The Potential Benefits and Costs of Interventions in Adolescent Well-being in India: Evidence from Return on Investment Models

Research Paper

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Abstract

Background

Adolescent population in India amounts to over 250 million boys and girls aged 10-19 years. Adolescence is a pivotal phase in health and growth, with implications for future population health, and social and economic potential. The objectives of the study are to: (i) explore the costs and benefits of interventions that promote healthy physical growth and social development for Indian adolescents and (ii) develop state-specific analyses for four states, i.e. Uttar Pradesh, Madhya Pradesh, Tamil Nadu and Assam.

Methods

Broad intervention areas are: physical, sexual and mental health; secondary schooling; road injuries and child marriage. Existing models are used and extended to incorporate available information on country and state specific characteristics.

Results

The estimated BCR for health interventions is 4.5 for India while it varies across states from 2.5 to 5.0. The BCR from the HPV vaccination program is 4.0 for India, which varies from 1.9 in Uttar Pradesh to 5.0 in Tamil Nadu. BCRs from educational interventions are 4.6 at the national level while it ranged from 1.6 to 3.8 across four states. In respect to road injury interventions, the BCRs are 3.0 at the national level. The benefit-cost ratio for interventions to reduce child marriage is 4.6 for India.

Conclusions

This study shows that comprehensive programs of investment in health and education of adolescents will yield gains four to five times costs in the medium term. The returns are much higher (in the range of BCRs of 12-16) if the programs are continued beyond 2030 and evaluated over the longer term. Returns would also be higher with accounting of the linkages between different areas and provides the scope of further research. However, the present analysis suggests that investment on huge demographic dividend of adolescent population in India has high economic and social returns and their formation must be a key national priority.

I. Introduction

India continues to make strong progress in its historic return to being one of the world's leading nations. This progress has been economic as well as social. On social front, for example, between 2005-06 and 2015-16 the proportion of girls aged 20-24 years married at or before reaching 18 years fell from 47.8% to 26.8%. In spite of this progress, major challenges remain. While population growth is slowing, the total population continues to rise, and there are now about 250 million boys and girls aged 10-19 years in India, nearly 19% of the total population. This massive cohort will grow to adulthood in a world made more complex by changing global trends and national realities. Their formation must be a key national priority. The central engine of economic development for two hundred years – industrialisation – is no longer available for many countries, as global competition for trade in goods is more intense and as the composition of demand shifts to services. This structural change has major implications for India's future trajectory. In this new world, many countries, including India, struggle to create sufficient jobs to meet the needs of the potential workforce, especially those with limited education and skills. Within India, as elsewhere, persistent inequalities across individuals, communities and states makes an effective response to these challenges more difficult.

The Key Role of Adolescents

Adolescence is a pivotal phase in health and growth, with adolescent nutrition, growth, learning and health risks affecting patterns of health and welfare across the life-course, with implications for future population health, and social and economic potential. It brings a maturation of all bodily systems. It is a phase of acute sensitivity to the physical, nutritional and social environment. Learning processes during adolescence are critical; this applies to all forms of learning, including the development of interpersonal awareness and social skills. In the knowledge-based service economy, both completion of good quality secondary education and strong interpersonal skills are increasingly important for access to good jobs.

The challenge of swift transition from childhood to adulthood exposes the individual to several health risks. Targeted interventions for them - in terms of controlling infectious diseases, providing better nutritional and health care support, detection and treatment of non-communicable diseases - are thus very important for shaping up the health and welfare of future citizens of the country[1]. Investment on adolescent health would help in shaping health in future years of life.[2,3,4] Adolescent health can influence future life chances, in terms of education and employment.[5,6] Health conditions and behaviors during adolescence have significant effect on the development process, with long-term effects; e.g. eating behavior[7], poverty[8], and social gradient[9]. The Lancet Commission highlights the "triple dividend of benefits" from investing in adolescents – through, i) building up their essential capabilities today, ii) ensuring healthy adulthood for them in future and iii) contributing to the welfare of the next generation of children. Kluve and his colleagues[10] argued that youth-targeted active labour market policies through skill and education in low- and middle-income countries do lead to impacts on both employment and earnings outcomes. Investments in adolescent health, education and overall wellbeing are therefore not only critical, but they are also key to sustainable development.

Investment on adolescents needs multi-dimensional interventions and the dividend has its effect in both short run and long run. This study is in line with the recommendations of Lancet Commission about the importance of investment in adolescent health and complements the study of Sheehan and his colleagues[11]. The study focuses on India and four Indian states, and explores the economic and social benefits of specific investments addressing major determinants of adolescent health and capability in Indian context. The study also considers four states of India with different geographic and socio-economic status, to analyze the effect of investment on adolescent populations. The objectives of the study are to: (i) explore the costs and benefits of interventions that promote healthy physical growth and social development for Indian adolescents and (ii) develop state-specific analyses of cost-benefit for investment on adolescents in the four states in India.

II. Methodology

II.a. Framework and methods: Interventions, cost and impact modelling

The framework for measuring interventions, the impact of those interventions in terms of improved outcomes for human beings and the economic and social gains from those better outcomes is depicted in Figure 1. Four broad intervention areas are considered: a) health, including physical, sexual and mental health; b) secondary schooling; c) road injuries and d) child marriage. These interventions are expected to yield potential benefits via broader impacts on human being. In particular, the economic benefits are measured by means of i) expanded labour supply and employment, ii) accelerated productivity, iii) job quality improvement, iv) enhanced human capital. Social gains, on the other hand, are measured by means of examining i) the number of lives saved; ii) morbidity, injury and disability reduced; and iii) the improvement in position of women in marriage and communities.

Some key challenges facing Indian adolescents, such as interpersonal violence towards girls and young women and the very high suicide rate among young females in India, could not be addressed owing to the inadequacy of the available data. Table 1 provides a summary of type of interventions, modelling approach and impact outcomes underpinning these interventions. The framework and measurements are applied to generate evidence in the Indian context. While a national average of measurements is provided, the study also examined four Indian states to account for the regional diversity and for socio-economic and health status inequities, namely: Assam (north-east part of India), Uttar Pradesh (northern part of India), Madhya Pradesh (middle part of India) and Tamil Nadu (southern part of India). See Table 2.

Figure1: Measurement framework, impacts on human beings, and social and economic benefits

