Building the foundations for sustainable development: a case for global investment in the capabilities of adolescents

Peter Sheehan, Kim Sweeny, Bruce Rasmussen, Annababette Wils, Howard S Friedman, Jacqueline Mahon, George C Patton, Susan M Sawyer, Eric Howard, John Symons, Karin Stenberg, Satvika Chalasani, Neelam Maharaj, Nicola Reavley, Hui Shi, Masha Fridman, Alison Welsh, Emeka Nsofor, Laura Laski

Investment in the capabilities of the world's 1·2 billion adolescents is vital to the UN's Sustainable Development Agenda. We examined investments in countries of low income, lower-middle income, and upper-middle income covering the majority of these adolescents globally to derive estimates of investment returns given existing knowledge. The costs and effects of the interventions were estimated by adapting existing models and by extending methods to create new modelling tools. Benefits were valued in terms of increased gross domestic product and averted social costs. The initial analysis showed high returns for the modelled interventions, with substantial variation between countries and with returns generally higher in low-income countries than in countries of lower-middle and upper-middle income. For interventions targeting physical, mental, and sexual health (including a human papilloma virus programme), an investment of US$4·6 per capita each year from 2015 to 2030 had an unweighted mean benefit to cost ratio (BCR) of more than 10·0, whereas, for interventions targeting road traffic injuries, a BCR of 5·9 (95% CI 5·8–6·0) was achieved on investment of $0·6 per capita each year. Interventions to reduce child marriage ($3·8 per capita each year) had a mean BCR of 5·7 (95% CI 5·3–6·1), with the effect high in low-income countries. Investment to increase the extent and quality of secondary schooling is vital but will be more expensive than other interventions—investment of $22·6 per capita each year from 2015 to 2030 generated a mean BCR of 11·8 (95% CI 11·6–12·0). Investments in health and education will not only transform the lives of adolescents in resource-poor settings, but will also generate high economic and social returns. These returns were robust to substantial variation in assumptions. Although the knowledge base on the impacts of interventions is limited in many areas, and a major research effort is needed to build a more complete investment framework, these analyses suggest that comprehensive investments in adolescent health and wellbeing should be given high priority in national and international policy.

Introduction

Adolescents and young adults, particularly girls and young women, are increasingly seen as driving forces in global health and international development.[1] The physical, cognitive, social, and emotional capabilities acquired during adolescence underpin wellbeing throughout the life-course, including the capacity to engage effectively in work and leisure, family life, and communities.[2] Equally, failure to acquire these capabilities during adolescence can have adverse long-term effects on individuals, families, and communities.

Powerful global forces are shaping this transformational life phase. Improvements in childhood nutrition and control of infectious diseases have reduced the age of puberty in many countries.[3,4] Conversely, the adoption of adult roles, including stable partnerships and marriage, parenthood, employment, and leaving home are occurring later in life.[5] Changing economic patterns, driven by globalisation, technology, and climate change, are reshaping the nature of jobs, requiring increased periods of education before employment.[6] Changing cultural and social norms around gender, child marriage, and attitudes to violence, together with the rapid spread of digital and social media, are now shaping social development across the adolescent years.[7]

In low-income and middle-income countries (LMICs), many specific factors affect both the health and social development and the capabilities of adolescents. To date, adolescents have benefited less than younger children from the epidemiological transition from communicable to non-communicable diseases as the main contributors to the burden of disease. For adolescents aged 15–19 years, the disease burden remains twice as high in LMICs (excluding China) as in the rest of the world. This increased burden arises from preventable and treatable problems, including HIV and other infectious diseases, poor sexual and reproductive health, undernutrition, and unintentional injury.[5] Child marriage is a crucial factor: in 42 LMICs, 36% of women aged 20–24 years were married or in union before 18 years of age, compared with 1–2% of women in high-income countries.[8] Rates of interpersonal violence are nearly 2·5 times as high in 75 LMICs as in the rest of the world.[9] The availability of quality education and employment for adolescents in LMICs also remains limited.

Action and investment to ensure that adolescents and young adults develop the capabilities for adult life is now a pressing agenda.[10] On Sept 25, 2015, the UN adopted the Sustainable Development Goals,[11] with specific targets to be achieved by 2030. These targets include reducing poverty and ending extreme poverty, ensuring healthy lives and promoting wellbeing at all ages,

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Victoria Institute of Strategic Economic Studies, Victoria University, Melbourne, VIC, Australia (P Sheehan DPhil, K Sweeny PhD, B Rasmussen PhD, J Symons PhD, N Maharaj BA, H Shi PhD, M Fridman PhD, A Welsh GradDip)**; Wils Consulting, Needham, MA, USA** (A Wils PhD)**; United Nations Population Fund, New York, NY, USA** (H S Friedman PhD, J Mahon MPH, S Chalasani PhD, L Laski MPH)**; Department of Paediatrics** (G C Patton MD, S M Sawyer MD) **and School of Population and Global Health** (G C Patton, S M Sawyer, N Reavley PhD)**, University of Melbourne, Parkville, VIC, Australia; Murdoch Childrens Research Institute, Parkville, VIC, Australia** (G C Patton, S M Sawyer)**; Centre for Adolescent Health Royal Children's Hospital, Parkville, VIC, Australia** (G C Patton, S M Sawyer)**; Whiting Moyne, Malvern East, VIC, Australia** (E Howard BEng)**; World Health Organization, Geneva, Switzerland** (K Stenberg MSc)**; and Human Support Services, Lagos, Nigeria** (E Nsofor BSc)

Correspondence to:
Peter Sheehan, Victoria Institute of Strategic Economic Studies, Victoria University, Melbourne PO Box 14428, VIC 8001, Australia
peter.sheehan@vu.edu.au

Key messages

- Coordinated investments in adolescent health and wellbeing provide high economic and social returns and are among the best investments that can be made by the human community to achieve the UN's Sustainable Development Goals and the Global Strategy for Women's, Children's and Adolescents' Health.
- Investment of US$5·2 per capita each year across 75 low-income and middle-income countries in programmes to improve physical, mental, sexual, and reproductive health and to reduce road traffic injuries will show economic and social benefits at ten times their costs by saving 12·5 million lives, preventing more than 30 million unwanted pregnancies, and averting widespread disability.
- At a cost of $3·8 per capita each year, programmes will substantially reduce child marriage, while showing benefits of about six times the costs.
- Initiatives to improve secondary school enrolment and quality of education are central to health, wellbeing, and human capital and have long-lasting benefits on health and welfare over the life-course. Investment of $22·6 per capita each year will generate economic benefits of about 12 times the costs by 2030, even before considering the broader health and social benefits of such interventions.
- These investments are most urgent for adolescent girls in low-income countries where gender inequity is often high. For many programmes, the greatest benefits will be seen in girls, but road safety programmes are especially important for boys. Improved secondary education will have substantial effects on the position of girls in low-income countries, but the full economic benefits of this transformation will take time to be realised.
- The evidence from this study suggests that large-scale investments in adolescents should be considered an essential element in life-course and intergenerational strategies for health and wellbeing, but a substantial body of further research is needed to fully understand the benefits and costs of some of the interventions considered here.

See Online for appendix

achieving inclusive and equitable access to education, and empowering women. Achieving these targets will not be possible without large-scale investments to build the capabilities of adolescents.

