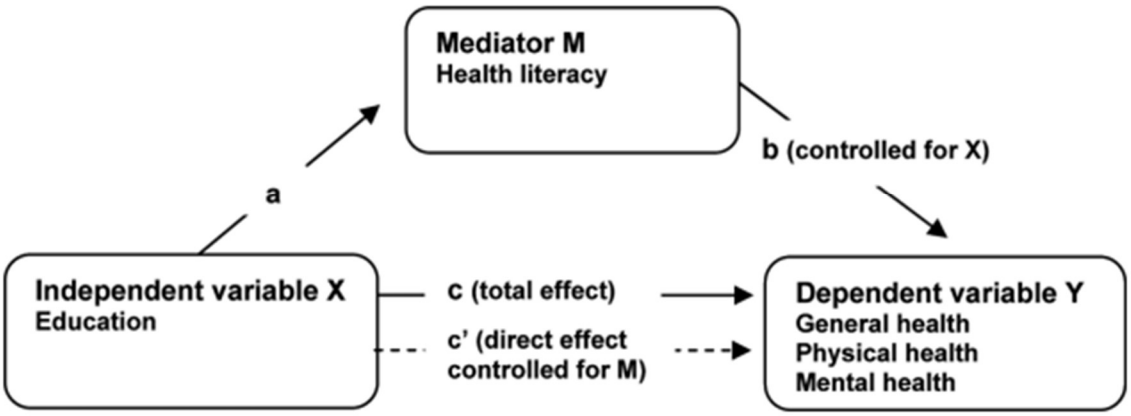
Source: Higgins, Lavin and Metcalfe. Health Impacts of Education: a review. 2008

Health Literacy

Lastly, in more recent literature, there has been a focus on health literacy as a crucial mediating factor. Van der Heide, Wang, Droomer et al. (20) have created a model of mediation analysis based on analysis of cross sectional data from a Dutch Adult Literacy and Life Skills Survey (ALL) along with self-rated health [SRH] status data. The authors found that health literacy, measured by the Health Activities and Literacy Scale (HALS) which was derived from a selection of health-related tasks included in the ALL, partially mediated the association between low education and low self-reported health status (general, mental and physical health). In this survey, the "respondents were asked, for example, to read a medicine dosage chart and indicate the correct dose for a child of a particular weight and age". The mediation analysis conducted indicates that health literacy plays a larger role among those with lower educational attainment than among those with higher education, but health literacy seems to be a more important pathway for lower secondary educated

people than for pre-primary/primary educated people (typically starting at age 3 and at age 5-6 till 11). The authors conclude that improving health literacy may therefore be a beneficial strategy for reducing disparities in health related to education, as "health literacy appears to play a role in explaining the underlying mechanism driving the relationship between low levels of education and poor health" (p.173).

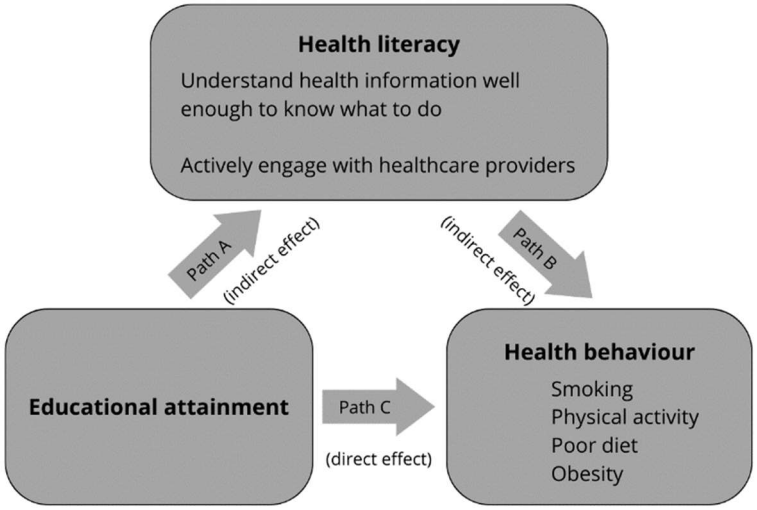
Figure 8.



Source: Van der Heide, Wang, Droomer et al. The relationship between health, education, and health literacy: Results from the Dutch adult literacy and life skills survey. 2013

In a similar analysis to van der Heide and colleagues, Friis, Lasgaard, Rowlands et al. (21) have more recently also investigated whether health literacy mediates the association between educational attainment and health behaviour. Using data from Denmark, the study showed that health literacy in general mediated the relationship between educational attainment and health behaviour. Particularly behaviours such as smoking, being physically inactive, having a poor diet, which could lead to obesity. Health literacy was measured by "two distinct health literacy dimensions from the 9-dimension Health Literacy Questionnaire (HLQ): (a) Understanding health information well enough to know what to do and (b) Actively engage with health care providers" (p.2). The authors developed a model of mediation analysis to illustrate the three direct and indirect effects of educational attainment (Fig. 9). The authors conclude that strategies and policies aiming to reduce health inequalities may benefit from adopting a stronger focus on health literacy within prevention, patient education as well as broader public health interventions.