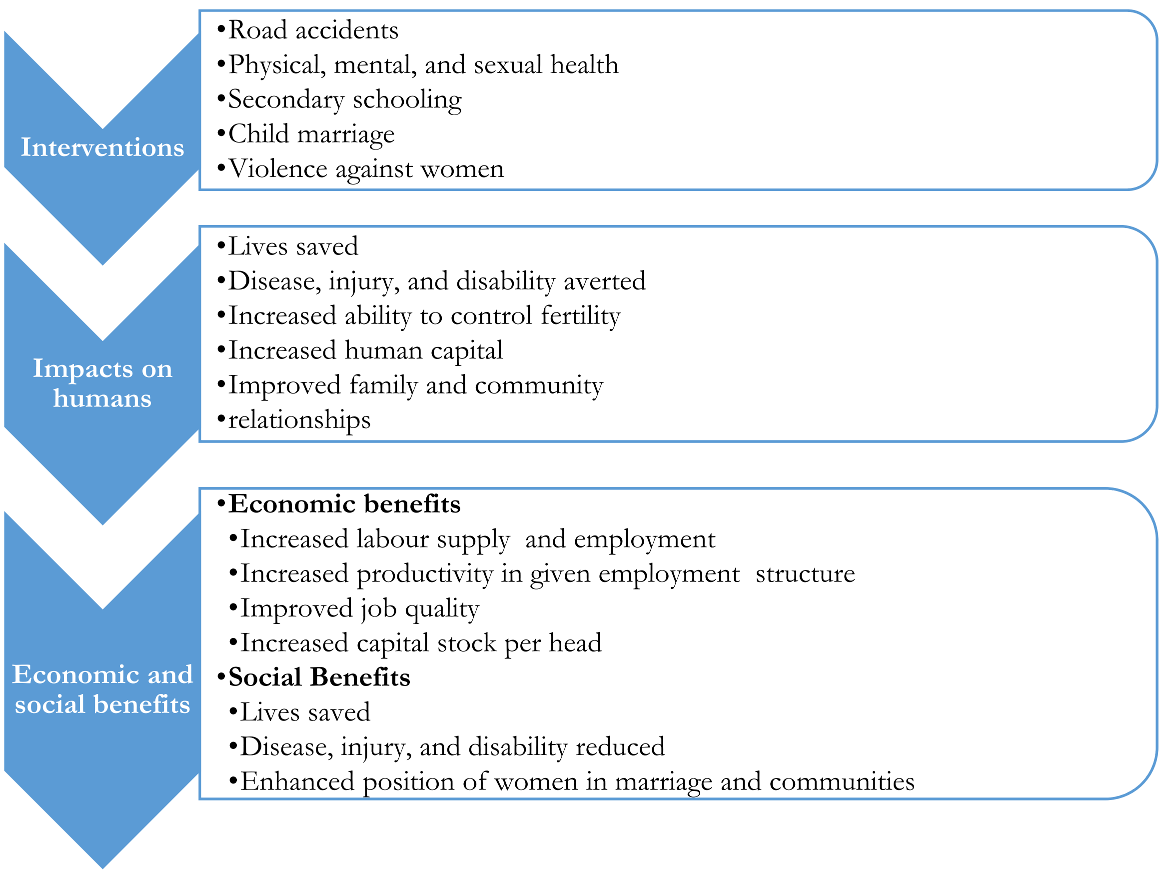

Table 1: Intervention, cost, and impact modelling

Modules	Modelling approach	Impact outcomes
Physical, mental and sexual health		
i. Maternal, newborn, and reproductive health; HIV/AIDS; malaria; and nutrition. ii. Non-communicable diseases, including depression and anxiety, alcohol dependence, and epilepsy. iii. Human papilloma virus programme	Model (i) and (ii) are based on the OHT, modified and adapted as necessary for the study of adolescents., following Sheehan et al. (2017). For HPV (model iii), separate modelling approach also following Sheehan et al. (2017)	i. Deaths and serious disability averted, reductions in other disabilities, and reduction in unwanted pregnancies ii. Reduction in disability due to depression, anxiety, and other non-communicable diseases. iii. Reductions in deaths from cervical cancer.
Education		
Increase in the number of rural schools; targeted 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.	Added to meta-analysis of the literature on interventions to reduce dropout rates and improve learning outcomes in Sheehan et al. (2017) using some Indian interventions. We did a regression analysis to determine the relative effects of sex, poverty, and rural location on education outcomes. We did modelling work to assess the effects of interventions on school completion and education quality. Adapted in Indian context.	Improved retention rates in secondary schools. Increased secondary school completion rates. Increased quality of education. Reduction in child marriage.
Child Marriage		
Two set of interventions are studied. One has a direct impact on child marriage, such as through changing social and cultural norms to reduce support for child marriage. The second is the schooling initiatives, which reduce early female dropout and hence also reduce child marriage.	Costs and impact of the direct measures are derived from the literature on existing programs, including in India where available. For the second set of interventions these estimates are taken from the education model.	Reduced child marriage is associated with longer and better quality schooling, higher productivity when at work and reduced fertility rates.
Road Safety		
The model estimates the cost and effectiveness of seven interventions, namely seat belt usage, helmet usage, the enforcement of alcohol limits, the enforcement of speeding limits, better preparation of novice drivers (e.g. such as graduated licensing systems) and building safe infrastructure – both urban/rural and highways infrastructure.	The costs and impact parameters are drawn from a meta-analysis of the international literature (Symons et al 2019), supplemented by India experience as far as possible.	Reduced road accidents lead to reduced adolescent deaths and serious injuries, with substantial economic and social benefits.

II.a.i. Health

The health interventions, cost and health benefits underlying adolescents are modelled employing the One Health Tool (OHT). The OHT is a comprehensive tool that utilizes demographic, epidemiological and health system resources captured globally. The widely accepted tool is regularly updated with information from newly released data and assessment studies, ultimately providing the opportunity to refine data at national and sub-national level. The tool has been used in earlier studies for different areas of health research: for mental health[12], for maternal and child health[13,14], for adolescent health[11,15], for stillbirth[16] or for depression and anxiety[17] and for overall health strategy[18,19] involving several countries.

Table 2: Summary Statistics for India and states

	India	Assam	Uttar Pradesh	Madhya Pradesh	Tamil Nadu
GDP per capita ($) (2017)	1779.4	1162.0	846.6	1281.7	2622.7
Population (in thousands) (2017)	1309533	34155.6	226032.1	81104.0	75688.8
Maternal Mortality Ratio (MMR) (Per 100000 Live Births) (2014-16)	130	237	201	173	66
Gross Enrolment Rate (Secondary) (2015-16)	80.01	77.59	67.75	80.49	93.92
Dropout rate (Secondary) (2016-17)	19.89	27.6	12.71	23.76	10.03
Child marriage rate (2015-16)*	26.8	32.6	21.2	30	15.7
Adolescent Birth Rate#	11%	17%	6%	11%	9%

*Note: * Percentage of Women age 20-24 years reported married before the age 18 years (%), #Percentage of adolescent women in registered pregnancies*

Source: Various policy documents published by GoI.

Health interventions were modelled employing two sets of scenarios: i) baseline scenario and ii) intervention scenario. The former assumed no policy and program change during the intervention period, while the later assumed a progressive acceleration of interventions from the period 2018 reaching up to the end of 2030, the terminal year of the interventions. Within the intervention scenario, two underlying target coverage levels are set. An ambitious 100% target coverage is set if baseline coverage is already at 85%, while the target coverage is set at 95%, when baseline coverage is less than 85%. Areas of interventions include maternal and child health, nutrition, malaria, TB, HIV-AIDS and non-communicable diseases, which includes depression, anxiety and epilepsy. For each of the scenarios described above, data for coverage and demographic characteristics are updated in OHT specific to the country and Indian states. The health outcomes considered in this study are: fall in unplanned birth, number of stillbirth averted, neonatal deaths averted, maternal deaths averted, deaths caused by communicable diseases, and morbidity averted (or increase in healthy life year lived) for non-communicable diseases. Benefits are estimated by using health outcomes with the assumption that by preventing death and serious disability, the interventions would enable people to enter the workforce and generate economic output. Economic models for mortality and morbidity are developed following the cohort of avoided deaths for each of the years from 2018 to 2030, classified by age and sex of the projected population. Intervention-specific costs are fed into OHT using India-specific data on drug prices, whereas health-system and program costs are estimated outside OHT. Unlike earlier studies, this study uses cost-component-specific data on different areas of interventions gathered from national and state-specific budget documents (for detailed methodology and data sources see the Appendix in Supplemental material).

A separate modelling exercise captured the health impact of Human Papilloma Virus (HPV) vaccination program for adolescent girls. Cervical cancer is fourth most common cancers in women worldwide, with 123,000 new cases and 67,000 deaths recorded in India in the year 2012.[20] Several studies have confirmed the cost effectiveness of HPV vaccination.[21,22,23] Using the Global Burden of Disease data, we estimated the impact on mortality caused by a two-dose vaccination program from cervical cancer for girls aged 11 years spanning the period 2018 to 2030. The HPV modelling exercise estimated Benefit Cost Ratio (BCR), where vaccination cost is compared to the socio-economic gains. These socio-economic gains - mortality averted by the vaccination program and the gains accruing from expanded workforce participation of girls and from social benefits – are used to estimate the benefit-cost ratio (BCR).

II.a.ii. Secondary education

Although India's primary education level has improved considerably in the recent past, the level of secondary education and its quality remains poor. Employability and earning levels are often compromised owing to this inadequacy. The intervention modelling around secondary education here attempts to quantify the impact on dropout rates and educational quality. In respect to education attainment, we employed data from District Information System for Education (DISE) while for the learning indicator, household survey data '*Annual Status of Education Report 2017 Beyond Basics*' were used.

Secondary level dropout rates are often influenced by the underlying socio-economic factors. Adolescents who are poor, who live in rural areas, who are females and tend to get married early, stand to drop out of the education system. These factors were modeled in a multivariate regression analysis, to tease out the marginal effect of each of the factor on dropout rates using National Statistical Office (NSO) household survey data on Social Consumption on Education in India (2017-18). The costs and improved educational outcomes associated with the interventions underlying these socio-economic factors were based on earlier meta-analysis involving the interventions and its influence of socio-economic factors on drop-out rates and learning outcomes.[11] The key interventions underscoring the model were: community intervention on child marriage especially girls, cash transfers for poor students to reduce drop-outs, community based remedial education program, and others (see Table 1). Two sets of costs were included, including the intervention costs and the expenses associated with completion of secondary school by additional number of students, who otherwise would have dropped out. As far potential educational outcomes are concerned, the model calculated the impact of interventions on dropout rates, grade repetition and learning quality, and generated projections of student numbers, and their level and quality of educational attainment. Both baseline and alternative scenarios were modelled, assuming the status-quo in the former while in the latter assuming the interventions to progressively be stepped up from the year 2018 to 2030. Unlike the health model, the education model allowed us to capture the outcomes continuing up to 2050 and the accompanying employment implications of these results going until 2100.

II.a.iii. Employment

A higher level and improved quality of secondary education often leads to productivity rise, formalization of employment and accelerated economic growth (GDP), although the reverse causality is also captured in the literature. Given the interlinkages between education and employment, and flowing from the education model, the employment model used here (adapting Sheehan and Shi 2019)[24] estimated the effect of these improved educational outcomes on the future productivity of those cohorts affected by them (including the effects of better quality learning) and also on a higher level of formal employment. The analysis then captures the potential effect on economic output (GDP) resulting from higher productivity of these cohorts.

II.a.iv. Road traffic injuries

Deaths and disability caused by road accidents, especially on adolescents, are one of the highest in that age group, inflicting significant social and economic damage in India. The potential gains from preventing such road deaths and injuries are enormous. The costs and benefits of interventions to reduce road traffic fatalities and injuries are generated from modelled estimates (See Sheehan et al. 2017[11] and Symons et al 2019[25] for details on the road traffic injury model. These studies draw heavily on Chisholm and Naci 2008[26], 2012[27]). The interventions considered here include behavioral measures (helmet usage, seat belt usage, enforcement of speed compliance, enforcement of alcohol limits, and graduated licensing), physical infrastructure (safer roads), and motor vehicle safety. The costs of implementing these measures during 2019-2030 were considered by assuming a cost allocation process using two dimensions: i) the propensity of adolescents to use roads and ii) their risky behavior. Employing these dimensions yield around 13% of the total costs of interventions, attributed to adolescents alone. An unchanged policy and program are assumed in the base case scenario, while alternative scenario builds on the potential interventions underscored above.

The base case data on deaths and serious injuries from road accidents namely, age, sex and vehicle type, are assembled from the Global Burden of Disease (IMHE), having regard also to the Million Deaths Study (MDS) and the accident database of Ministry of Road Transport MoRTH 2017. India-specific data on the effectiveness of road-safety measures are used when available, while we relied on international evidence when Indian data are missing. It may be further observed that effectiveness estimates of interventions vary widely in the literature and these variations may reflect the intensity with which the interventions are applied. The costs and gains from these interventions were modeled to estimate the economic and social benefits and hence to calculate benefit-cost ratios (BCRs).