The 2016 *Lancet* Commission[5] on adolescent health and wellbeing recommended increased investments to transform health, education, family, and legal systems to support the acquisition of the physical, cognitive, social, and emotional capabilities that underpin wellbeing across the life-course. Such investments can yield "a triple dividend of benefits"[5] around essential capabilities during adolescence, future adult-health trajectories, and the welfare of the next generation of children.

This Health Policy paper complements the findings of the *Lancet* Commission and other reports[12] by considering the economic and social benefits of specific investments addressing major determinants of adolescent health and capability. However, as the Commission itself noted, knowledge about interventions to improve adolescent wellbeing is limited in several areas, such as child marriage and intimate partner violence. Therefore, we had two objectives: the first was to analyse the costs and benefits of interventions that promote healthy physical growth and social development during adolescence, and the second was to identify key gaps in existing knowledge and hence identify areas in which further research is required. We considered five areas for intervention: physical, mental, and sexual health; secondary schooling; child marriage; violence against women; and road traffic injury.

Interventions, costs, and impact modelling

The figure shows a schematic representation of the overall method used to model the costs and impacts on human lives of the interventions and to estimate their economic and social benefits. A summary of the basic modelling framework is shown in panel 1 and the intervention areas are described in more detail in the appendix.

Health

Modelling tools to estimate the costs and effects of selected interventions for a wide range of countries are only well developed for health, with the prime example being the inter-UN agency OneHealth Tool (OHT).[17] The OHT is a state of the art modelling tool that is regularly updated and uses available epidemiological resources for the integrated assessment of the costs and effects of selected health interventions.[18] We used this tool in this study, building on its use in previous studies of maternal and child health,[19] stillbirths,[20] depression and anxiety,[21] and cardiovascular disease (Bertram MY, unpublished). Adaptation of the OHT model for adolescents is available for 40 countries, which account for about 90% of adolescents in LMICs. Interventions modelled with the OHT include those addressing physical, sexual, and reproductive health; maternal and newborn health; and some non-communicable diseases that are important for adolescent health, namely depression, anxiety, alcohol dependence, and epilepsy. A summary of the interventions, methods, and impact outcomes is provided in table 1, and the countries covered are listed in the appendix (p 5). 75 countries of low income, lower-middle income, and upper-middle income were covered. We used the World Bank classification of countries by income status for 2016 to classify countries into these categories.[28]

Two scenarios were estimated in the modelling of health interventions. The unchanged policy scenario assumed that the estimated treatment coverage in 2015 would continue unchanged through to the end of the intervention period (2030). The intervention scenario assumed a progressive increase to a high level of coverage by 2030, with the estimated treatment coverage in 2030 being in line with the accelerated scale-up path described by Stenberg and colleagues,[19] in which treatment coverage would reach more than 80% in most countries by 2030. Intervention-specific costs were estimated using the OHT, whereas health-system and programme costs were based on previously published methods.[23] By contrast with Stenberg and colleagues,[19] real costs were indexed by the growth rate of gross domestic product (GDP) per worker over time, rather than being held fixed.

A similar approach was used to model the health impacts of a human papilloma virus (HPV) vaccination

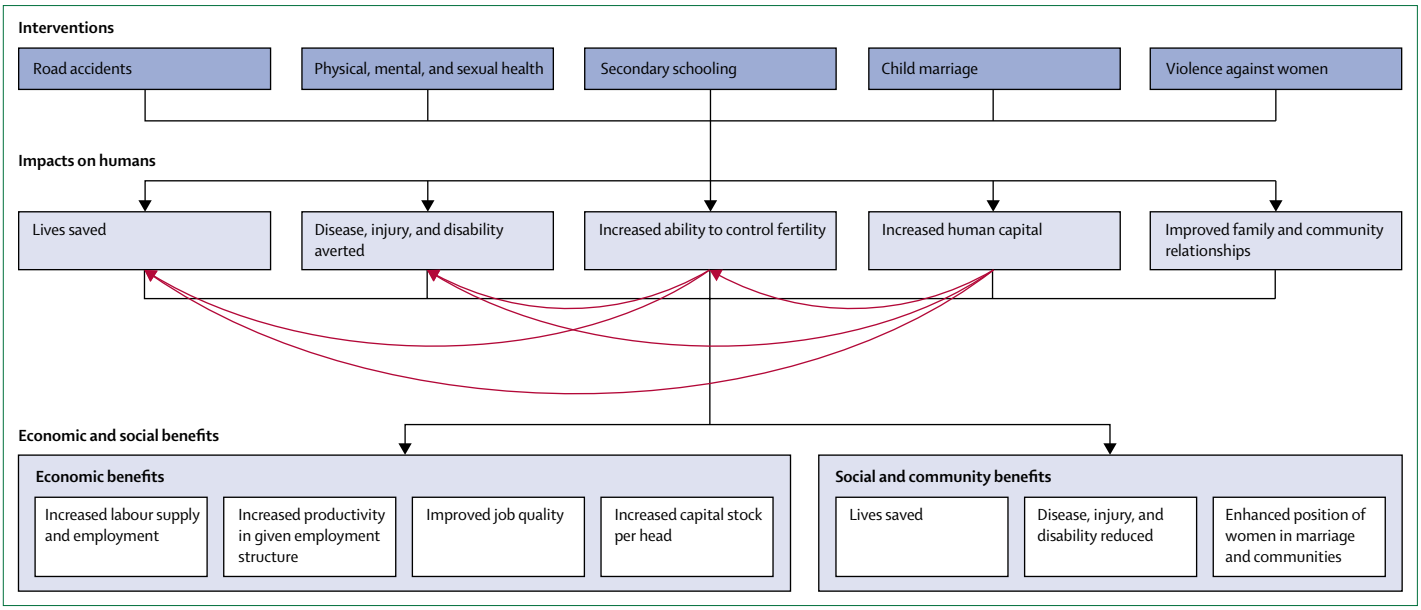

Figure: **Measurement framework, impacts on human beings, and social and economic benefits**

programme to prevent cervical cancer, which accounts for about 235 000 deaths each year worldwide.[29] About 80% of the cervical cancers worldwide occur in low-income countries.[30] Previous modelling studies[31,32] have found HPV vaccination to be cost-effective and particularly beneficial in low-income countries, which do not have access to government-funded cervical screening programmes. Additionally, the benefit of HPV vaccination is highest among women with low incomes.[33] By use of data on death rates by age and country from the Global Burden of Disease 2013 (GBD 2013) study,[9] we modelled the effect of a two-dose vaccination programme[34] on deaths from cervical cancer for girls aged 12 years in each of the years from 2015 to 2030. The economic benefit arising from increased workforce participation due to deaths averted and the associated social benefit was compared with the costs of the HPV programme to calculate returns on investment and was expressed as a benefit to cost ratio (BCR). Further detail about the method used is provided in the appendix (p 19).