Figure 9.



Source: Friis, Lasgaard, Rowlands et al. Health Literacy Mediates the Relationship between Educational Attainment and Health Behavior: A Danish Population-Based Study. 2016

4.3 Additional evidence

There is a large body of literature available on the evidence of a relationship between education and specific health outcomes including mortality, life expectancy, SRH, depression, diabetes, obesity, cardiovascular disease and pain. As this review did not focus on a single specific health outcome, the evidence presented here is not comprehensive but rather an overview of some of the literature available. The literature is mainly from North America, particularly the US, and Europe with some studies from Korea and Australia.

The health gradient

A number of authors discuss a health gradient, which suggests that more education is linked with better health and a longer life. Zajacova and Lawrence (8) and Zajacova (22) have observed this effect among American adults in terms of highest level of attainment (high school, bachelor degree and so on). Similarly, looking at the United States, Goldman and Smith (23) have found that the value of education in achieving better health has increased over the last 25 years. They explore disease prevalence (arthritis, diabetes, heart disease, hypertension, and diseases of the lung), self-reported health and behavioural risk factors (e.g. smoking). Their sample included adults aged 40-64 and included an indicator variable for not having health insurance. The result may be due to growing income inequalities and growing disparity by education in the probability of having major chronic diseases during middle age. Furthermore, more educated people are better accessing and benefitting from

advances in medical knowledge, treatment, and availability of effective drugs. They found that more education had an effect both in protecting against onset of disease and promoting better health outcomes amongst those with a disease. Along with better access to health insurance, the more educated individuals increasingly adapted better health behaviours, particularly not smoking and engaging in vigorous exercise.

A study across 22 European countries found that overall, people with low education (lower secondary or less) were more likely to report poor general health and functional limitations (24). The results show some differences between countries, age and gender. The authors found that educational inequalities in health are relatively small in a certain number of countries (Austria, Norway, Sweden, and the United Kingdom) while large inequalities were found for others (Hungary, Poland, and Portugal). The odds ratio for the UK was 1.17 (CI 0.83–1.65) for men and 1.31 (CI 0.94–1.82) for women. Furthermore, education was not significantly related to functional limitations among men and women in four countries, including the United Kingdom. Health effects of education are stronger at ages 25–55 than in the higher age groups, particularly for functional limitations. The effect of education is stronger for women than men in most countries. The authors conclude that despite their results showing inequalities in health resulting from variation in educational outcomes are found across countries, they are modifiable.

Some have suggested that educational attainment, typically years in education or highest level achieved, has little causal effect on the education-health gradient. A study of health outcomes by age 31 (25) found little causal effect of on SRH, using three different models of analysis. Using a simple regression of SRH on education, without controlling for multiple relevant variables found that “31-year-olds with a bachelor's degree have SRH that is 0.5 points higher, on average, than 31-year-olds who never completed high school” (p.24). However, when using a fixed effects model that controls more fully for selection and confounding variables, the results suggest no statistically significant SRH benefits to completing a high school diploma/GED or even an associate's degree. The variables included; race/ethnicity, parental educational attainment, family income and wealth as well as variables about school life; school engagement, being bullied and lying and cheating. The fixed effects model does show that completion of a bachelor's or graduate degree statistically significantly improves SRH, but the improvement is just 0.07 to 0.08 points on the SRH scale. This is only about 15% of the previous, uncontrolled OLS estimates. The authors acknowledge that a limitation of their study is that it ends at age 31, “just 2-3 years after graduate school and 2-3 decades before most adults show any sign of chronic illness or disability” (p.26). However, age 31 is 13 years after a typical high school graduation and 10 years after a typical completion of bachelor’s degree, which is why they believe a follow-up period of 10-13 years seemed long enough to observe some level of effects of education.

Lee (26) has explored the education gradient in relation to depression in South Korea. They found that education affects depression through different underlying mechanisms. These mechanisms include cognitive ability, economic resources, social status, social network, and health behaviour. The single most important pathway was through developing cognitive ability. The author further found that through these pathways, "educational attainment influences not only depression for an individual but also for one's spouse, particularly for women, and parents" (p.121).

Kimbro, Bzostek, Goldman et al. (27) explored how this gradient varies by race and ethnicity in the United States. They discuss the 'Hispanic gradient', whereby Hispanics (particularly foreign-born) often fare better than expected given their typically lower levels of education. The authors note that this is in line with previous research demonstrating immigrants tend to have better morbidity and mortality outcomes. They propose several explanations for this. Firstly, the 'healthy migrant' effect, whereby "people who immigrate to the United States are healthier than those who remain in their home country" (p.369). The data to test this effect is however 'woefully' inadequate. Secondly, the presence of different or reversed socio-economic status [SES]-health relationship in countries of origin (e.g. in Mexico smoking is more likely among upper classes).