II.a.v. Child marriage

One of the social and cultural challenges facing Indian adolescents is the fact that the practice of child marriage remains high. Early marriage often tends to influence health and economic outcomes in a negative manner. Health impacts resulting from child marriage can include elevated risks of child and maternal mortality and disabilities, unsafe abortion, still and premature births, and many others[28]. In terms of social and economic impact, there is a significant effect in terms of low education outcomes, inability to complete secondary schooling, reduced economic participation, weak earning potential and poor productivity gains.[29,30,31,32] The primary purpose of examining the dimension of child marriage is to model the effectiveness of child marriage interventions, in terms of costs and benefits. Interventions on child marriage are grouped under two dimensions: i) child marriage specific interventions; and ii) education linked interventions. Child marriage reduction programs included in the modelled interventions are life skills, community mobilisation and conditional economic incentives, while education programs included are education incentives, greater access to schools to rural girls, pedagogical changes and others. Potential outcome measures estimated are early dropouts, years of schooling, and extent of secondary schooling completion. These educational outcomes are expected to result in economic gains by way of productivity improvement and access to better employment, leading to higher levels of GDP per capita. Together with the costs of the interventions, the results of these benefit estimates to provide a cost-benefit ratio.

II.b. Valuation of economic and social benefits

In order to derive economic and social benefit estimates resulting from the suite of interventions outlined above, we employed three sets of models, namely: (i) basic valuation model; (ii) demographic dividend model; and (iii) productivity model.

II.b.i. Basic valuation model

Substantial economic and social gains ensue when mortality and morbidity is averted through interventions. The underlying economic model generates age and gender specific population cohorts after allowing for averted deaths, for the years from 2018 to 2030, at the national level and for the four states. By applying the country-specific mortality rate for each age and gender, the progression of these population cohorts across these years are tracked. The contribution that each cohort makes to the economy is estimated through their labour force participation and their influence on GDP. An augmented labour force, even at the base case labour productivity, is likely to accelerate GDP per capita. The base data for these demographic and labour force participation projections were derived from the UN and the International Labour Organisation (ILO) respectively. In respect of the effect of enhanced ability to work resulting from averted morbidity, a similar approach was adopted, with allowance for the various element of reduced productivity expected from people working with a disability. In addition to this increased GDP arising from an augmented labour force, there is also a social benefit of every life saved. Following other studies, we valued this social benefit at 0.5 times of average per capita GDP per annum.

II.b.ii. Demographic dividend model

Countries are reaping the benefits of reduced fertility rates and India is no exception. The total fertility rate (TFR) has reduced from 5.2 to 4.5 during 1971 to 1981 and from 3.6 to 2.4 during 1991 to 2012 (Census 2011). Health and non-health interventions to reduce fertility include direct interventions involving sexual and reproductive programs targeted at reduction in unmet need for contraception, falls in pregnancy rates owing to the rise in girls' education, and programs that target child marriage. There are three sets of potential gains that accrue from low fertility rates, which are linked to one another: i) a fall in the dependent population vis-à-vis the workforce, which is expected to push up GDP per capita; ii) a rise in GDP per capita resulting from increased female participation in the workforce given the reduced birth rate; iii) a reallocation of resources to productive investment rather than consumption, prompted by slowing population growth. The demographic dividend model captures the economic benefits arising from the reduction in the fertility rate. Our model borrows from the study of Ashraf et al. (2013)[33] for capturing the relationship between reduced fertility and its resulting increased investments in human capital on growth of GDP per capita.

II.b.iii. The productivity model

The productivity impact model includes four channels through which better education influences economic activity, relative to the unchanged policy base case (detailed in Sheehan et al. 2019)[24]: (i) increased years of schooling and (ii) improvements in the quality of education both lead to higher productivity and higher earnings in employment; (iii) the rise in secondary school completion leads to an increase in the relative share of formal employment vis-à-vis informal employment; and (iv) an increase in secondary completions results in a rise in the share of female workforce.

III. Findings

III.a. Costs of interventions

For the range of interventions outlined above, the associated costs for all-India and the four study states are highlighted in Table 3. As interventions are scaled up costs rise, and so the costs to 2030 are calculated as net present values in real terms (adjusted for price rise), using an annual discount rate of 3%, which is normal practice. The health intervention costs are predicated on several state-specific parameters including epidemiologic prevalence, target coverage, demographic characteristics, government budget allocation for medicines, health system etc. These costs comprise two elements: recurring costs and capital costs. The former includes expenses associated with program costs such as salaries and wages, medicines and supplies, and so on, while elements of the health system costs include both capital and recurrent expenditure.

Based on 78 health interventions for the adolescent population, the national level total cost is expected to be USD 79.4 billion overall and USD 6.62 billon annually, while in per capita terms, it works out to USD 5 per capita per annum (refers to total population). In respect to the two-dose HPV vaccination intervention, the total cost is estimated at USD 1.6 billion and about USD 0.1 per capita annually.

As far as state-specific costs are concerned, Uttar Pradesh requires USD 10.1 billion (USD 3.7 per capita per annum), while in Assam, Tamil Nadu and Madhya Pradesh, the respective intervention costs are USD 1.99 billion, USD 3.52 billion and USD 2.50 billion. In respect to HPV vaccination in states, the respective costs are USD 0.3 billion and for Assam, Tamil Nadu and Madhya Pradesh the cost are USD 0.04, USD 0.08 billion and USD 0.10 billion.

The net present value of costs involving educational interventions for the period of 2018–30 was USD148 billion for all-India, which amounts to an average annual cost of USD12.34 billion or USD9.3 per capita each year. Average cost of education interventions per year was USD0.86, 2.18, 0.71 and 0.97 billion for the states of Assam, Uttar Pradesh, Tamil Nadu and Madhya Pradesh respectively. Average per capita cost on education was relatively much higher at $26.3 in Assam compared to the other states. This is largely due to very high unit costs of education in that state. Pupil-Teacher-Ratios for different levels of education were way below the targets that were set in the model, resulting in very high teacher salary cost per pupil. These high levels of average PTRs in Assam are probably due to many schools located in sparsely populated areas.

Table 3: Estimates of the intervention costs in India and across states

	India	Assam	Uttar Pradesh	Tamil Nadu	Madhya Pradesh
Total net present value cost to 2030 (US$ billions)					
Adolescent health services	79.39	1.99	10.09	3.52	2.50
HPV vaccinations	1.61	0.04	0.30	0.08	0.10
Education*	148.08	10.80	26.12	8.57	11.64
School attendance interventions	45.90	3.46	8.61	2.86	3.39
Education quality interventions	41.40	2.65	6.94	3.41	2.77
Incremental schooling costs	49.23	4.17	7.92	1.86	4.45
Child marriage (programme costs only)	11.54	0.52	2.65	0.44	1.03
Road accidents					
Average annual cost (US$ billions)					
Adolescent health services	6.62	0.17	0.84	0.29	0.21
HPV vaccinations	0.13	0.004	0.03	0.01	0.01
Child marriage (programme costs only)	0.96	0.043	0.22	0.037	0.086
Education*	12.34	0.86	2.18	0.71	0.97
Road accidents					
Average cost per capita# each year (US$)					
Adolescent health services	5.0	4.9	3.7	3.9	2.6
HPV vaccinations	0.1	0.1	0.1	0.1	0.1
Child marriage (total costs)	3.7	8.8	3.1		
Education*	9.3	26.3	9.6	9.4	12.0
School attendance interventions	2.9	8.4	3.2	3.1	3.5
Education quality interventions	2.6	6.5	2.6	3.8	2.8
Incremental schooling costs	3.1	10.2	2.9	2.0	4.6
Child marriage (programme costs only)	0.7	1.3	1.0	0.5	1.1
Road accidents					
Memorandum item—2017 data					
Total population (million persons)	1325.7	34.2	226.0	75.7	81.1
Adolescent population (10–19 years; million persons)	254.1	6.9	49.4	11.6	16.5
Adolescent share of total population (%)	19%	20%	22%	15%	20%

Note: Includes child marriage. # Refers to total population.

III.b. Impacts

All round gains from the range of health interventions are expected, including deaths averted, disability prevented and healthy life-years gained. The education benefits would include significant gains in secondary education completions, a rise in average grade attained and measured increases in education quality, which in turn are likely to accelerate GDP through a rise in productivity. The health model generated an estimated benefit of 270,000 adolescent deaths averted and the prevention of disability for 40,000 adolescents (Table 4). The cumulative fall in morbidity prevalence for non-communicable diseases involving adolescents would be about 9.74 million. Similarly, the fertility rate for women aged 15-19 is reduced by 25%, which would result in prevention of 4.88 million unplanned births. The HPV vaccination program is expected to yield a reduction of 240,000 deaths from cervical cancer in India. At the state level, an estimated number of deaths averted would be 7,000 in Assam, 68,000 in Uttar Pradesh, 8,000 in Tamil Nadu and 21,000 million in Madhya Pradesh. Serious disability averted is estimated to be 2,000 in Assam, 6,000 in Uttar Pradesh, 1,000 in Tamil Nadu and 5,000 in Madhya Pradesh.

The family planning interventions are likely to see unplanned birth fall by 107,000 in Assam, 399,000 million in Uttar Pradesh, 61,000 million in Tamil Nadu and 193,000 in Madhya Pradesh. Deaths prevented from HPV vaccination program for cervical cancer is likely to be 7,000 million in Assam, 46,000 in Uttar Pradesh, 12,000 in Tamil Nadu and 15,000 in Madhya Pradesh. As far as education is concerned, average grade attainment would rise for all the states, with Uttar Pradesh expected to have the highest increment at nearly 1.5 years. The rates of secondary education completion would increase by 38.5% for girls and 33.2% for boys at the national level. Secondary completion rates are likely to go up significantly for the states of Assam and Madhya Pradesh. School quality would increase in all the states by more than 40% during the period 2018-2030.