Separate approaches to those used for the other interventions were developed for interventions to reduce intimate partner violence against women and child marriage (see panels 2 and 3, with more detail in the appendix). For intimate partner violence against women, the scarcity of data and evidence precluded the provision of preferred investment metrics, but our general conclusions are shown in panel 2. The effect of increased education of girls on reductions in neonatal mortality—one aspect of the two-way associations between health and education[5]—was also modelled outside of the OHT. Education interventions lead to increased years of school completed by girls aged 15–19 years and hence to an increased average education level for girls of this age giving birth. The impact parameter used—that an additional year of the mother's education is associated with a 6·5% reduction in mortality for children aged 0–5 years—was a conservative estimate at the bottom of the range from a 2016 meta-analysis.[64] Increased effects for maternal education on child mortality have been found in other analyses.[65–67]

Secondary education

In many LMICs, both the proportion of adolescents that complete secondary school and the quality of the education they receive is relatively low.[68] This limited education restricts their opportunities in different ways, including the level and quality of their future employment. Much of the existing literature on multi-country education costing[24,25,69] focuses on estimating the costs of schooling for the target level of educational attainment and does not address the costs of the interventions necessary to achieve the target level of school attendance.[26,27] In this study, we built on recent work by UNICEF and the World Bank[27] to develop a modelling tool (appendix p 25) to quantify the impact of targeted interventions to reduce dropout rates and improve school quality on secondary school attendance and educational quality. This model is linked to modelling work for the International Commission on Financing Global Education Opportunities[70] and covers 72 LMICs countries.

To model interventions for secondary schooling, the unchanged policy scenario used demographic and educational attainment projections from the UN Educational, Scientific and Cultural Organization model.[68] Estimates of academic quality were based on data from the 2016 Programme for International Student Assessment[71] and Trends in International Mathematics

Panel 1: The basic modelling framework

We ran two scenarios for the various models used: an unchanged policy scenario and an intervention scenario. In the unchanged policy scenario, the intervention variables were held constant at their estimated level in 2015 for the period of 2015–30. 2015 values of gross domestic product (GDP) per person in the labour force and GDP per capita were based on estimates from the World Bank,[13] International Labour Organization (ILO),[14] and the UN.[15] For both scenarios, GDP per person in the labour force and GDP per capita were increased over the modelling period for each country, in line with long-term trends; projected populations were drawn from the 2015 UN population projections[15] and labour force participation rates (by country, age, and sex) were drawn from the 2015 ILO projections.[16] Specifications for other elements of the unchanged policy scenario were provided in each component analysis.

In the intervention scenario, the interventions were progressively scaled up from their 2015 level to reach a high level by 2030, at which time they were ceased. Other features of the intervention scenario were identical to the unchanged policy scenario, and the effects of the interventions were determined relative to the unchanged policy scenario. Thus, the period from 2015 to 2030 would be the investment phase and, at the end of that period, the investment would cease. However, the benefits from these investments would continue well beyond the investment period: people for whom death or morbidity was averted or who received an improved education as a result of interventions before 2030 would enjoy those benefits well beyond 2030. Where the economic benefits relate to work, these benefits would continue until retirement age, subject to typical changes in participation rates, or, if there were continuing social benefits, until death. However, for some interventions, such as those for depression or anxiety, the duration of benefit might be limited in the absence of further treatment.

The analysis was done in real terms—ie, with no allowance for inflation on either costs or benefits. However, economic benefits typically increase in line with GDP per worker, whereas social benefits increase with GDP per capita. For consistency, costs were assumed to increase in real terms in line with GDP per worker.

and Science Study[72] for many countries and were interpolated for other countries. We did a multivariate regression analysis using data about individual countries from Demographic and Health Surveys[8] and Multiple Indicator Cluster Surveys[73] to estimate the marginal effect of each of the four primary risk factors (rural location, sex, poverty, and marital status) on dropout rates for each country. Evidence about the costs and effects of the selected interventions targeting these risk factors, and hence dropout rates, was assembled from meta-analyses.[70,74–76] The selected interventions (table 1) were targeted within each country on the basis of the risk factor analysis. The interventions were progressively scaled up from 2015 to reach their full impacts by 2030 (panel 1).

The model estimated the effects of the interventions on dropout rates, grade repetition, and learning quality, and produced projections of the number of students and their level and quality of educational attainment up to 2100. The model also estimated the costs of the interventions in two parts: the costs of the interventions themselves and the costs of educating the additional number of students through to the final year of secondary school. Interventions to reduce child marriage were also added to this model (panel 3).

Employment

The literature distinguishes between various channels through which improved education outcomes influence economic activity. Both increased years of schooling and improved quality of schooling lead to increased productivity and earnings in a given form of employment, while completing secondary school offers improved prospects of formal rather than informal employment and an increased chance of being employed.[77–80] There is a vast, multi-country research literature on the impact of the level and quality of education on productivity and growth[77–79,81] and fewer studies on the impact of improved education on the type and level of employment.[80,82–84]

Some well known models[77,81] directly estimate the impact of improved schooling on GDP growth rates on the basis of panel regression analyses relating the two variables, with suitable controls. These models typically show large effects for improved schooling on GDP levels. For example, Hanushek and Woessmann[81] found that an increase of one standard deviation in school quality led to an increase of nearly 50% in GDP by year 2030. However, Hanushek and Woessmann have been widely criticised for ignoring reverse causality effects.[85] Here we used a more detailed and conservative approach, drawing on the medical literature for evidence about key parameters, to quantify effects through the channels noted above (ie, impact of more and improved schooling on productivity in a given form of employment and on the likelihood of finding formal rather than informal employment) on a country-specific basis and on the level rather than the growth of GDP (see appendix p 34). We also acknowledge that observed outcomes reflect demand as well as supply factors.

Road traffic injuries

The model used for road traffic injuries followed that developed by Chisholm and Naci[86] and was based on data about deaths and disability arising from road accidents by age, sex, and vehicle type (bicycles, motorcycles, cars, other vehicles, and pedestrians) for 75 LMICs from the GBD 2013 study.[9] The unchanged policy scenario assumed constant GBD 2013 mortality rates for each country—by age (10–14 years, 15–19 years), sex, and vehicle type—on the basis of UN population projections.[15]

We did a structured search of the journal literature and a review of the grey literature to identify key interventions to reduce serious road traffic injuries, together with their estimated efficacy (effects on road traffic fatalities and injuries) and costs (appendix p 53). Seven interventions were identified (table 1). The intervention scenario assumed that the coverage of interventions increased from the estimated coverage in 2015 to full coverage by 2030, for the relevant age and vehicle types. Estimates of the efficacy and costs of these interventions were derived from key studies identified in the literature,[86–91] although the information base was limited and unduly reliant on estimates from high-income countries. The interventions