Schnittker (28) has examined the effect of education on the relationship between income and health. Using nationally representative data from the United States, the analysis revealed three key results. Firstly, for all levels of income, those with more education have consistently and considerably better health. Secondly, the income gradient flattens as education increases, meaning that fewer income-based disparities exist among the better educated. Lastly, the effect of education is largest at lower levels of income. Using four regression models, all results are statistically significant.

A 'glitch' in the health gradient has been observed in a particular cohort study by Zajacova, Rogers and Johnson-Lawrence (29). The glitch was in the health gradient for adults with some college education (disrupted or not-completed college education), as well as recipients of technical/vocational associate degrees. "Although these groups had more schooling than high school graduates, they reported at least as many health problems and conditions ranging from cardiovascular and respiratory conditions to acute illness, pain, and functional limitations as the high school graduates" (p.2010). The authors investigate several possibilities for the glitch in this cohort study; reporting bias, differential knowledge about conditions or reverse causality (health problems prevented the college dropouts from reaching their educational goals). Some of the glitch could be due to confounding factors, meaning that unobserved characteristics drive both educational attainment and health outcomes. The authors have no answer to the glitch but suggest their possible explanations be tested out in future research.

Lastly, in a later paper, Zajacova, Rogers and Grodsky et al. (30) further explore this gradient for pain specifically. After adjusting for covariates including employment, economic resources, health behaviours, physical health conditions, and psychological well-being, they found that educational disparities in pain are no longer statistically significant except for the GED and ''some college'' categories, where pain is higher than expected (the 'glitch'). GED's are American General Education Development tests completed at high school level (an alternative to an American high school diploma).

Exploring mediators

Various mediators are often included in the research on the relationship between education and health. Sheikh, Abelsen and Olsen (31), examining data from Norway (the Tromsø Study), use SES as a mediator between education and health. SES indicators included income, management position, occupational hierarchy position and subjective social status. They found that SES was associated with education in the expected way; people who reported low education had lower SES ($p<0.05$) and, similarly, having low education was associated with being unhealthy and having a low level of well-being ($p<0.05$). The analysis also showed that those who reported a lower SES were more likely ($p<0.05$) to be unhealthy and to have a low level of well-being. After adjusting for several confounding variables (age, gender, childhood SES, exposure to passive smoking in childhood, having enough friends, number of friends, marital status and physical activity in hours/week), the authors conclude that the findings suggest that education is associated with health and well-being in adulthood and that most of this effect is mediated by indicators of SES.

White et al. (32) found that, generally, higher levels of education increased the likelihood of healthy ageing amongst Canadian adults. The authors examined data from the Manitoba Study of Health and Aging which collected data by personal interview, self-reported questionnaire, and clinical examination about physical, cognitive, social and psychological health. They were interested in the role of income and occupation in the association of education with healthy ageing and the results showed some gender differences. For men, after adjusting for education, income measures (perceived income adequacy and life satisfaction with finances) predicted healthy aging among men (mediating effect). Occupation did not have this effect among men. For women, neither income nor occupation measures explained the significant association between education and healthy ageing.

Similarly, Tran and Tran (33) look at the relationship between education and health in Australian women using health behaviours and social interactions as 'submeasures'/mediators. The authors find a statistically significant positive effect of education on health amongst women in Australia. The authors go on to investigate potential mechanisms which might explain this relationship between

education and health. After carrying out various additional analyses, they find that the results indicate that women with higher education might have better health by investing more in healthier behaviours and social capital.

As mentioned above, there is also a focus on health literacy in the literature. Particularly how this links to health behaviours, both healthy behaviours (prevention) and risk behaviours (harming). Yamashita et al. (34) find evidence which partially supports the notion that health information seeking behaviours are directly linked to educational attainment, and provide some of the first nationally representative evidence for how education functions through distinct health literacy components to shape health information seeking behaviours by health status. They conclude the need and importance of addressing health literacy disparities in accessing and using health information.

Factors such as occupational class, working conditions and individual lifestyle have also been investigated in Norway to determine the mediating effects they have on education and back pain disability (35). The authors of this paper found that "each additional year of formal education was associated with decreased risk for disability pensioning from back pain for both men [age adjusted Hazard Ratio (HR) 0.77; (95% CI 0.72–0.82)] and women [HR 0.76 (0.71–0.82)]" (p.1267). 'Disability pensioning' refers to early retirement on health grounds. However, when adjusting for occupational class and factors related to working conditions (authority to plan own work, physically demanding work, concentration and attention and job satisfaction) and individual lifestyle (smoking, body mass index, physical exercise and alcohol consumption) the effect of education was reduced by 39% [HR 0.86 (0.79–0.93)] for men and by 21% [HR 0.81 (0.73–0.89)] for women.

Lastly, van der Pol (36) has explored the relationship between education, health and time preference. Time preference refers to individual's preferences over the 'timing of outcomes' and influences how individuals make decisions such as, for example, whether or not to invest in education, whether to save or borrow money and whether to engage in health harming behaviours such as smoking, drinking and drug use. The results show that the effect of education on health reduces but does not disappear when controlling for individuals' time preferences. This study, however, has several limitations, one of them being that the survey questions about time preference are hypothetical and choices may differ if presented in real life as well as depend on the personal situation of the individual at the exact time of the question.