Table 4: **Impact of the interventions on selected aspects of adolescent welfare across countries**

	India	Assam	Uttar Pradesh	Tamil Nadu	Madhya Pradesh
Health (cumulative effect to 2030; millions)					
Adolescent health (excluding NCDs)					
Deaths averted	0.27	0.01	0.07	0.01	0.02
Serious disability averted	0.04	0.00	0.01	0.00	0.01
Morbidity averted from interventions targeting NCDs					
All adolescents	9.74	0.28	1.83	0.41	0.59
Male adolescents					
10–14 years	0.10	0.00	0.03	0.00	0.01
15–19 years	3.86	0.11	0.72	0.16	0.23
Female adolescents					
10–14 years	0.10	0.00	0.03	0.00	0.01
15–19 years	5.69	0.17	1.06	0.25	0.35
Fertility management					
Reduction in births	4.88	0.11	0.40	0.06	0.19
Reduction in fertility of women aged 15–19 years (%)	25%	28%	24%	23%	26%
Human papilloma virus vaccination programme					
Deaths due to cervical cancer averted (over lifetime of adolescents treated)	0.24	0.01	0.05	0.01	0.02
Child marriage (change in female marriage rates in 2030)					
Aged 15–19 years (% reduction)	26.0	1.6	21.5	5.3	32.3
Aged 15–19 years (reduction in percentage points)	3.2	0.1	1.4	0.3	3.6
Disability-adjusted life-years averted					
Increase in average grade attained (grades)					
Girls	1.3	0.5	1.3	0.2	0.8
Boys	1.4	0.2	1.5	0.3	0.9
Share of 20–24 year olds who have completed year 12 (% increase)					
Girls	33.2	94.2	26.3	37.7	178.4
Boys	38.5	99.7	27.0	1.7	75.4
School quality index (% increase)	43.4	43.4	53.5	50.7	51.9
Change in activity of 20–24 year olds in 2030 (million persons [%])					
Formal employment	1.1	2.2	0.9	-0.3	1.5
Informal employment	-0.4	-0.6	0.0	-0.8	-0.1
All employment	0.2	0.3	0.3	-0.6	0.4
No employment, education, or training	0.1	0.6	0.4	-0.6	0.6
Productivity per employee of 20–24 year olds (change by 2030; %)					
Individual earnings effect	0.1	0.2	0.1	0.1	0.2
School quality effect	0.6	0.8	0.7	0.8	0.7
Change in employment type effect	0.1	0.2	0.1	0.0	0.1
Total	0.1	0.2	0.1	0.1	0.2
Change in cumulative total to 2030; 1000s (%)					
Road deaths averted					
All adolescents	89169	2239	19334	4234	12926
Male adolescents	72988	1833	15826	3466	10580
Female adolescents	16181	406	3508	768	2346
Serious and profound disabilities averted (all adolescents)					

One of the spin-off improvements from better educational outcomes is the likely rise in formal employment and a concurrent fall in informal employment. It is estimated that productivity per 20-24 aged worker, arising from all improved educational outcomes, would increase in the range of 15 to 28% for the states as well as for the entire country. The highest contribution of this increase in productivity is likely to result from the improvement in school quality.

III.c. Return on investment

The return on investment approach here is primarily based on calculating Benefit-Cost Ratios (BCRs). The BCR is the ratio of the estimated value of benefits to cost of interventions. The results suggest that, for all interventions considered, the gains are obtained much later than the period in which the costs are incurred. For instance, if drug treatment saves a person's life the costs are met now but the gains of continued life extend long into the future. Similarly, different interventions may yield gains at a relatively later stage. For example, interventions involving health which save a 10-year old's life will commence a long series of benefits from the time in which the life is saved. By contrast, an intervention that results in the 10 year old attending school until year 12 will begin an additional series of costs and benefits, only when the adolescent enters the workforce (measured in terms of activity levels of persons 20-24 years and beyond). Expressed in financial terms, these timing differences are addressed by measuring both benefits and costs in net present value (NPV) terms.

In providing comparable measurements of BCRs, these timing differences are critical. Three approaches adopted in considering timing differences are:

(i) For the health estimates, the costs and interventions occur during 2019-30, but the benefits continue to accrue not only during 2019-30 but across lifetimes of the individuals considered;

(ii) In respect to education, the interventions phase-in gradually over 2019-30 to a peak in 2030, and continue to be stable at that level until 2050 (with costs incurred over 2019-30 or 2019-50 as appropriate). Benefits are then assessed on two counts:
   a. Only employment and productivity gains are considered over 2019-50;
   b. Gains in productivity and employment continue up to the retirement age of all individuals influenced by education interventions.

(iii) As far the road accident interventions are concerned, these involve both investments in building capacity (e.g. road infrastructure and management capacity) and spending on monitoring and enforcing behavioural change. Interventions build up to peak levels by 2030; but decline subsequently (because capacity has been created), but spending on behavioural change continues at 2030 level to 2050. Benefits accrue through the lifetime of individuals involved, but no longer than 2100.

Given the nature of differences in interventions, it is hard to be definitive about comparability of BCRs across areas. It may be noted that, unlike other interventions, health interventions are assumed to be implemented until 2030 and the outcomes are realized until that year, but the benefits arising from those health outcomes continue to be counted after 2030. The following paragraph highlights key results emerging from the modelling exercise.

The BCR health results at national level and four Indian states are presented in Table 5, on the basis that the interventions continue only to 2030 but the benefits reflect the lifetime experience of those whose health is improved. The estimated BCR for health interventions is 4.5 for India while it varies across states from 2.5 to 5.0. Among the states, the BCR is lowest for Uttar Pradesh, possibly owing to very low base of per capita GDP, just on 50% of the national average (Table 2). While the estimated per capita cost of the health interventions in Uttar Pradesh is also below the national average, the differential is not as great as for per capita GDP. This result – that the BCR is lower is the poorest state studied – is, however, is contrary to the original results reported in the literature[15]. Because Uttar Pradesh is by far the largest of the states studied, the total cost of the interventions for this state is high, even though the return on the investment is not. The BCR from the HPV vaccination program is 4.0 for India, which varies from 1.9 in Uttar Pradesh to 5.0 in Tamil Nadu.

It may be observed that the BCR results are generated from the complex interaction between three models outlined above, namely, the basic valuation model, the demographic dividend model and the productivity model. These three components and their interactions are expected to produce varying state-specific estimates of BCRs. For instance, in the case of Madhya Pradesh, all three components are moderately high, resulting in high BCR for health. On the other hand, for Uttar Pradesh, the first two components drive the magnitude of estimates owing to huge population volume. But due to low productivity, the benefits reaped through first two components are not translated into high BCR. One possible explanation of the divergence of the results from Sheehan et al. (2017)[11] is that demographic dividend is significantly low in high-income countries as compared to low-income countries, and thus first two components are dampening the gain from productivity effect for high-income countries. But for India, sub-national demographic characteristics in terms of magnitude do not vary greatly; and so productivity effect often dominates the other two effects.

BCRs from educational interventions, assuming costs and improved educational outcomes run only to 2050 – are 4.6 at the national level while it ranged from 1.6 to 3.8 across four states. The BCR's are much higher (13.4 for all India and from 4.9 to 10.6 for the four states) if productivity benefits are counted until the retirement age of the cohorts concerned. The higher BCRs for the longer period of benefits considered reflects both the lags in the process of schooling and in better schooling feeding into higher productivity, but also the fact that the investment in system costs tends to be front-loaded into the 2019-30 period, so that costs per annum are lower over 2031-50 than over 2019-30. Again, the state BCRs are lower in the two poorer states (Uttar Pradesh and Assam) than in the other two states.

Table 5: Selected BCRs for key interventions for India and four states

	India	Assam	Uttar Pradesh	Tamil Nadu	Madhya Pradesh
Health[1]					
Interventions modelled with the OneHealth Tool	4.5	2.7	2.5	3.3	5.0
Human papilloma virus vaccination programme	4.0	2.5	1.9	5.0	2.7
Education[2]					
Benefits to 2050	4.6	1.6	2.3	3.8	3.4
Benefits to cohort retirement age	13.4	4.9	7.1	10.3	10.6
Road accidents[3]					
Benefits to 2050	3.0				
Benefits to cohort retirement age	11.9				
Child marriage[2]					
Benefits to 2050	4.6	1.9	2.3	2.6	3.8
Benefits to cohort retirement age	16.8	7.0	9.0	9.0	14.8

[1]Interventions to 2030 only. [2]Interventions phased in to full level by 2030, continued at that level to 2050. [3]Interventions phased in to full level by 2030, behavioural interventions continued at that level to 2050 with infrastructure investments phased down.

In respect to road injury interventions, the BCRs are 3.0 for benefits included only to 2050 but 11.9 at the national level in which the benefits of higher productivity carried forward to the retirement age of the individuals concerned. Individual BCRs for transport for the four states are not available. The benefit-cost ratios for interventions to reduce child marriage are also high – 4.6 for benefits to 2050 and 16.8 for benefits to retirement age – reflecting the diverse benefits to be achieved from these programmes.

IV. Discussion and Conclusion

This study shows that comprehensive programs of investment in the health and education of adolescents will yield gains four to five times costs in the medium term. The returns are much higher (in the range of BCRs of 12-16) if the programs are continued beyond their phase up period to 2030 and evaluated over the longer term. These high returns are obtained without taking full account the linkages discussed above. Investment in the formation of the 250 million Indian adolescents who will be critical to the future of the country should be a central national priority. This study shows that not only is such investment a key priority, it is also an investment with high economic and social returns, surpassing those of many of the investments (e.g. in physical infrastructure) which governments currently undertake. Road accidents and neglect of safety is a case in point. They are major cause of death and serious injury in India, both for the population as a whole and for adolescents 10-19 years (and particularly for young males aged 20-24 years). While estimates differ, it is likely that 250,000 Indians die on the roads each year and more than 500,000 persons suffer very serious injuries. India has adopted modern road transport systems – cars, trucks, freeway systems and so on – without investing commensurately in modern road safety systems that make these viable in safety terms. Major investment in interventions to reduce road accidents should be a high priority, both for adolescents and for the community as a whole.