	Nature of evidence base for intervention selection	Modelling approach	Impact outcomes
Physical, mental, and sexual health			
Maternal, newborn, and reproductive health; HIV/AIDS; malaria; and nutrition.	Reviews.[19,22,23]	Based on the OHT, modified and adapted as necessary for the study of adolescents. When interventions related to maternal, newborn, and reproductive health were involved, the intervention settings used followed those of Stenberg and colleagues.[19]	Deaths and serious disability averted, reductions in other disabilities, and reduction in unwanted pregnancies.
Non-communicable diseases, including depression and anxiety, alcohol dependence, and epilepsy.	Evidence for depression and anxiety based on a review.[21]	Based on the OHT, modified and adapted as necessary for the study of adolescents. For depression and anxiety, the OHT development and settings followed those used by Chisholm and colleagues.[21]	Reduction in disability due to depression, anxiety, and other non-communicable diseases.
Human papilloma virus programme.	Evidence based on authors' review of cost-effectiveness and epidemiological studies (appendix p 15).	Based on the OHT, modified and adapted as necessary for the study of adolescents. Separate modelling approach to the OHT. For details see appendix.	Reductions in deaths from cervical cancer.
Education			
Increase in the number of schools; target interventions to reduce dropouts (eg, rural school supplies, financial transfers, free school uniforms, and child marriage programmes); learning quality enhancements (eg, improved teaching methods such as remedial help and learning aided by computers, television, or radio); and malaria prevention to increase school attendance.	We did an extensive meta-analysis of the literature on interventions to reduce dropout rates and improve learning outcomes (appendix p 25). We did a regression analysis to determine the relative effects of sex, poverty, and rural location on education outcomes (appendix p 25). We did modelling work to assess the effects of interventions on attendance and education quality. Consultations with experts.	Based on work by Wils[24] for the UN Educational, Scientific and Cultural Organization,[25] and by UNICEF,[26,27] we built a new model to estimate the costs and effects of interventions to reduce high school dropout rates and improve education quality, and estimate the cost incurred by having increased enrolments in schools.	Improved retention rates in secondary schools. Increased secondary school completion rates. Increased quality of education. Reduction of pregnancies and sexually transmitted diseases.
Child marriage			
Direct interventions included group learning programmes on life skills and broad-based group formation programmes. Also, interventions to increase school attendance in girls.	We did an extensive literature review of the relationship between education and early marriage and of targeted programmes to defer early marriage (appendix p 46).	Model of the associations between the education model, the OHT, and the employment model developed to estimate the costs of the intervention programmes to improve school retention and the benefits derived through increased productivity of employment.	Reduction in child marriage. Increased secondary school attendance and completion.
Intimate partner violence against women			
Group training and community mobilisation programmes.	We did an extensive review of the literature reporting on intervention programmes to reduce forms of intimate partner violence and their costs and effectiveness. The impact of intimate partner violence was derived from the 2013 Global Burden of Disease study.[9] We consulted broad literature on various methods and approaches to determine the costs of intimate partner violence and estimate the value of benefits from intervention programmes.	We built a new model to estimate the economic and social value of reduced intimate partner violence disability-adjusted life years from assumed effectiveness of specified interventions. Our model also estimated the costs of the proposed interventions.	Targeted outcomes were reduction of deaths, disabilities (mental health, HIV/AIDS and injuries), and community costs arising from intimate partner violence. Data did not permit quantitative estimation of outcomes.
Road safety			
Behavioural measures (eg, helmet use, speed compliance, alcohol testing, seat belt use, and graduated licensing); motor vehicle safety; and infrastructure expenditure (safer roads).	We did an extensive review of the road safety literature, mainly from high-income countries (appendix p 57).	We developed a new model to apply the experience of three decades of road safety programmes in high-income countries to 75 low-income and middle-income countries.	Averted deaths of male and female adolescents. Reduction of injury and the resulting disability.

OHT=OneHealth Tool.

Table 1: **Intervention, cost, and impact modelling**

resulted in projected reductions in mortality rates by age, sex, and vehicle types. In this study, we used data on injuries from road accidents from the GBD 2013 study[9] and estimated what proportion of those injuries will lead to continuing impairment in the ability to work. We estimated the economic and social benefits of the avoidance of deaths and serious injury caused by road accidents using the methods described for health interventions. That approach was conservative in ignoring benefits from averting the majority of road injuries, which are less serious or less permanent.

Valuation of economic and social benefits

We used two methods, in addition to the employment model, to estimate the economic and social benefits (figure) generated by the impacts the interventions had on human lives. The methods are described in further detail in the appendix (p 7).

Basic valuation model

When interventions avert mortality or morbidity, both economic and social benefits are generated. The main economic benefits arise when those whose lives are saved

Panel 2: Intimate partner violence

Intimate partner violence, which has many causes, is influenced by early marriage and the related effect of low rates of education achievement for adolescent girls.[35–41] For example, Kidman[36] reported an adjusted odds ratio for past year physical or sexual intimate partner violence of 1·42 (95% CI 1·35–1·50) for women married at age 15–17 years, compared with those married at 18 years or older. Interventions to delay early marriage and improve school completion rates will help to address intimate partner violence.

We did cost-benefits analyses of direct interventions to reduce intimate partner violence, although these analyses were constrained by the scarcity of data such that it was not possible to generate benefit to cost ratios (BCRs) for these interventions. We used a model of the benefits and costs of interventions to reduce intimate partner violence to clarify the data limitations and areas in which further work is urgently needed. Although we were unable to generate reliable BCRs within an acceptable confidence range, the analysis did suggest that, with plausible values of the key parameters, the benefits derived from the interventions to reduce intimate partner violence will exceed the costs.

The model used new country-specific data regarding intimate partner violence, by age, from the Global Burden of Disease 2013 (GBD 2013) study.[9] The health consequences of intimate partner violence include those related to physical (eg, injury or disability), sexual and reproductive (eg, HIV/AIDS), and mental (eg, anxiety or depression) health, as well as death (eg, maternal mortality or homicide).[42] The GBD 2013 study[29,43] incorporated the estimated burden of mental health, HIV/AIDS, and injuries from intimate partner violence for girls aged 15–19 years. Our model used these estimates to predict the economic and social value of disability-adjusted life-years (DALYs) saved by the interventions.

Intimate partner violence is gender-based violence (physical, sexual, and other forms) perpetrated by partners. Intimate partner violence perpetrated by men is more prevalent and severe.[44,45] The WHO report on global and regional estimates of violence against women[42] suggested that 30% of all women who have ever had a partner have experienced intimate partner violence. The factors affecting violence against women are complex, best exemplified in an ecological model that described factors beginning with the individual and extending to the family, community, and broader society.[46–48] Although interventions might be at each of these levels, this study considered interventions focused at the individual and community level.

The most promising interventions are group training programmes and community mobilisation programmes.[49] Group training aims to improve life skills and the empowerment of girls aged 14–20 years and includes education in cultural norms and mentoring on sexual and reproductive health.[50] Several studies[50–55] have assessed the effectiveness of group training programmes. Of these studies, two[50,54] have described data allowing estimation of intervention costs and effectiveness, which ranged from 38% to 83%. Whereas the measure of effectiveness varied between studies, in the case of Sarnquist and colleagues[54] and Bandiera and colleagues[50] the measure was sexual assault. Other studies[51–53,56] have reported the incidence of physical and sexual intimate partner violence. Whereas mostly quantitative results were available for Africa, the results for south Asia were qualitative.

Community programmes systematically involve a range of stakeholders, including community activists and local governmental and cultural leaders.[51,56] Programmes such as SASA!,[51] Safe Homes and Respect for Everyone,[52] and TOSTAN,[56] each of which had a substantial impact on intimate partner violence (20–52% reductions), were reviewed, but there was insufficient detail to provide a basis for modelling. The model for intimate partner violence is outlined in the appendix (p 50). BCRs for interventions targeting intimate partner violence were determined by the effectiveness of the intervention programme and cost per participant, the country-specific DALY rate for intimate partner violence in 15–19 year olds, and an income factor, which was mainly dependent on GDP. Whereas the DALY rate and determinants of the income factor came from reliable sources,[9,13–15] estimates of effectiveness and cost per participant were less reliable.