No effect

Braakman (12), using a natural experiment approach, analysed data from 13 academic cohorts (individuals born between 1957 and 1970) along with data from the British Labour Force Survey (LFS) and the Health Survey for England (HSE) in

England. The author uses LFS and HSE data from 1998 to 2002. For these cohorts, compulsory schooling laws changed and this approach created exogenous variation in the likelihood to obtain any sort of academic degree between January and February born individuals for the 13 academic cohorts. For background information, British children, depending on their month of birth, had to stay in school either until Easter or until the summer of the respective year. Pupils born between September 1 and January 31 could leave school at Easter while those born between February 1 and August 31 had to stay until the summer. "For birth cohorts prior to 1957 who could leave school at the age of 15 these regulations only varied the length of education by one term (or by about two to three months). When the minimum school leaving age was raised to 16 – effective for birth cohorts from (September) 1957 onwards – however, this regulation began to influence the likelihood that individuals took the O-level and CSE exams. These were conducted each year in the summer and were normally taken at the age of 16. While the exams were open to all students regardless of whether they left school at Easter or stayed until the summer, the likelihood of having taken (and passed) the exams was much higher for individuals being born after the January-February-cut-off" (p.4). For this group, the author observes an approximately 2 to 3% higher probability of having obtained a degree.

He found that the within-cohort differences in education "did not transform into corresponding differences in various objective health measures or in health related behaviour like smoking or drinking" (p.20). The author stresses that the results do not rule out a causal link between higher forms of education and health. The author concludes that the results are both in line with previous evidence using changes in compulsory schooling laws but also contradicts some previous research, which uses similar identification strategies. "The question of whether there is a causal link between education and health seems to be open" (p.21).

5. Discussion

This review found a largely consistent body of evidence showing the relationship between education and health is mediated by various factors and 'pathways'. Due to the broad nature of this review and nature of the evidence it is impossible to define the most important mediating factor or mechanism in the education-health relationship and it is difficult to disentangle the multiple relationships between causes, confounders and mediators. The studies use different measures, methods of analysis, effects size equations and control for different covariates and variables. However, there are broadly three pathways and mechanisms – work/income, psychosocial environment (including sense of control) and health knowledge and behaviours. Generally, the more variables researchers control for, the smaller the association between education and health, which suggests they are mediating

factors, or even confounding factors in some cases. It is worth noting that temporality is also important, some papers in this review include factors which are not mediators *between* education and health but, for example, parental education and socio-economic factors may affect a child's education which in turn affects health outcomes through the three pathways mentioned in this review.

When reviewing the evidence there are several points to consider. Firstly, it is important to consider the differences in the impact of education on health across countries with very different educational, social security, healthcare and political systems. Lochner (37) suggests that education "may improve health and mortality less in Europe, where health care tends to be universal and economic inequality is generally lower" as compared to the United States, for example, where universal healthcare does not exist. Around half of the papers included in this review explore data from the United States. Considering that a large part of literature is from the United States, the relevancy and applicability of the findings to the Welsh context is questionable. Additionally, educational systems and curricula across the world have changed over the years. Many of the studies included in this review use data from the last century to explore adult health outcomes.

Secondly, Zajacova and Lawrence (8) argue that a sizeable proportion of education-health research has been grounded in a fundamental cause theory. This theoretical approach "operationalizes the complex process of schooling solely in terms of attainment and thus does not focus on differences in educational quality, type, or other institutional factors that might independently influence health" (p.275). They argue that this theory also places a focus on individual-level factors – individual attainment, attainment effects, and mechanisms – and leaves out the social context in which the education and health processes are embedded. Zimmerman and Woolf (13) make similar arguments using a socio-ecological model.

Moreover, Cohen and Syme (17) reflect on whether years of education is the most important 'element in the equation' or if this is used simply because it is the easiest to measure. Perhaps the focus should shift to quality of education or levels of literacy and numeracy.

The literature mostly focuses on education as a 'driver of opportunity' (increasing skills and job prospects) but there is also some evidence suggesting that education can perpetuate cycles of intergenerational and socioeconomic disadvantage (8)(19). This reproduction of inequality involves both educational institutions (differences in school resources, quality of instruction, academic opportunities, peer influences, or teacher expectations) as well as socio-economic status and other background characteristics.

Lastly, there are also ethnicity and gender differences in the effect of education on health outcomes. Despite their typically lower levels of education, Hispanics in the United States often fare better than expected (27). A Canadian study using data

from the 1990s found that neither income nor occupation measures explained the significant association between education and healthy ageing (32). A study from Australia found women with higher education might have better health by investing more in healthier behaviours and social capital (33). Further research should aim to investigate gender differences as mediators of the relationship between education and health may vary. Gender and ethnic differences in educational attainment is a well-researched area in the UK. A recent example of this is the Deaton Review on education inequalities by the Institute for Fiscal Studies (38).