The Neglect of Linkages: A Limitation

Health and education are complex and pervasive, interacting on one another at many points in the lifecycle, especially in the adolescent years. The neglect of the linkages involved in adolescent development is a major limitation of the literature, and of this study. As we use the term, a linkage exists whenever any characteristic of an adolescent or her development affects her other characteristics or capabilities, now or in the future, or those of her family. Thus, for example,

- poor nutrition and other forms of ill health affect her ability to learn;
- limited education affects her ability to learn about and follow best practice health methods, with adverse implications for her own health and that of her children;
- child marriage and a subservient position in the household leads to early childbirth, high lifetime fertility and truncated education;
- low educational outcomes tend to lead to an inability to obtain high quality, formal employment, and so on.

These linkages are critical, both because they can drive a process which 'locks-in' disadvantaged groups to poor outcomes and because they amplify the impact of policy interventions, as improved outcomes in one area flow on to benefits in other areas also. These linkages, both within and across generations, have received insufficient attention in public policy and preventive health actions. While some are represented in this study, many are not. A more systematic representation of these linkages would likely increase the BCRs shown for each of the broad classes of intervention.

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Supplementary Appendix

This Appendix is a supplement to main paper and describes the methodology used for estimating the benefit and cost of interventions reported in the main paper.

A1. Investment Case of Adolescent Health for India

In this section of appendix, we are describing health related interventions for adolescents, the data sources used for all-India and four states (Assam, Madhya Pradesh, Tamil Nadu and Uttar Pradesh), and the methodology of estimation of benefit cost ratio for investment on adolescent health. The interventions in health of adolescents are related to physical, sexual and reproductive health, communicable and non-communicable diseases.

Methodology and Data

The adolescent population is here defined, as the population with age between 10 and 19 years[1]. The study primarily follows the approach for adolescents which is used in Sheehan et al. (2017) and refined the methodology and data for India. To capture the effect of the demographic and epidemiological factors across different disease categories and to incorporate locational influence on these factors, these interventions are modelled using OneHealth Tool (OHT). The tool was developed by UN Inter-Agency Working Group on Costing (IAWG-Costing) in association with WHO and encompasses a large range of epidemiological information across interventions and countries. The tool, provided by Avenir Health, is regularly updated from newly released data and also provides the opportunity to add data for sub-national level. The tool has been used in many epidemiological studies in the past, especially in areas like maternal and child health (Adesina & Bollinger 2013), non-communicable diseases (Chisholm et al. 2018), and overall health strategy (Cantelmo et al. 2018, Wong 2018).

Developing an investment case for interventions related to adolescent health requires the scope of identifying and incorporating a set of cost-effective interventions specific to adolescents into the model. There should be scope of identifying the target population and the proportion of population who would be benefitted from the interventions. The cost of interventions encompassing different components and the impact of the interventions in terms of economic and social benefit needs to be

[1] https://www.who.int/health-topics/adolescents/coming-of-age-adolescent-health

quantified and can be translated into monetary terms. The present model incorporates all these aspects for both national and subnational level. The estimated economic and social benefits thus calculated are compared to the intervention costs to estimate the benefit-cost ratios.

Identification of interventions

There are 78 different interventions related to adolescent health incorporated in this model. Selected interventions relevant for adolescent population in India (and each of four states) are: Maternal and child health (24 interventions), Nutrition (4 interventions), Malaria (7 interventions), TB (8 interventions), HIV-AIDS (24 interventions), Non-communicable diseases which include depression, anxiety and epilepsy (10 interventions). The period of analysis is 2018 to 2030. The details of the interventions are described below (Table A1.1).

Table A1.1: Interventions modelled for health for adolescent population

Sl. no.	Areas of Intervention		Description
Maternal/newborn and reproductive health			
1	**Family planning**	CPR	Any method of contraception
2	**Safe abortion**	Safe abortion services	Abortion at health facility only (Public and Private)
3	**Management of abortion complications**	Post-abortion case management	We assume value of Safe abortion services as Post-abortion case management
4	**Management of ectopic pregnancy care**	Ectopic case management	Abortion done by doctors only
5	**Pregnancy care - ANC**	Tetanus toxoid (pregnant women)	Includes mothers with two injections during the pregnancy of her last birth, or two or more injections (the last within 3 years of the last live)
6		Syphilis detection and treatment (pregnant women)	% Pregnant women treated for Syphilis to Total sero positive for Syphilis
7	**Pregnancy care - Treatment of pregnancy complications**	Hypertensive disorder case management	Currently taking medicine to lower BP out of total diagnosed pregnant women by doctor or health professional during 2015-16 NFHS survey
8		Management of pre-eclampsia (Magnesium sulphate)	We assume it's same as Hypertensive disorder case management
9	**Childbirth care - Facility births**	Labor and delivery management	Skilled delivery (includes doctor, auxiliary nurse midwife, nurse, midwife, lady health visitor, and other health personnel)
10		Active management of the 3rd stage of labour	Delivery done by doctors only

11		Management of eclampsia (Magnesium sulphate)	Delivery done by doctors only
12		Neonatal resuscitation (institutional)	Institutional Delivery
13		Kangaroo mother care	Institutional Delivery
14	***Childbirth care - Home births***	Clean practices and immediate essential newborn care (home)	Either used Disposable delivery kit (DDK) or Clean blade to cut the cord at home during delivery
15	**Childbirth care - Other**	Antenatal corticosteroids for preterm labor	Default value of OHT
16		Antibiotics for pPRoM	Institutional Delivery
17		Induction of labor (beyond 41 weeks)	Delivery at public (govt. /municipal hospital, uhc/uhp/ufwc, chc/rural hospital/block phc) and private hospital/maternity home/clinic
18	**Postpartum care - Treatment of sepsis**	Maternal sepsis case management	Delivery done by doctors only
19	**Postpartum care - Treatment of newborn sepsis**	Newborn sepsis - Full supportive care	Newborn those had postnatal check-up within 2 days
20		Newborn sepsis - Injectable antibiotics	Institutional Delivery
21	**Postpartum care - Other**	Clean postnatal practices	Newborn those had postnatal check-up within 2 days
22		Chlorhexidine	Institutional Delivery
23	**Other Sexual and reproductive health**	Treatment of PID (Pelvic Inflammatory Disease)	Delivery done by doctors only
24		Treatment of urinary tract infection (UTI)	Default value of OHT
Malaria			
26	**Prevention**	Insecticide treated materials	Those have mosquito bed net for sleeping during NFHS -4
27		Pregnant women sleeping under an ITN	Pregnant women sleeping under ITN
28		Indoor residual spraying	
29		IPT (pregnant women)	Pregnant women sleeping under ITN
30	**Case management**	Malaria treatment (children 5-14)	Malaria treatment for under 5 yr. children
31		Malaria treatment (adults, excluding pregnant women)	Adults get treatment for malaria except pregnant women
32		Treatment of malaria (pregnant women)	Pregnant women get treatment for malaria
	TB		
33	**TB diagnosis: Culture and DST**	Drugs susceptibility testing for first-line drugs: New TB cases	Historical value cannot be change as per OHT
34		Drugs susceptibility testing for first-line drugs: Previously treated TB cases	Historical value cannot be change as per OHT

35	**First-line TB treatment**	First-line TB treatment: Initial treatment	total patients put on DotS out of total TB cases detected
36		First-line TB treatment: Initial treatment for children	total patients put on DotS out of total TB cases detected
37		First-line TB treatment: Previously treated	First-line TB treatment: Previously treated
38		First-line TB treatment: Previously treated for children	First-line TB treatment: Previously treated for children
39	**MDR and XDR TB**	Second-line treatment/ MDR treatment	Treatment for MDR TB
40		XDR treatment	Treatment for XDR TB
	HIV/AIDS		
41	**Prevention - Under Programme Costing**	Mass media	Information about AIDS from mass media (Radio, TV, cinema, newspaper/magazine, poster/ hoarding, Exhibition/ mela)
42		Community mobilization	Information about AIDS via community mobilization (Education program, health workers, political leader, religious leader, community meeting)
43		Youth focused interventions - In-school	Information about AIDS from school/teacher
44		Workplace programs	People get information about AIDS from work place
45		Blood safety	Blood banks under NACO and have access to safe blood
46		Unsafe injections replaced with AD syringes	Total syringe return out of distributed
47		Reduction in number of other injections	Reduction in number of other injections
48		Universal precautions	IDU: needle exchange
49	**Prevention - Other**	IDU: outreach	Coverage of IDU
50		IDU: needle exchange	Total needle return out of distributed
51		IDU: drug substitution	Coverage of IDU
52		Interventions focused on female sex workers	Interventions focused on female sex workers
53		Interventions focused on male sex workers	Interventions focused on male sex workers
54		Interventions focused on men who have sex with men	Interventions focused on men who have sex with men
55		Youth focused interventions - Out-of-school	Intervention focused on youth , out of school
56		Voluntary counseling and testing	Percent distribution of women age 15-49 and men 15-54 eligible for HIV testing by testing status.
57		Condoms	Total usage of condom among 15-49 yr. sexually active men
58		Male circumcision	Men had circumcision irrespective of religion