Accordingly, we aimed to provide estimated BCRs for a range of programme effectiveness rates and costs per participant, including those estimated for a Kenyan group training programme[54] and the group training component of the Building Resources Across Communities (BRAC) programme.[50] Depending on assumptions, costs ranged from US$7·80 to $71·76 for the Kenyan programme and from $29·29 to $73·23 for the group training component of the BRAC programme. A large part of this variation was due to differences in the treatment of programme administration costs.

BCRs for a range of intervention costs (from $10 to $70 per participant) and effectiveness rates (from 10% to 80%) were estimated and are shown in the appendix (p 54). Based on the assumptions used in the model, only intervention programmes with an effectiveness of at least 30% and costing no more than $30 per participant were cost-effective, with a BCR of more than 1·0. The time taken for the interventions to reduce intimate partner violence was also a significant factor. This model assumed that the effects of the interventions on the incidence of intimate partner violence persisted on a decay function basis from 3 years after the intervention, but the evidence for this assumption was also limited.[53,57,58] Key areas in which further work is needed are the effectiveness of interventions in reducing intimate partner violence, the duration for which this effect persists, unit costs of interventions on a large scale (especially in south Asia), and quantification of the benefits of averted intimate partner violence.

or whose morbidity is averted enter (or re-enter) the workforce and produce economic output. In this study, we used the basic valuation model to model the economic benefit of mortality or morbidity averted because of the interventions. The economic modelling of mortality followed, for each country, the cohort of avoided deaths, by age and sex, for each of the years from 2015 to 2030. As the cohort aged, it was subject to country-specific mortality rates (applicable to that age group, sex, and year), which were based on UN projections,[15] and to labour force participation rates, which were based on International Labour Organization projections.[14] The contribution of the enhanced labour force to GDP was calculated by multiplying the number in each age and sex category by a country-specific labour productivity rate that varied with age and year. The total GDP was calculated by summing the GDP produced by each cohort for each year of the period in which they were in the labour force. A similar approach was taken for morbidity averted, taking into account reduced participation rates and productivity due to absenteeism and reduced productivity at work[92] for those in ill health.

Stenberg and colleagues[19] assumed the value of a life-year to be 1·5 times the GDP per capita, assuming that the economic benefit was 1·0 times the GDP per capita and the social benefit was 0·5 times the GDP per capita. Following this approach, we applied a value of 0·5 times the sample average GDP per capita to each healthy life-year gained from the interventions to estimate the social benefit of improved health.

Demographic dividend model

We used the demographic dividend model to estimate the benefits on growth in per-capita GDP arising from the reduction in high fertility rates for those countries in which fertility rates are decreasing. Such reductions can arise from sexual and reproductive health interventions that reduce the unmet need for contraception, from the effect of increased education of girls on pregnancy rates, and from reduced child marriage. The powerful benefits of such fertility reductions arise from three interlinked factors: first, GDP per capita increases when the dependent population is decreased relative to the working population; second, when the birth rate falls, the resulting increased labour supply by women leads to increased GDP per capita; and third, when rates of population growth slow, the capital resources of society can be devoted to investments in productivity rather than to meeting the needs of the expanding population.[93,94] Estimates of the impact of reduced fertility rates on growth in GDP per capita were based on the model developed by Ashraf and colleagues and applied to Nigeria.[94] We calculated a reduced form association between the reduction in the total fertility rate and the growth rate of GDP per capita over time. To be conservative, and to allow for its application to countries with a lower income than Nigeria, we reduced this impact relationship by 50% for our intervention scenario, consistent with the approach used by Stenberg and colleagues.[19]

Findings

Costs of interventions

Table 2 shows the costs of the interventions for countries of low income, lower-middle income, and upper-middle income, which typically increased over time as coverage rates were increased and which increased in real terms in line with the projected growth in GDP per worker. Costs are expressed as net present values in real US dollars (ie, controlling for inflation), with a standard discount rate of 3% per annum. Per capita refers to the whole population of the countries to which the interventions were applied.

For the 66 adolescent health interventions modelled for 40 countries by use of the OHT (appendix p 7), the total cost for the period of 2015–30 was $358·4 billion, which was an average of $22·4 billion per annum. This cost amounted to an average of $4·5 per capita each year for the 40 countries. The cost of a comprehensive two-dose HPV vaccination programme across 75 countries from 2015 to 2030 was estimated to be $10·0 billion or $0·1 per capita each year.

Child marriage would be reduced both directly by targeted programmes to reduce its incidence and indirectly through measures to increase school attendance by girls. The total cost of interventions related to child marriage for the period of 2015–30 was $162·1 billion, which was an average of $10·8 billion per annum or $3·8 per capita each year, to which was added a pro-rata share of the relevant school attendance measures for the cost-benefit analysis.

The costs of programmes to reduce road traffic injuries strongly reflected individual country incomes and GDP per capita levels. The total discounted cost of programmes for the period of 2015–30 was $46·4 billion or $3·1 billion per annum, but the annual per capita costs varied from $0·3 in low-income countries to $1·0 in countries of upper-middle income.

The costs of the educational initiatives for 72 countries covered those related to increasing school attendance and to improving educational quality, as well as those related to educating the increased number of students. The total cost for the period of 2015–30 was $1774·1 billion, giving an average annual cost of $118·3 billion or $22·6 per capita each year. These costs reflect the high costs of schooling generally, the costs of both inducing more students to stay at school and educating them for up to 6 years when they do stay, and the cost of improving the quality of schools. Even so, across the 72 countries covered, these costs represented an increase of only 30% in the cost of secondary schooling from the unchanged policy scenario.

The annual per capita costs of the interventions would vary between countries for several reasons. Low-income countries tend to have a higher proportion of adolescents in the population and lower initial coverage rates of interventions than do countries of middle income,

Panel 3: Child marriage

Child marriage is widespread in low-income and middle-income countries (LMICs), particularly in south Asia and sub-Saharan Africa. Averages for those LMICs for which data are available indicate that 5·4% (range 0·1–10·7%) of women were married at age 15 years, whereas 31·6% (range 15·8–47·4%) of women were married at age 18 years in 2016.[8] Rates of child marriage are very high in a small number of countries. The rates of child marriage also tend to be substantially higher in rural areas than in urban areas. Child marriage is much lower in adolescent girls with secondary education than in those without.[59]

Child marriage has adverse effects on the health, education, and economic outcomes of adolescent girls.[12] A major adverse outcome of child marriage is teenage pregnancy because it truncates the education of young girls and severely constrains their employment options. Teenage pregnancy has a number of adverse health consequences, including maternal death, illness, and disability.[12] These poor health outcomes further adversely affect education and employment options and cast the families of such women in a poverty trap.[60] Child marriage is an important reason for early dropout from school.[59,61,62]

This study aimed to estimate these education, health, and employment effects. We modelled the positive effect of reducing child marriage on employment prospects, not only through more accessible education programmes that reduce dropout due to early marriage, but also through specific interventions to delay marriage. We also modelled the beneficial effect of delayed marriage on health, including the extent to which delayed marriage reduces pregnancy rates and therefore child and maternal mortality, although we did not estimate the wider effects of reduced disease and disability.