6. Strengths and limitations of review

There are both and strengths and limitations to this review. The review provides an overview of the evidence and the well-documented relationship between education and health. However, as this was a high level, rapid literature review it cannot claim to be all-encompassing. A large proportion of the literature reviews and discussion papers included in this review have not provided information about the methods used for the evidence searches and whether the evidence has been critically appraised.

Additionally, due to the nature of this review, no formal critical appraisal of the evidence was undertaken. A data extraction table, including information on methods and limitations, has been developed.

7. Conclusion

Overall, it is clear from the literature that there is persistent and strong association between education and health, although some exceptions do exist (12). The causal association gets smaller as mediating factors and confounding variables are taken into account. The various models and frameworks included in this paper demonstrate pathways and mechanisms through which education indirectly affects various health outcomes (general, mental and physical). These pathways include health knowledge and behaviours, employment and income, and social and psychological factors.

Although there is a relationship between education and health in the literature, there are several points to consider to understand how education can affect health outcomes. Education should be understood in the context of a wider inter-related system, which means unpicking specific affects can be challenging.

The relationship is not straight-forward, there are mediators, moderators and confounding variables to take into account to properly understand how education

and health relate to one another. These, again, are interconnected and not mutually exclusive.

The relationship between education and health is also not a linear relationship. The literature suggests there is a reverse causality, meaning health also impacts educational attainment. In addition to reverse causality, literature has also examined intergenerational effects and looked at how parental educational attainment and SES affects the health outcomes of their children. There are also age, gender and ethnic differences as well as differences between countries depending on social and political environments.

Furthermore, quality of education is not simply about outcomes at the individual level but also at community and policy level. Literature highlights the importance of looking beyond the individual outcomes as the quality of education is dependent on (and affects) community resources and characteristics as well as broader social and political level. One paper (13) argues that an increased awareness and understanding of the importance of education for both the individual and the wider community will be essential to setting policy priorities and reducing both social and health inequities.

While there is a large body of literature, much of it is from the United States where education policies, curricula and health care systems are different from the Welsh and UK context. One study from the United States (23) suggests an increasing importance of education over the last 25 years but Lochner (37) also discusses the possibility that education has a greater effect on health in America than Europe due to the lack of universal healthcare. Evidence from Europe and the UK are largely in line with each other and conclude that education has an important effect on future health outcomes through various pathways and mediators. There is one notable exception to this, a study from the UK (12). Moreover, as the findings in the literature have been derived from longitudinal and cohort studies which were initiated in the last century, it is important to acknowledge that educational policies have changed in the intervening decades.

8. Implications of findings

Taking income into account, for example, there is evidence that those with more education maintain a health advantage independent of income and that the effect of income decreases with more education. In turn this means that the effects of education on health become greater among those with less income. This suggests the need to focus on the educational attainment of those likely to be from lower socio-economic backgrounds and likely to go into lower paying jobs.

There is a general call for less focus on individual-level factors in the literature and more focus on the quality of education individuals receive as well as the broader social and political context of education and health processes. The quality of education has impacts that go far beyond the individual, affecting the community level and social policy level. This is something to consider for the future when developing a systems map of the factors affecting educational achievement in Wales. It will be important to ensure broader policy and context level considerations in addition to understanding individual level factors.

Lastly, as the New Curriculum for Wales focuses on 'soft skills', numeracy and literacy, there may be opportunities for future research to examine the impacts of these changes on health, well-being and equity outcomes.

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Appendix 1 – Reduced data extraction table

Title	*Authors*	*Publication date*	*Country*	*Conclusion*
The causal relationship between education, health and health related behaviour: Evidence from a natural experiment in England	Braakman N	2010	United Kingdom	The author found that the results from this natural experiment, which looked at the impact of longer time in school and higher qualification but not factors such as quality of education, indicate neither an effect of education on various health related measures nor an effect on health related behaviour, e.g., smoking, drinking or eating various types of food.

Pathways between education and health: a causal modelling approach	Chandola T, Clarke P, Norris J et al.	2008	United Kingdom	Authors find that the association between education and health appears to be explained by a combination of mechanisms: adolescent health and adult health behaviours for men and women, adult social class among men and parental social class among women. They conclude that improvements in population educational attainment may not automatically lead to improvements in population health, and that health policies for improving health and reducing health inequalities need to target specific causal pathways.
Education: A Missed Opportunity for Public Health Intervention	Cohen and Syme	2013	United States	This review suggests that benefits of education arise from receiving high-quality education. Educational quality is essential across an individual's school trajectory (e.g., early childhood through higher education). When quality varies, fade out effects are commonly observed. Quality is defined differently in early childhood and kindergarten through 12th grade than in higher education. Often public health researchers conceptualise education solely as years of education attained starting with kindergarten; the authors argue that early childhood education and educational quality are critical facets of the educational experience to consider as well. Authors make recommendations for future research.
Education and health: Evaluating theories and	Cutler D and Lleras-Muney A	2006	United States	Authors found that the magnitude of the relationship between education and health varies across conditions, but they are generally large. Adding controls for occupation and industry had very little effect on the coefficient of education