59		PMTCT	Historical value cannot be change as per OHT
60		Post-exposure prophylaxis	Babies received NVP prophylaxis out of total diagnosed, for minimum period of 6 weeks
61	**Care and treatment**	ART for men	Historical value cannot be change as per OHT
62		ART for women	Historical value cannot be change as per OHT
63		Cotrimoxazole for children	Historical value cannot be change as per OHT
64		Pediatric ART	Historical value cannot be change as per OHT
Nutrition			
65	**Women of reproductive age and adolescent girls**	Intermittent iron-folic acid supplementation (menstruating women where anemia is public health problem)	Pregnant women taking IFA for more than 100 days
66	**Pregnant and lactating women**	Daily iron and folic acid supplementation (pregnant women)	Pregnant women taking IFA for more than 100 days
67		Calcium supplementation for prevention and treatment of pre-eclampsia and eclampsia	Default value as no such intervention in India
68		Nutritional care and support for pregnant and lactating women in emergencies	Supplementary food mother received during pregnancy and breast feeding from Aganwadi Center
Non-Communicable Diseases			
	Mental, neurological, and substance use disorders		
69	**Anxiety disorders**	Basic psychosocial treatment for anxiety disorders (mild cases)	Treatment for depressive disorder
70		Basic psychosocial treatment and anti-depressant medication for anxiety disorders (moderate-severe cases)	Treatment for depressive disorder
71		Intensive psychosocial treatment and anti-depressant medication for anxiety disorders (moderate-severe cases)	Treatment for depressive disorder
72	**Depression**	Basic psychosocial treatment for mild depression	Treatment for depressive disorder
73		Basic psychosocial treatment and anti-depressant medication of first episode moderate-severe cases	Treatment for depressive disorder

74		Intensive psychosocial treatment and anti-depressant medication of first episode moderate-severe cases	Treatment for depressive disorder
75		Intensive psychosocial treatment and anti-depressant medication of recurrent moderate-severe cases on an episodic basis	Treatment for depressive disorder
76		Intensive psychosocial treatment and anti-depressant medication of recurrent moderate-severe cases on a maintenance basis	Treatment for depressive disorder
77		Psychosocial care for peri-natal depression	Treatment for depressive disorder
78	**Epilepsy**	Basic psychosocial support, advice, and follow-up, plus anti-epileptic medication	Treatment for Epilepsy

Development of scenarios

Two scenarios are developed in modelling the interventions for health. The Baseline scenario assumes that estimated treatment coverage in 2018 would remain same at the end of the intervention period (2030). We have developed another alternative scenario: Ambitious scenario. For Ambitious scenario, a progressive increase to SDG level of coverage by 2030 is assumed. In this scenario, target coverage is 95% unless baseline is already at 85% of more. When baseline is 85% or more, target coverage for the ambitious scenario is set at 100%. For each of the scenarios, data for coverage and demographic characteristics are updated in OHT specific to the region. In case of Ambitious scenario, coverage rates between 2018 and 2030 are interpolated using the front-load interpolation setting within the OHT. This study incorporates the changing pattern of contraceptive use across income groups for different scenarios to capture the effect on fertility and demography, and hence the population in need for interventions is also changed depending on the fertility behavior.

Estimation of costs

For estimating cost associated with different scenarios, cost is divided into three parts: Intervention cost, System cost and Program cost. Intervention costs are cost of widening the intervention coverage above existing levels of coverage. Program cost, on the other hand, is the cost incurred specific to the programs related to the interventions by the government. System cost estimates the cost of activities to strengthen the health system to ensure increased coverage and delivery of the healthcare. Intervention-specific costs are estimated using India-specific data on drug prices using the OHT, whereas health-system and program costs are estimated outside OHT. For estimation of intervention cost, data on unit cost for each medicine are collected for India and are provided as input in the model. In contrast to Sheehan et al. (2017), this study uses cost-component-specific data on different areas of interventions gathered from the data from India and state-specific budget documents. Cost estimates for respective scenarios are developed by use of projected values of number of services which vary due to increased intervention coverages for alternative scenarios. An additional increment of 15% of program cost is assumed for adolescent-specific designed cost for ambitious scenario in future years. Cost estimates for adolescents are considered for the analysis with suitable fragmentation of cost-components for adolescents using available data of prevalence of disease conditions in adolescent age group. India-specific values of coverage, cost and demographic characteristics are utilized in OHT to estimate health outcomes specific to region, age and gender.

Estimation of impact of interventions

Impact of interventions are measured in terms of reduction in mortality and morbidity that are gained from the interventions for each disease category for each year across different age groups and sex. Since the target population in this study is adolescent population, the impact of interventions on the adolescent age groups are considered, both for male and female. For those areas, in which adolescent specific age groups are not provided in the outcomes of OHT, suitable apportioning is done to estimate the impact on adolescent population. For female population, another impact is through change in fertility rates and number of births.

The health outcomes that are considered in this study are: number of stillbirth averted, neonatal deaths averted, maternal deaths averted, deaths caused by communicable diseases like TB and HIV, and morbidity averted (or increase in healthy life year lived) for non-communicable diseases like depression, perinatal depression, anxiety and epilepsy. Mortality and morbidity outcomes are generated in OHT for each scenario and the difference between the outcomes of the ambitious and baseline scenarios provides us with the impact of the intervention. Similar to the analysis in Sheehan et al. (2017), for mothers and newborn children, it is also assumed that in addition to deaths, serious disability can occur and can lead to decrease in productivity. It is assumed that serious disability from obstructed labor was 6 times that of the number of deaths in adolescent mothers affecting their productivity and participation in workforce. Similarly, it is assumed that premature birth leads to serious disability and this was assumed to be 1·65 times the number of deaths. Serious disability in newborn from asphyxia was assumed to be 0·9 times and from congenital abnormalities equal to the number of deaths.

Estimation of benefits

Benefits are estimated by using health outcomes to generate economic benefits with the assumption that by preventing death and serious disability, the interventions would enable people to enter the workforce and generate economic output.

Economic models for mortality and morbidity are developed following the cohort of avoided deaths for each of the years from 2018 to 2030, which is classified by age and sex. As the cohort ages, it is subject to the mortality rates applicable to that age group, sex and year based on estimates from UN World Population Prospects data (2017). A corresponding labour force participation rate for this age, sex and year sourced from the International Labour Organization projections of labour force participation rates (ILO 2018) is applied to quantify the impact of intervention. Average productivity, which is first calculated for 2017 by dividing the World Bank estimate of GDP in current Indian rupees by the labour force in that year (World Bank 2018), is used to quantify the productivity in the economy. The average productivity is assumed to be increasing at an annual rate reflecting trends over recent years for projection for future years. GDP growth rate is around 7% in recent years in India (World Bank 2018). Employment growth rate is 1- 1.5% for India (ILO 2018). So the conservative estimates of labor productivity is around 5%, which is assumed in this study. India being a fast emerging economy, might join middle or upper-middle income subsequently and would gradually move to even high income economy. So labour productivity is expected to fall. This study assumes a secular decline in productivity up to 2100. It is assumed that after 2065, labour productivity rate might fall to 0.5% and continue till the end of the century. Total GDP is estimated by summing the GDP produced by each cohort for each year of the period in which they are in the labour force. The contribution to GDP of each cohort of persons who would otherwise suffer from serious disability is calculated in a similar way as for mortality, using the same assumptions about participation rates and productivity.

Demographic dividend, which reflects the benefits arising from the impact of the reduction in high fertility rates on growth in per capita GDP, is an important component of economic benefits (Canning and Schultz 2012; Ashraf et al. 2013). In this study, that is captured through sexual and reproductive health measures like reducing the unmet need for contraception. The demographic dividend measured here consists of increased income per head (GDP per capita) for the population arising from three sets of factors: (1) when working population increases relative to dependent population, GDP per capita increases; (2) increased labour supply by women caused by reduction in birth rate leads to increased GDP; and (3) when population growth reduces, the capital resources of society can be invested for increasing productivity, instead of meeting the needs of the expanding population. The estimates of the demographic dividend are largely based on the methods used by Ashraf et al. (2013), which was further followed by Sheehan et al. (2017) and Stenberg et al. (2014).

Apart from the economic value, a social benefit value is estimated along with. Benefits of improved health are generally estimated by quantifying the benefits of being alive and it is generally done by estimating the value of a statistical life year (Viscusi et al. 2003, Jamison et al. 2013). Stenberg et al. (2014), in their study assumed that the value of a life year is 1·5 times GDP per capita, of which economic benefit was represented as GDP per capita, and social benefit as 0·5 times GDP per capita. In this study also, social benefit of improved health resulting from each healthy life year gained from the interventions is assumed to be 0·5 times GDP per capita. This value was calculated for the year 2018 and assumed to increase at the same rate as productivity growth.

Benefit-cost ratios, in this study, are expressed both excluding and including social benefits. The first measure is for economic benefits alone and is calculated by dividing the net present value (NPV) of the economic benefits from mortality and morbidity avoided by the net present value of the costs of the intervention. The second measure includes both economic and social benefits and then divided by NPV of costs to estimate the benefit-cost ratio (BCR). A discount rate of 3% is utilized to estimate the NPV for both estimating the net present value of cost and benefit, and a sensitivity analysis (with discount rates 2% and 5%) was performed.

Specification of data for India and four selected states

The study uses wide range of data sources to build up the India-specific model. National Health Family Surveys (NFHS) (2005-06 and 2015-16) are the major sources of intervention coverage data for Maternal and child health, HIV/AIDS and Nutrition. Apart from that, coverage data for Malaria is collected from NFHS, WHO World Malaria Report 2017, and Rapid Survey on Children 2013-14. Coverage data for HIV/AIDS is also collected from NFHS and NACO (National Aids Control Organization) Annual Report 2015-16. For TB, coverage estimates for India by Goyal et al. (2017) has been used. For intervention coverage data on mental health, the study incorporated depression, anxiety and epilepsy for India, for which National Mental health survey 2015-16 has been used as a source of data. Coverage data is obtained for 2005-06 and 2015-16 and values are projected for 2018. Data for which values are not available for two years which can be used for projection, 2015-16 values are assumed to be the values for 2018. For the indicators, for which exact parameters are not available, closest proxies are taken. For example, coverage value of institutional delivery is considered as a proxy for Induction of labor beyond 41 weeks. The coverage values are linearly interpolated between baseline and alternative scenario values between the year 2018 and 2030.