The education interventions included improving the infrastructure of existing schools, ensuring schools are within reach, and providing financial support. Specific interventions to reduce early marriage for adolescent girls in Africa included a Berhane Hewan-type community-based education programme[63] to help change cultural norms about the desirable marriage age and a group training programme on life skills that empowers girls to resist marriage.[48]

Our model estimated marriage rates for girls aged 15–19 years in 65 low-income and middle-income countries to decrease from 21·0% in 2015 to 14·9% in 2030 (a decline of 29%) and to 11·0% in 2050. Some of this decline was estimated to occur as a result of demographic factors. However, 72% of the estimated decline was due to the proposed interventions, with most of the decline due to education interventions targeting increased attendance.

Reduction of child marriage rates would result in an increase in the average years of schooling and secondary school completions. This higher level of schooling would lead to increased employment in the formal sector, with higher productivity. These additional employment benefits form the largest component of the economic benefits arising from reduced child marriage rates. The other benefits, both social and economic, which were estimated with the OneHealth Tool and were due to reduced mortality, had only a small effect. The benefit to cost ratios (BCRs) resulting from a reduction in marriage rates are set out in the findings and the appendix (p 46). The BCRs for the interventions were high, averaging 5·7 across all countries, and were estimated to average 6·9 for low-income countries. However, the BCRs varied considerably between countries, reflecting different initial conditions with respect to poverty, the proportion of individuals living in rural areas, and other demographic factors.

One limitation of this analysis was that, although programmes such as those discussed here for Africa,[48,63] have been implemented in south Asia with apparent success (and often by local associates of the organisations implementing them in Africa), no quantitative assessment of the costs and effectiveness of the programmes in south Asia has been done. This absence means that the quantitative evidence for both costs and benefits was drawn from the experience in Africa, despite a high proportion of child marriage being in Asia.

implying a more rapid increase in coverage and costs up to 2030. Conversely, these countries tend to have lower costs for locally delivered interventions than do countries of middle income.

Impacts on human beings

The immediate effects of these investments would be on the health and wellbeing of adolescents (table 3). Implementation of these interventions in 40 countries from 2015 to 2030 would avert 7·0 million adolescent deaths and 1·5 million cases of severe disability. The cumulative number of healthy life-years gained from interventions related to non-communicable diseases would be 5·9 million. For the same period, increased use of modern contraceptive methods and other factors would lead to the prevention of 33·9 million unplanned births. The HPV vaccination programme would avert 5·1 million deaths from cervical cancer in 75 countries, mainly in older women. Each of these effects, with the exception of the effects on non-communicable diseases, would be much more pronounced in low-income countries.

For data reasons (panel 3), we modelled child marriage using the marriage rate for 15–19 year old female adolescents. For the 31 countries studied, interventions would reduce this rate by 29·0% or 6·2 percentage points relative to the unchanged policy scenario by 2030. For low-income countries, the

reduction in the child marriage rate would be 36·3% or 9·0 percentage points. This measure is likely to understate the effect on girls married before 18 years of age, because the interventions would be targeted at girls younger than 18 years, and not at girls aged 15–19 years.

The three main effects of the secondary education interventions are reported in table 3. By 2030, the increase in the average grade attained (relative to the unchanged policy scenario) would be 1·3 grades for women and 1·1 grades for men. This increase would be higher in low-income countries than in middle-income countries (1·8 grades for women and 1·5 grades for men in low-income countries *vs* 0·3 grades for both men and women in countries of upper-middle income), reflecting lower-grade attainment in low-income countries than in middle-income countries. By 2030, the rates of secondary education completion would be increased by 75·4% for girls and 57·7% for boys for 72 countries, and they would be increased by 120·5% for girls in low-income countries. Measured education quality would be low in low-income countries in the unchanged policy scenario, but would nearly triple by 2030 as a result of these initiatives. Given the time lag between interventions and educational outcomes, the gains in grade attainment and secondary completion rates would all rise substantially if the initiatives were to be maintained beyond 2030.

These increases in education attainment and quality would generate changes in the quality of employment and work productivity (table 3). These effects would lead to a 36·7% increase in the total productivity of successive cohorts of 20–24 year olds by 2030, with the largest proportional effects seen in low-income countries (52·4% increase). Whereas job creation depends on both supply and demand factors, an increased rate of secondary school completion provides an increased incentive to create formal jobs rather than informal jobs (ie, own-account workers and family helpers). The interventions studied here project an increase of 12·0 million formal jobs for people aged 20–24 years by 2030, with about 9·0 million individuals moving from informal employment to formal employment and an increase in total employment of about 3·0 million individuals.

The road-safety initiatives covering 75 countries were expected to avert nearly 0·5 million adolescent deaths in the period of 2015–30, which is nearly a third of the 1·5 million deaths projected in the unchanged policy scenario, as well as 385 700 cases of severe and profound disability (table 3). Among adolescents, these effects would be particularly experienced by 15–19 year old boys, although girls and younger adolescents would also be affected. The impact of these interventions is likely to be much higher for people aged 20–24 years than for people aged younger than 20 years, although this age group was not studied here.

	Low income	Lower-middle income	Upper-middle income	Total
Total net present value cost to 2030 (US$ billions)				
Adolescent health services (40 countries)	31·9	179·7	146·8	358·4
HPV vaccinations (75 countries)	1·3	5·7	3·0	10·0
Child marriage (total costs; 31 countries)	14·9	145·7	1·5	162·1
Education* (72 countries)	155·7	749·0	869·4	1774·1
School attendance interventions	46·0	245·8	276·2	568·0
Education quality interventions	62·6	310·8	316·4	689·8
Incremental schooling costs	35·0	96·5	275·8	407·3
Child marriage (programme costs only)	12·1	95·9	1·0	109·0
Road accidents (75 countries)	2·3	16·8	27·3	46·4
Average annual cost (US$ billions)				
Adolescent health services (40 countries)	2·0	11·2	9·2	22·4
HPV vaccinations (75 countries)	0·1	0·4	0·2	0·7
Child marriage (total costs; 31 countries)	1·0	9·7	0·1	10·8
Education (72 countries)	10·4	49·9	58·0	118·3
Road accidents (75 countries)	0·2	1·1	1·8	3·1
Average cost per capita each year† (US$)				
Adolescent health services (40 countries)	4·3	4·3	4·9	4·5
HPV vaccinations (75 countries)	0·1	0·1	0·1	0·1
Child marriage (total costs; 31 countries)	2·1	4·3	1·2	3·8
Education* (72 countries)	19·2	17·6	30·9	22·6
School attendance interventions	5·0	6·0	9·8	7·3
School quality interventions	6·8	7·6	11·2	8·8
Incremental schooling costs	3·8	2·4	9·8	5·2
Child marriage (programme costs only)	3·6	1·6	0·0	1·3
Road accidents (75 countries)	0·3	0·4	1·0	0·6
Memorandum item—2014 data, 75 countries				
Total population (million persons)	613·4	2713·0	1877·1	5203·5
Adolescent population (10–19 years; million persons)	145·1	541·7	249·3	936·1
Adolescent share of total population (%)	23·7%	20·0%	13·3%	18·0%

*Includes child marriage. †Measured across the whole population, for the countries in the income group covered by the interventions.