evidence (Working paper 12352)				(for majority of health measures) and in some cases the effect of education actually became stronger. The effect of education on health behaviours is generally either reduced by adding these controls (e.g. for smoking, or days drinking), or it remains stable but in all cases, the effect of education remains significant. Overall, the results suggest very strong gradients where the better educated have healthier behaviours along virtually every margin (although some of these behaviours may also reflect differential access to care).
Education and Health	Egerter S, Braveman P, Sadegh-Nobari T et al.	2011	United States	Authors describe the pathways through which education affects health based on existing literature (3 broad pathways: Health knowledge, Literacy, Coping & problem-solving; Work; Psychosocial environment). They conclude that current evidence indicates that one of the most effective strategies for reducing health disparities in this country could be to take steps to close the gaps in educational attainment. Reviewing specific policies and programs to increase educational attainment was beyond the scope of this brief.
4. What are the effects of education on health?	Feinstein L, Sabates R, Anderson T et al.	2006	OECD	Authors find considerable international evidence that education is strongly linked to health and to determinants of health such as health behaviours, risky contexts and preventative service use, and they find that a substantial element of this effect is causal. Those with more years of schooling tend to have better health and well-being and healthier behaviours. Education is an important mechanism for enhancing the health and well-being of individuals

				because it reduces the need for health care, the associated costs of dependence, lost earnings and human suffering. It also helps promote and sustain healthy lifestyles and positive choices, supporting and nurturing human development, human relationships and personal, family and community well-being. Authors also emphasise the extent that education effects health as a result of impacts on features of the self, particularly self-concepts and attitudes, and so if the quality of education is not appropriate to the developmental needs of the individual, education can have directly harmful effects.
Health Literacy Mediates the Relationship Between Educational Attainment and Health Behaviour: A Danish Population-Based Study	Friis K, Lasgaard M, Rowlands G et al.	2016	Denmark	Health literacy, particularly the ability to understand health information, is a mediator in the relationship between educational attainment and health behaviour. The findings indicate that strategies for improving public health and reducing health inequalities may be improved through a stronger focus on health literacy. Health literacy is very closely linked to education and health inequalities. Interventions aimed at improving health behaviour and health status have the potential to become more targeted and effective when informed by robust data on the health literacy of the target populations.
The increasing value of education to health	Goldman D and Smith J	2011	United States	Authors found that the value of education in achieving better health has increased over the last 25 years; both in protecting against onset of disease and promoting better health outcomes amongst those with a disease. Besides better access to health insurance, the more educated increasingly

				adapted better health behaviours, particularly not smoking and engaging in vigorous exercise, and reaped the benefits of improving medical technology. Rising health disparities by education are an important social concern which may require targeted interventions. Authors conclude that we need a better understanding of what the barriers are that make it more difficult for the less educated to invest in their health and benefit equally from the health enhancing improvements.
What mediates the inverse association between education and occupational disability from back pain? - A prospective cohort study from the Nord-Trøndelag health study in Norway	Hagen K, Tambs K and Bjerkedal T	2006	Norway	Authors found that each additional year of formal education was associated with decreased risk for disability pensioning from back pain for both men and women. Working conditions contributed most to the explanation for men, while occupational class, working conditions and life style factors contributed equally for women. Subgroup analyses indicate small differences between full-time and part-time employees, while some differences were found between subcategories of back diseases. The study indicates that there is a strong and unexplained effect of education on back pain disability pensioning, which is not mediated by occupational class, working conditions or individual lifestyle.
Education Improves Public Health and	Hahn R and Truman B	2015	North America (United States and Canada)	Authors summarize the extensive literature demonstrating that formal education is a contributing cause of health (examples of association with various different measures).

Promotes Health Equity				They constructed a model indicating the 3 major pathways linking education and health outcomes in adulthood.
Health Impacts of Education: a review	Higgins C, Lavin T and Metcalfe O	2008	Ireland and Northern Ireland	In this review of evidence, authors find strong links between education and health. Greater levels of education can lead to: improved chances of finding secure, well paid employment, with subsequent health benefits; more opportunities for social development and enhanced social skills, with positive impacts for both the individual and wider community, and subsequently, for general health; greater likelihood of developing knowledge, attitudes and behaviours conducive to good health. On the other hand, education can also contribute to increased health inequalities by perpetuating cycles of intergenerational and socioeconomic disadvantage. Ensuring this does not happen requires strategic investment in education, an appreciation of the links between education and health and strong champions supporting the role of education in contributing to a healthier society.
Race, Ethnicity, and the Education Gradient in Health	Kimbro R, Bzostek S, Goldman N et al.	2008	United States	Authors propose several explanations for the finding that lower-educated foreign-born people have better health outcomes than their US-born counterparts. The authors conclude that the SES-health paradigm must become more flexible to incorporate and understand differences in the way education influences health across race/ethnicity and nativity