For demographic data, UN Population Prospect Data for India is considered for 2018. For state level, UNFPA population projection data for different age groups is utilized for 2018. Demographic data includes data on Total Fertility Rate, Age-specific fertility rate, Sex ratio at birth, Contraceptive Prevalence Rate, Contraceptive Method Mix data. Age-specific population, fertility rate and other demographic indicators are collected for adolescent female population, i.e. for women of 15-19 years of age. Prevalence of different contraceptives is also defined for population using the demographic data pertaining NFHS-4 (2015-16). For Ambitious scenario, Contraceptive Prevalence Rate is assumed to cover unmet needs. Family planning inputs are provided for 5-year age-groups separately so that we can obtain fertility and birth results at 5-year age groups and the data is obtained from NFHS survey 2005-06 and 2015-16.

Cost has three components: Intervention Cost, Program Cost & System Cost. Intervention cost comprises cost of Total Medicines, commodities, and supplies, which is derived from OHT using the intervention coverage, health system of the country, cost of medicines, prevalence of diseases and demographic characteristics. The data for unit cost of drugs are collected from TNMSC (Tamil Nadu Medical Services Corporation Ltd. (TNMSC) 2017-18, RMSC (Rajasthan Medical Services Corporation) 2017-18 and Pharma Trac Data 2018-19. Program Cost consists of cost of different government programs on maternal and child health, nutrition, HIV/AIDS, TB and mental health. The cost data is collected from National Health Mission website for all states and UTs and these together provides All-India program cost data. Cost data is collected across different categories of

Human resources, training, supervision, monitoring & evaluation, infrastructure & equipment, transport, Communication, Media and Outreach, advocacy and general program management for each of these program heads. The program cost data from NHM is collected for 2017-18 because data for all states and UTs were available for this latest year. Data on all the states and UTs are aggregated to calculate the all-India value and the data is then adjusted to inflation. For HIV/AIDS, Central Government Detailed Demand for Grants data has been used to distribute costs across different components. Program cost allocated for adolescent population is estimated using the proportion of adolescent population in total population and in people affected by these diseases. System Cost is the cost incurred to run the health system of the country, which are not included in the above mentioned programs. This is obtained from data published by National Health Mission 2017-18 and National Health Accounts 2014-15. The data is allocated across different categories of Human Resources, Infrastructure, Logistics, Health Financing and Governance. The data is obtained for each and every states and UTs of India and clubbed together to obtain all-India values. Data is updated for 2018-19 using the inflation rate. System cost allocated for adolescent population is estimated using the proportion of adolescent population in total population.

For the economic model, data for employment growth and labour force participation rate across age, sex and year are collected from the International Labour Organization projections of labour force participation rates (ILO 2016). GDP data is obtained from World Bank estimate of GDP in current Indian rupees by the labour force (World Bank 2018).

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A2. Investment Case for Human Papilloma Virus Vaccine Program for Adolescent girls for India

Cervical cancer was the fourth most common cancer in women in the world, after breast cancer (2·1 million cases), colorectal cancer (0·8 million) and lung cancer (0·7 million) (Arbyn et al. 2020). There were approximately 570 000 cases of cervical cancer and it caused 311 000 deaths in 2018. The estimated age-standardized incidence of cervical cancer was 13·1 per 100 000 women globally (ibid). The share of the cases are very high in developing nations (Lowy 2012). According to Cancer Registry Abstract 2017, cervical cancer is second most common cancer among women in India. It contributes to approximately 6–29% of all cancers in women in India (Bobdey et al. 2016). Cervical cancer is more common among rural women than urban women, which is largely attributed to traditional customs including marriage at an early age and multiple pregnancies, as well as lack of awareness of symptoms, resulting in late presentation (Das and Patro, 2010). Majority (88%-92%) of the cervical cancer cases are detected late during the course of disease, when the chances of cure decline further (Prinja et al. 2017). Additionally, there is very low vaccination coverage against human papillomavirus (HPV) in India, causing alarming increase in incidences of cervical cancer. This section describes the methodology of estimating benefits and costs of the introduction of a program to vaccinate adolescent girls against the human papilloma virus, the benefits of which are a large reduction in adult deaths from cervical cancer.

According to WHO, there are more than 100 types of HPV, of which at least 14 are cancer-causing and two HPV types (16 and 18) cause 70% of cervical cancers and pre-cancerous cervical lesions. It is mainly transmitted through sexual contact. There are currently three types of HPV vaccine available: Cervarix (GSK) protecting against HPV types 16 and 18; Gardasil 4 (Merck) protecting against HPV types 16, 18, 11 and 6; and Gardasil 9 (Merck) protecting against HPV types 16, 18, 11, 6, 31, 33, 45, 52 and 58. For this study, it is assumed that a vaccine against HPV would prevent 70% of cervical cancers. Primary prevention against HPV starts with HPV vaccination of girls aged 9-14 years, before they become sexually active. World Health Organisation (WHO) recommended a 2-dose schedule for a vaccination program in 2014.

Country level studies show that the vaccine-type HPV prevalence has decreased from 11.5% in 2003–2006 to 5.1% in 2007–2010, a decline of 56% among females aged 14–19 years comparing the HPV prevalence data from the vaccine era (2007–2010) and the pre-vaccine era (2003–2006) in United States (Markowitz et al. 2013). There are also studies on economic and health benefits of HPV vaccination and screening (Campos et al. 2011, Sharma et al. 2012, Goldie et al. 2012). There had been a few studies in India on cervical cancer. Kabekkodu et al. (2015) and Sreedevi et al (2015) focused on epidemiology of cervical cancer in India, while Prinja et al (2017) estimated cost-effectiveness of Human Papillomavirus Vaccination for Adolescent Girls in Punjab State. The study finds that incremental cost per QALY gained for HPV vaccination was found to be INR 73 (USD 1.12 and Int$ 3.38). Given all the data uncertainties, there is a 90% probability for the vaccination strategy to be cost-effective in Punjab state at a willingness-to-pay threshold of INR 10,000, which is less than one-tenth of the per capita gross domestic product.

In this study, benefit-cost modelling for HPV vaccination is developed for all-India and four states: Assam, Madhya Pradesh, Tamil Nadu and Uttar Pradesh. Economic cost of HPV vaccination is compared with the economic benefit that the vaccination can provide in terms of increased labour force participation and increased productivity of women. For development of the model on HPV, the study uses death rates from cervical cancer reported in the Global Burden of Disease Study (GBD) 2016 (IHME 2018) and the study exclusively focuses on the role of HPV vaccination in the prevention of cervical cancer only. Other HPV-related conditions like anal, penile, vulvar and vaginal cancers which can also be prevented from HPV vaccination are not considered in the study.

The modelling is developed for India following the same for cervical cancer as proposed in Sheehan 2017. The modelling assumes that two doses of the vaccine are given to a proportion of girls aged 11 in each of the years 2018 to 2030 depending on the coverage of vaccination. Since the coverage of HPV vaccine is currently not high in India, it is assumed that the vaccination program begins by only covering a very small percentage of the 11 year old cohort but increases to a target coverage rate at the end of the intervention period. The default values for coverage rates are 1% for the initial year rising to 95% by 2023 and coverage rates in the years between these years are attained by interpolation. Based on earlier studies, it is assumed that 70% of deaths can be averted due to the vaccine. Age and sex specific death rates are applied to 11 year old cohort to estimate the effect of vaccine through use of UN projections of population (UN 2018) up to the year 2100. Economic contribution is estimated through multiplying the number of girls entering the labour force to average productivity. The age of entering labour force is assumed to be 15 years for the girls and labour force participation is thus calculated from population projection for the cohort. Average productivity, on the other hand, is estimated by dividing World Bank estimates of GDP measured in current USD in 2017 by the total labour force estimates by ILO for 2017. Productivity is assumed to be increasing at a rate of 5% in the initial years (staring from 2018), which gradually decreases up to the year of assessment of 2100. Net present value of GDP for those years is estimated with discount rates 2%, 3%, 5% and 7%.

Cost of vaccination is estimated by multiplying the unit cost of vaccine with the coverage rate of the vaccine and number of 11 years old girl for the year 2018 to 2030. Unit cost of vaccination per immunized girl is assumed to be $10.2. Similar to the benefit analysis, net present value of the cost is estimated using the discount rates 2%, 3%, 5% and 7%.

Apart from economic benefit, social benefits associated with the deaths averted by the vaccination program are estimated following a similar procedure to that in Shehaan et al. (2017). It is assumed that additional social benefit for one life year is half of per capita GDP. Total social benefit is thus estimated and discounted similar to the previous method of estimation of net present value. The economic benefit and social benefit together provide us the estimate for net present value of benefit which is divided by net present value of cost to estimate benefit cost ratios.

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A3: Investment case for adolescent education in India

I. Introduction

The human capital theory suggests that investment in education and health of population not only increases individuals' earning over one's life time period but also enhances labour market outcomes and economic growth (Schultz 1961; Mincer 1974). For instance, investments in the health and education of children today deliver economic returns in the future, when those children grow up to be healthier, better-educated, and more productive adults (Weiss 1995; Thomas and Burnett 2015, Kim 2018). More recently World Bank is developing a model to simulate the effects that increased human capital could have on economic output over the rest of the 21st century (Collin and Well 2018).