Table 2: **Estimates of the interventions costs across countries**

BCR results

BCRs were derived from detailed estimates of costs (table 2) and benefits (appendix p 73), although the modelling was done at the country level. The BCR results, shown in table 4, are the unweighted means over individual-country BCRs (at a 3% discount rate) across country groups. The unweighted mean BCRs were high for all areas modelled, including 5·7 for child marriage, 5·9 for road traffic accidents, 17·0 for HPV vaccination programmes, 10·2 for health interventions, and 11·8 for education interventions. A BCR of more than 2·0 is considered high for a social programme, and the very high BCR for the HPV programme reflects the high returns that are known to result from low-cost, effective vaccines.

BCRs varied greatly among countries, both within and across groups. For interventions aimed at health, HPV, and road accidents, a pronounced income gradient was

	Low income	Lower-middle income	Upper-middle income	Total
Health (cumulative effect to 2030; millions)				
Adolescent health (excluding NCDs)				
Deaths averted	2·1	4·5	0·4	7·0
Serious disability averted	0·4	1·0	0·1	1·5
Life-years gained from interventions targeting NCDs				
All adolescents	0·9	3·6	1·4	5·9
Male adolescents				
10–14 years	0·1	0·2	0·1	0·4
15–19 years	0·3	1·3	0·5	2·1
Female adolescents				
10–14 years	0·1	0·2	0·1	0·4
15–19 years	0·5	1·8	0·7	3·0
Fertility management				
Reduction in births	11·6	17·8	4·5	33·9
Reduction in fertility of women aged 15–19 years (%)	33·1%	27·7%	23·3%	28·8%
Human papilloma virus vaccination programme				
Deaths due to cervical cancer averted (over lifetime of adolescents treated)	1·9	2·5	0·7	5·1
Child marriage (change in female marriage rates in 2030)				
Aged 15–19 years (% reduction)	36·3%	26·1%	13·1%	29·0%
Aged 15–19 years (reduction in percentage points)	9·0	4·7	1·8	6·2
Intimate partner violence against women (cumulative effect to 2030; millions)				
Disability-adjusted life-years averted through interventions	0·4	2·6	0·2	3·2
Education (change by 2030)				
Increase in average grade attained (grades)				
Girls	1·8	1·2	0·3	1·3
Boys	1·5	1·0	0·3	1·1
Share of 20–24 year olds who have completed year 12 (% increase)				
Girls	120·5%	51·1%	17·6%	75·4%
Boys	88·1%	41·6%	17·6%	57·7%
School quality index (% increase)	126·9%	77·5%	39·1%	92·7%
Change in activity of 20–24 year olds in 2030 (million persons [%])				
Formal employment	2·6 (35·2%)	7·3 (16·3%)	2·1 (5·8%)	12·0 (22·7%)
Informal employment	–1·9 (-7·9%)	–5·4 (-8·6%)	–1·6 (-6·1%)	–8·9 (–7·9%)
All employment	0·7 (2·0%)	1·9 (1·5%)	0·5 (0·7%)	3·1 (1·6%)
No employment, education, or training	1·2 (5·1%)	2·4 (10·0%)	0·6 (5·8%)	4·2 (7·8%)
Productivity per employee of 20–24 year olds (change by 2030; %)				
Individual earnings effect	18·0%	8·0%	2·6%	11·5%
School quality effect	24·2%	14·7%	5·9%	17·7%
Change in employment type effect	10·2%	6·5%	2·9%	7·5%
Total	52·4%	29·3%	11·4%	36·7%

(Table 3 continues on next page)

observed, with higher BCRs for low-income countries than for middle-income countries. This income gradient was due to many factors, including the fact that the social (as opposed to the economic) benefits of averting mortality or morbidity were valued in terms of the average sample GDP per capita, rather than a country-specific measure. One consequence of this income gradient was that, when the BCR was measured by dividing total benefits for a given country grouping and intervention type (table 2) by total costs (appendix p 73), the result (effectively a weighted mean) was quite different from the unweighted means (table 4). For low-income countries, the two measures (appendix p 76) were both high and similar across intervention types, but for the two other country groups (particularly for the upper-middle-income group) the two measures diverged.

In addition to the confidence intervals shown in table 4, two other approaches to assess uncertainty are shown in the appendix (p 77). One approach was calculation of the unweighted BCRs for the case in which benefits were 20% lower and costs were 20% higher than projected, and the other approach was calculation of the results on the basis of increased discount rates, namely 5% and 7%. This exercise showed that the calculated BCRs remained high even when the costs and benefits varied adversely from the modelled outcomes and when discount rates higher than 3% were used. In the adverse costs and benefits scenario, the total BCRs ranged from 3·9 to 11·3 across interventions, while, even at a 7% discount rate, the BCRs ranged from 2·5 to 5·5. These results confirmed the finding of high BCRs despite considerable variation in assumptions.

Discussion

The adoption of the Sustainable Development Goals and the broadening of the Every Woman Every Child Agenda[96] to include adolescents in the new Global Strategy for Women's, Children's and Adolescents' Health result in a pressing need for economic analyses to guide investment priorities.

We showed high rates of return for several investments targeting adolescent health, with a BCR of about 10·0 arising from 12 million deaths averted, almost 6 million healthy life-years gained from interventions for mental health and substance-misuse disorders, and prevention of more than 30 million unwanted pregnancies in adolescents. Several investments outside of the health system would also bring substantial benefits. Investments in secondary education would increase secondary school completion rates by more than 60% across all countries by 2030, with that increase being substantially larger for girls than for boys, particularly in low-income countries. These increased rates of secondary school completion would in turn generate increased rates of formal employment and improved productivity and earnings by 2030. Similarly, an investment of less than $1·0 per capita each year in the prevention of road traffic injury would reduce deaths and serious disability by about 30%. Per capita investments in reducing child marriage of $3·8 per year would bring substantial benefits to adolescent girls: reductions in rates of child marriage would be around 30% by 2030, with the greatest

reductions in low-income countries. The evidence suggests that appropriate programmes can be effective in reducing violence against women, although insufficient data on costs and benefits were available to produce quantitative estimates.

Overall, BCRs for investments in health systems were highest for low-income countries. Investment in education showed high BCRs for all country groups to 2030, but the benefits would be long term and the investments would need to be continued beyond 2030 to realise the full benefits. Interventions to reduce road traffic injury and child marriage also had high BCRs, especially in countries of low and lower-middle income.

This study supports the proposition of the *Lancet* Commission[5] on adolescent health and wellbeing that investments in adolescents will bring a triple dividend in adolescence, adulthood, and the next generation. The BCRs reported here, ranging from about 6·0 to 17·0 on a 3% discount rate, were high by any standards. For infrastructure projects, a BCR of 2·0 (benefits double costs) is regarded as very high, and would provide a strong trigger for investment.[5] Some other studies have found comparable BCRs, although methods and uncertainty levels differed across studies. For example, for interventions in reproductive, maternal, and child health, Stenberg and colleagues[19] found BCRs of 8·7, and BCRs of about 9·0 were reported by the *Lancet* Commission on investment in health.[5] Chisholm and colleagues[21] reported a BCR of 5·3 for investments to reduce depression and anxiety. Heckman and colleagues[97] reported BCRs of 7·0–10·0 for the Perry Preschool Project in Michigan, USA, a finding that has been widely used to support enhanced investment in early childhood programmes. The high BCRs for adolescents reported here provide powerful support for large-scale investment in this neglected age group.