				status, and it must be sensitive to the complex mechanisms that generate those differences.
Pathways from education to depression	Lee J	2011	Korea (South)	Authors found that cognitive ability, economic resources, social status, social network, and health behaviour explain all of the education gradients. Education affects depression through different underlying mechanisms, and the single most important pathway is through developing cognitive ability. Through these pathways, educational attainment influences not only depression for an individual but also for one's spouse, particularly for women, and parents. Authors conclude this might be attributed to changes in education policy in Korea, which increased basic levels of education for both men and women in this cohort, thus there is less of a measurable differential in cognitive ability across the population in the cohort sample, leaving other mediators to explain more of the variance in emotional health.
Non-production benefits of education: crime, health and good citizenship (Working Paper 16722)	Lochner L	2011	United States, United Kingdom and EU countries	The author reviews literature, which establishes that education and human capital impact a wide range of personal decisions and activities. Education has been shown to reduce crime, improve health, lower mortality, and increase political participation. The social benefits from these impacts can also be sizeable. Much of the evidence on the causal effects of education on crime, health, and citizenship has come from changes in compulsory schooling laws, which primarily affect secondary schooling choices. Given the rise in college attendance throughout the world, additional efforts to study

				this margin are needed. The author also finds that comparisons across estimates from the U.S. and Europe seem to suggest that education may improve health and mortality less in Europe, where health care tends to be universal and economic inequality is generally lower.
An education gradient in health, a health gradient in education, or a confounded gradient in both?	Lynch J and von Hippel P	2016	United States	Authors find that at age 31, there is not primarily an education gradient in health. Instead, they partly observe a health gradient in education and partly a confounded gradient that results from adult health and education having similar antecedents. This finding is not surprising. There is an established literature showing that healthier adolescents tend to become more highly educated. Authors conclude that because some health effects of education are likely cumulative, the education-health gradient is an excellent subject for future research, especially since previous studies have reached mixed conclusions regarding the later life health benefits of education.

What is the relationship between education, literacy and self-reported health? (ADULT SKILLS IN FOCUS #4)	OECD, Borgonovi F	2016	OECD	Reviewing OECD survey data, the author found that better-educated individuals are more likely to report better health than less-educated individuals, even after controlling for a variety of individual background characteristics. The strength of the association between years of schooling, literacy and self-reported health is reduced, but remains large and statistically significant after controlling for individuals' background characteristics. However, the strength of the relationships between education and self-reported health and literacy and self-reported health differs greatly across countries. They also find that education is associated with health in all countries even when controlling for cognitive ability.
How are health and life satisfaction related to education? (Education Indicators in Focus)	OECD	2016	OECD	Reviewing OECD data, authors found that both education and skills are associated with better health and having a higher education is associated with being more satisfied with life, with some exceptions. Authors conclude that the well-being of a population cannot be measured purely through economic indicators. Social outcomes such as health and life satisfaction are perceived as important aspects of well-being. The data reviewed shows that education, cognitive skills and social and emotional skills all play a role in increasing health outcomes and life satisfaction.
Education and the Changing Shape of the	Schnittker J	2004	United States	Results from 2 large and nationally representative data sets indicate that the positive relationship between income and health varies substantially in both its strength and shape by

Income Gradient in Health*				level of education. Education improves health and its effects are larger at lower levels of income. Moreover, education reduces the strength of and curvature of the income-health relationship. Consequently, those with more education have better health for all levels of income, and fewer income-based disparities exist among the well educated than among the less well educated.
Education and health and well-being: direct and indirect effects with multiple mediators and interactions with multiple imputed data in Stata	Sheikh M, Abelsen B and Olsen J	2017	Norway	This study contributes to the literature on mediation analysis, as well as the literature on the importance of education for health-related quality of life and subjective well-being. Authors conclude, after adjusting for several confounding variables, that the findings suggest education is associated with health and well-being in adulthood and that most of this effect is mediated by indicators of SES.
Women's health: a benefit of education in Australia	Tran D and Tran H	2019	Australia	Authors find that an additional year of schooling can lead to an increase in self-reported health, physical health, mental health and a reduced likelihood of having long-term health conditions. Women who are not in the labour force are likely to enjoy higher benefits of education compared to their employed counterparts. The findings also suggest that the relationship between education and health can be explained

				by the extent of positive health behaviours and social capital as mediators.
The Relationship Between Health, Education, and Health Literacy: Results From the Dutch Adult Literacy and Life Skills Survey	van der Heide I, Wang J, Droomers M et al.	2013	The Netherlands	This study provides strong evidence that health literacy serves as a pathway by which education affects health. Although the relationship between low education and poor health can be explained in part by health literacy, poor health literacy is also relatively common among those with a high level of education. The findings of this study suggest that strategies for reducing disparities in health related to education may benefit from attention to health literacy. For example, adapting health information in a way that can be more readily accessed, understood, and used by those with difficulties in reading and calculating, may improve their opportunities to maintain or improve their health.
Health, education and time preference	van der Pol M	2011	The Netherlands	The author found that self-reported health was dependent on education and other individual characteristics. When including time preference the coefficient on education was reduced. This was also shown for other health measures, including smoking. However, the reductions in the education coefficient were relatively small. Moreover, the coefficient on education remained statistically significant, indicating that there is a substantial exogenous effect of education on health. The largest reduction in the education coefficient occurred when income was included in the regression model. Given that education and income are correlated, this may suggest that one of the mechanisms through which education

				affects health is by raising income levels. However, the education coefficient remained statistically significant, suggesting that there are likely to be other mechanisms through which education affects health. Author concludes that further research is needed.
Why Education Matters to Health: Exploring the Causes	Virginia Commonwealth University, Robert Wood Johnson Foundation	2014	United States	Authors discuss three main connections between health and education: education can create opportunities for better health (income, healthy behaviours, social/psychological benefits, healthier neighbourhoods); poor health can put educational attainment at risk (reverse causality - attendance, concentration, learning disabilities; conditions throughout people's lives - beginning in early childhood - can affect both health and education (contextual factors - social policies, individual/family characteristics)
Education and health in 22 European countries	von dem Knesebeck O, Verde P and Dragano N	2006	European countries	The authors conclude that their results confirm that educational inequalities in health are a generalised though not invariant phenomenon. Variations between countries, sexes and health indicators might be one explanation for the inconsistent results of other studies on age differences in the association between socioeconomic position and health.
The role of income and occupation in the association of education with healthy	White C, St John P, Cheverie M et al.	2015	Canada	Authors found that education was a significant predictor of healthy aging. As educational attainment increased, the likelihood of healthy aging also increased. This was not significantly associated with gender. They also found that perceived income adequacy and life satisfaction with finances explained the beneficial effects of higher education on

aging: results from a population-based, prospective cohort study				healthy aging among men, but not women. Identifying predictors of healthy aging and the mechanisms through which these factors exert their effects can inform strategies to maximize the likelihood of healthy aging.
The Roles of Education, Literacy, and Numeracy in Need for Health Information during the Second Half of Adulthood: A Moderated Mediation Analysis	Yamashita T, Bardo A, Cummins P et al.	2019	United States	Findings from this study provide evidence of the mediation relationships between education, literacy, numeracy and health, and moderation effect of self-rated health among adults (50+ years old). Poor health was found to alter both the effect of education on health information seeking as well as the mediation effects through literacy and numeracy. Given the identified moderated mediation effects, researchers, educators, and health practitioners should be aware of the complex interactions and distinctive roles of literacy and numeracy in the context of health information seeking. In later life, literacy and numeracy skills are critical to take advantage of existing and emerging health information over and above one's educational background. Addressing health information disparities by education and health literacy may reflect a key step toward improving population health.
Education, gender, and mortality: does schooling have	Zajacova A	2006	United States	The author explored gender differences in the effect of education on mortality, using nationally representative data with a 20-year follow up period and a comprehensive set of socioeconomic and lifestyle measures. They found schooling

the same effect on mortality for men and women in the US?				to have the same effect on mortality for men as for women. Each year of additional schooling was associated with 5% lower odds of dying for both genders. Some of the education effect was due to its association with health behaviours and income, but about half of the effect remained unexplained, a finding that has been reported in most previous studies.
The Relationship Between Education and Health: Reducing Disparities Through a Contextual Approach	Zajacova A and Lawrence E	2018	United States	Reviewing existing evidence from high-income countries, the authors conclude that education and health are central to individual and population well-being. They are also inextricably embedded in the social context and structure. Authors make recommendations for future research, which needs to expand beyond the individual-focused analyses and hypothesize upstream, taking a contextual approach to understanding education and health. This will require interdisciplinary collaborations, innovations in conceptual models, and rich data sources.
The Relationship Between Education and Pain Among Adults Aged 30-49 in the United States	Zajacova A, Rogers R, Grol-Prokopcyk E et al.	2020	United States	Authors find a significant and steep pain gradient: greater levels of educational attainment are associated with less pain, with 2 important exceptions. First, adults with a high-school equivalency diploma (GED) and those with ''some college'' have significantly higher pain levels than high school graduates despite having an equivalent or higher attainment, respectively. Second, the education-pain gradient is absent for Hispanic adults.
Glitch in the gradient:	Zajacova A, Rogers R and	2012	United States	Authors find that the presecondary and baccalaureate levels are consistent with the health gradient. An unexpected

Additional education does not uniformly equal better health	Johnson-Lawrence V			finding occurs among adults with some college but no degree, and those with technical/ vocational associate degrees: these groups report more pain and a higher prevalence of a broad range of conditions than high school graduates who never attended college. Findings challenge the broadly accepted educational gradient in health and underscore the need for both researchers and policymakers to examine detailed educational categories in public-health research.
Understanding the Relationship Between Education and Health	Zimmerman and Woolf	2014	United States	Authors review evidence on the health benefits associated with education at the individual level (education impacts a range of skills, education increases economic and social resources), at the community level (food access, spaces and facilities for physical activity, access to health care, community economic resources, crime and violence) as well as the larger social context and social policy. Authors also discuss reverse causality and "*selection phenomenon* caused by the detrimental effects of illness on educational success". Authors conclude that despite decades of research documenting the connections between education and health, there is still much to learn about the mechanisms that enable this connection. Unpacking this is not just an exercise in scientific inquiry; it is also essential to setting policy priorities.