In many countries, adolescent girls face major inequities around health, education, employment, and social development. The range of interventions outlined in this study would have a transformative effect on the lives of many adolescent girls—by saving lives and avoiding serious illness, reducing child marriage, avoiding unwanted pregnancies and unsafe abortion, reducing intimate partner violence, improving educational outcomes, and providing access to better jobs. Although we were unable to estimate separate BCRs for girls and boys, the interventions will probably provide high economic and social returns for both sexes. Education is key to improved capabilities for both sexes that will in time create assets in family, work, and community life. Although needs differ by sex, a balanced programme of investment will enhance the capabilities of both girls and boys.

Large-scale, sustained investments are needed to achieve these outcomes. The discounted total cost to 2030 of all the interventions studied, except those for education and child marriage, would be $414·8 billion ($27·7 billion per year). This would amount to $5·20 per capita each year across the population of these countries, or 0·13% of their 2014 GDP. For education, the overall total would be $1774·1 billion: $118·3 billion per annum, $22·6 per capita each year, or 0·57% of their 2014 GDP. The total annual investment across all programmes would amount to 0·15% of the global GDP. Although much of this investment will need to come from domestic resources, external developmental assistance is likely to have an important role. Support of the Global Strategy for Women's, Children's and Adolescent's health by the Global Financing Facility will be one important mechanism.[98] Domestic sources might include taxation to increase government revenues, including those that are beneficial for health (eg, taxation of tobacco, alcohol, and unhealthy foods), as well as diverting increased resources into health.[99,100] The 2016 International Commission on Financing Global Education Opportunities has outlined strategies that include developmental assistance and growth of domestic resources for education.[70]

This study aimed to make the best use of the available evidence related to interventions to improve adolescent welfare, although it had several limitations. In most

	Low income	Lower-middle income	Upper-middle income	Total
(Continued from previous page)				
Road accidents involving 10–19 year olds [change in cumulative total to 2030; 1000s (%)]				
Road deaths averted				
All adolescents	90·2 (31·2%)	276·5 (31·7%)	127·8 (31·7%)	494·5 (31·5%)
Male adolescents				
10–14 years	17·6	48·5	17·8	83·9
15–19 years	47·6	164·0	80·0	291·6
Female adolescents				
10–14 years	9·5	21·8	11·0	42·3
15–19 years	15·5	42·2	18·9	76·6
Serious and profound disabilities averted (all adolescents)	62·9 (28·3%)	241·3 (30·1%)	81·5 (29·1%)	385·7 (29·2%)

NCDs=non-communicable diseases.

Table 3: **Impact of the interventions on selected aspects of adolescent welfare across countries**

	Low income	Lower-middle income	Upper-middle income	Total
Health				
Interventions modelled with the OneHealth Tool	12·6 (12·0–13·2)	9·9 (9·0–10·8)	6·4 (5·1–7·7)	10·2 (9·9–10·5)
Human papilloma virus vaccination programme	22·4 (21·9–22·9)	12·8 (12·3–13·3)	14·0 (11·7–16·3)	17·0 (16·7–17·3)
Education	11·0 (10·7–11·4)	12·8 (12·3–13·2)	10·3 (8·7–11·9)	11·8 (11·6–12·0)
Road accidents	6·6 (6·4–6·8)	5·6 (5·5–5·7)	4·9 (4·4–5·4)	5·9 (5·8–6·0)
Child marriage (based on 31 countries)	6·9 (5·7–7·7)	4·1 (3·4–4·7)	8·9 (6·7–11·9)	5·7 (5·3–6·1)

Data are mean (95% CI). BCRs are shown as unweighted means (at a 3% discount rate) for the country groupings to avoid dominance of the results by one or two large countries. Means were calculated with the bootstrap technique,[95] with resampling 1000 times. For weighted mean results, see appendix (p 73). BCRs=benefit to cost ratios.

Table 4: **Selected BCRs for key interventions across countries**

areas, data were incomplete and systematic evidence about the cost and effectiveness of interventions was scarce. In none of the areas studied was the basic literature on the cost and impact of interventions or the modelling tools as well developed as for sexual, reproductive, maternal, and child health. Extensive basic research is needed to improve the evidence base, to develop the modelling tools further, and to design more effective measures of the uncertainty surrounding the estimates. In selecting parameter estimates in the face of limited information, we have adopted a conservative stance, as noted at many points in the text.

The factors studied here have complex interactions over time, and our treatment of these interactions leads to limitations in two different ways. First, the various models used independent unchanged policy scenarios that were based as much as possible on common projections of demographic and other variables; however, the models were not linked interactively. Thus, for example, whereas the health and road accident initiatives will lead to lives saved, and hence to an increase in the adolescent population, fertility initiatives will lead to fewer births and a decrease in the population. A number of specific linkages have been made, such as those between education, health, and employment in the case of child marriage, but no systematic linking of the models in this input/output sense has been done. A more comprehensive attempt is also needed to define and model specific linkages across interventions and outcomes. For example, a well documented association exists between education and health at later stages of the life-course,[5,59] and there is much evidence of an association between health and learning outcomes.[60,101–105]

Secondly, the intergenerational linkages also require more attention, given the continuities between maternal preconception, adolescent undernutrition, infectious diseases, mental health disorders, risks of non-communicable diseases, and child health for the next generation.[5] It would also be valuable to further disaggregate by age (10–14 years old, 15–19 years old) and sex, and to extend this analysis to 20–24 year olds. Although much additional research is required, in many dimensions, this first study takes an important step in the long process of building a full understanding of the interventions to improve adolescent health and wellbeing.

Conclusion

Our findings complement those from the earlier investment framework for women's and children's health. There is little doubt that the actions outlined for adolescents can be taken to scale in countries.[106,107] In spite of the limitations of this study, high BCRs were clearly associated with several investments in adolescent health and wellbeing. The focus of these actions differs from those in early childhood, both in the diversity of settings for action as well as the time course to benefits. The evidence presented here suggests that the triple dividend from adolescent investment could be very large, with effects across health, wellbeing, and the many capabilities essential for both productivity across the life-course and for the effective raising of the next generation. Large-scale investments in adolescence should therefore be considered an essential element in life-course and intergenerational strategies for health and wellbeing.

Contributors

HSF, LL, SC, and JM developed the study concept. PS, KSw, BR, and AWi created the detailed research strategy and directed its implementation. GCP, SMS, and NR provided data and analytical inputs throughout the study. KSw led the OHT modelling, with input from HSF, KSt, and EN and support from MF and HS. KSw and MF undertook the HPV modelling. AWi developed the education model, with input from PS, KSw, BR, and HS. BR led the child marriage and intimate partner violence components, with contributions from SC, NM, HSF, and AWe. PS developed the employment model, with support from KSw and AWi. EH, JS, PS, and KSw did the road injuries modelling. All authors contributed to the final text, which was initially drafted by PS, with major contributions from GCP, SMS, KSw, BR, HSF, LL, JM, and SC.

Declaration of interests

We declare no competing interests.

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