Accordingly, a large number of literature estimated the impact of the level and quality of education on productivity and economic growth across different countries (Psacharopoulos and Patrinos 2004; European Commission 2005; Wahrenburg and Weldi, 2007; Montenegro and Patrinos 2012; Barro 2013; Hanushek and Woessmann 2015; Collin and Weil 2018). Presenting the investment case for adolescent in India, this study aims to conduct a cost-benefit analysis of increased years of secondary schooling and quality of secondary schooling by comparing the costs of achieving the improved educational outcomes to the benefits generated for youth, adult population and overall economy in India.

Like in many other developing countries, secondary education completion rate in India is less than 50%with wide variations across the states, ranging from 95% in Himachal Pradesh and 83% in Tamilnadu to as low as 39% in Assam and 35% in Bihar (National University of Educational Planning and Administration [NUEPA] 2016). The corresponding figure is about 80% in developed countries. This has far reaching implications for labour force participation by youth and adult population, labour productivity and economic growth. One the one hand labour force participation rate among adult population (age 15 years and above remains low (at around 50%) and on the other majority of them (approximately 90%) of all employed are absorbed in informal sector, with self-employment accounting for the largest share (National Statistical Commission 2012). Low educational and skill endowments of labour force have also been identified as the prime reasons of low levels of workers' earnings and low labour productivity (World Bank 2015a).

The role of better education on the earnings and productivity of individuals and on the economic growth of the nation as a whole is critical. 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. Improved education scenario, relative to the unchanged base case policy, is supposed to influence economic activity of population through four different channels:

(i) increased years of schooling leads to higher productivity and higher earnings in employment;
(ii) improvements in the quality of education also leads to higher productivity and earnings in employment;
(iii) a rise in secondary school completions leads to an increase in the relative share of formal employment and a decline in the share of informal employment; and
(iv) an increase in secondary completions also leads to a rise in WPR because of increased employability of population.

In a systematic review study Kluve et al. (2017), argued that youth-targeted active labour market policies through skill and education in low- and middle-income countries do lead to impacts on both employment and earnings outcomes. However, much less research has been undertaken on the cost-benefit analysis of largescale educational interventions, especially in studies covering many countries. In a rigorous assessment of a specific program, the Perry preschool program in the USA, Heckman et al. (2010) found benefit-cost ratios for the program between 7 and 10, with a 3% discount rate. A rare recent example is of a study covering many countries is Psacharopoulos (2014), which attempts a preliminary cost-benefit analysis of the post-2015 education targets and found a range of benefit-cost ratios from 4 to 37 for various elements assessed for developing countries. In a recent multi-country study including India, Sheehan et al. (2017) estimated that increase in education attainment and quality would generate 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). This resulted into a benefit-cost ratio (BCR) of 11.8 for all countries taken together and a BCR of 12.8 in lower-middle income countries.

Indian studies in this regard are rather scanty as far as studies reporting BCR are concerned. A few studies in the past estimated benefits of education on individual labour outcomes including individual earnings and labour productivity (Duraisamy 2002; Dutta 2006; Fulford 2014; Sequeira et al. 2016; Kingdon and Theopold 2008; Vatta et al. 2016). For instance, Kingdon and Theopold (2008) find higher returns to education in the local labour market increase the opportunity cost of schooling for poor males, resulting a negative relationship between returns and schooling participation. However, they find that the relationship is positive in case of non-poor males and females. A study by the World Bank (2015b) indicates that participation in skill development programmes by 21-24 years population in India increases the employability by 5-12 percentage points, with great degree of variability across gender, states and types of training programme. Another study by the World Bank (2018) estimated impacts of participation in vocational training by adolescent population in India. The study finds significant jump in employment rates and real wages by pass-outs of the training programmes. Kingdon and Unni (2001) investigates the extent to which education contributes to women's observed lower labour force participation and earnings than men, and whether any contribution of education to the gender wage differential is explained by men and women's differential educational endowments or by labour market discrimination. However, no study to our knowledge, has estimated BCR of secondary education in the Indian context although there are a few studies which estimated costs of improving educational outcomes in general. The present study aims to fill up this gap in literature by estimating costs and benefits of improved secondary education and finally estimating the BCR improving secondary school participation and quality in India.

The main objective of the present study is to assess the likely impact of improved secondary education (participation as well as quality) through a set of specified interventions on labour market outcomes in terms of types of employment (formal and informal) and labour productivity in India. Since the improved schooling outcomes involves various interventions and costs, the study finally conducts cost-benefit analysis of the interventions in the secondary education in India. Further, since the level of education in general and secondary completion rates widely vary across states in India, the results are also presented for four selected Indian states representing different geographical regions, levels of educational achievements and economic development. The four states considered in this study are: i) Assam, ii) Madhya Pradesh, iii) Tamilandu and iv) Uttar Pradesh. Among these, Tamilnadu represents high educational achievements and economic development while the rest three are largely poorer states with low educational achievements. Of the three, Madhya Pradesh and Uttar Pradesh belong to Central India while Assam is part of North-East India. A few representative economic and educational Indicators in the four states along will all India are presented in Table A3.1.

Table A3.1: Economic and education Indicators in four states and all India

	Assam	MP	UP	TN	India
Population in 2018 (In Lakh)	341.6	811.0	2260.3	756.9	13523.2
GDP/SDP per capita in INR (Current Prices) - 2018-19	94,385	99,783	74,402	2,15,049	1,05,688
LFPR (15 and Above) -2017-18	47.5	56.7	44.6	55.1	49.8
Literacy age 7 years and above					
Female	67.3	60.0	59.3	73.9	65.5
Male	78.8	80.5	79.2	86.8	82.1
Person	73.2	70.6	69.7	80.3	74.0
Gross enrolment ratio primary					
Girls	107.6	93.5	96.2	104.4	100.7
Boys	104.7	95.4	88.6	103.4	97.9
Total	106.1	94.5	92.2	103.9	99.2
Gross enrolment ratio upper primary					
Girls	98.8	98.1	83.5	95.7	97.6
Boys	87.7	90.5	68.2	92.6	88.7
Total	93.1	94.0	75.1	94.0	92.8
Gross enrolment ratio secondary					
Girls	83.0	79.3	67.9	96.2	81.0
Boys	72.5	81.5	67.7	91.9	79.2
Total	77.6	80.5	67.8	93.9	80.0
Gross enrolment ratio upper senior primary					
Girls	39.5	43.2	59.3	90.6	56.4
Boys	38.2	47.0	62.2	74.1	56.0
Total	38.8	45.3	60.8	82.0	56.2

II. Methods

This paper builds on an education model developed by the Education Commission (Wils 2015) which projects improved schooling outcomes—in terms of school enrolment ration, years of schooling, school quality, secondary completion rates and other education outcomes—which might be achieved in developing countries, including India by SDG terminal year 2030. The education model also projects costs of achieving those outcomes and the related resource gaps up to 2030. The model computes the evolution of student numbers up to the attainment of the education goals and multiply those numbers with unit costs based on assumptions regarding teachers' salaries, materials and ongoing support, and school construction (Wils 2015). However, the Education Commission model does not target levels of learning improvements by 2030. Also, the model does not specify what kind of interventions are required to achieve the educational targets. The analysis in this paper further used adolescent and economic models, developed by the Victoria Institute of Strategic Economic Studies (VISES), for estimating costs of a set of specified interventions to achieve increased secondary education participation, learning outcomes and secondary completion rate up to 2030 on account enhanced interventions (Sheehan et al. 2017). The set of interventions specified and the related estimated costs in the VISES model is presented in Table A3.2.

Table A3.2: Types of proposed interventions, target coverage, intervention effectiveness and cost of intervention as % of overall expenditure on education

		Intervention effectiveness at reducing gaps			Cost as percent of base costs (%)
School Interventions for adolescents/ secondary schooling	Target coverage (%)	Dropout (including at transition)	Repetition	Learning gaps	
Basic quality	100	1.31	1.96	1.96	
Rural school supply	100	49	0	0	10
Improve school infrastructure (incl WASH)	100	17	0	0	5
Pedagogical changes	0	20	14	14	10
Remedial education	100	0	15	15	10
Double hours on task	0	0	12	12	10
Instruction in MT or similar	0	0	25	25	5
Malaria prevention and control	0	0	12	12	1
Information to parents and community	100	0	12	12	1
Cash transfers for poor students	100	19	0	0	10
Public private partnerships	0.25	16	0	0	0
Community intervention on marriage	17.3	40	0	0	$ 31.5
Berhane Hewan type for rural girls	11.3	30	0	0	$ 80.5
Computer Assisted Learning Program	100	0	0	12	4
Community Based Remedial Education Program (STRIPES)	100	0	0	9	3

The VISES model was also used for estimating labour force participation rates, formal and informal employment and labour productivity up to year 2050. While the details of the education and adolescent models are available in Sheehan et al. (2017), the data sources and technical points of the economic model used for estimating labour market impacts and economic growth are discussed in the following paragraphs.

2.1. Data

The study uses range of data of sources. Education outcomes are derived from an education model developed by the Education Commission (Wils 2015) and using data collated from the District Information System for Education (DISE), India for the period 2008-09 to 2015-16 and the United Nation's 'UNESCO Institute for Statistics' (UIS). The education model also used data from National Sample Survey (NSS) on education (NSS 2014), NSS 71st round for estimating grade and age wise enrolment, drop-out rates and risk factors for drop put and out of school children in different age cohorts and age wise completion rates of different levels of education. Indicators on the learning achievements of students have been used from Annual Status of Education Report (Rural) [ASER] (2008). More details on education outcome and the related data sources are presented in Sheehan et al. (2017).

Data on labour force, gross domestic product (GDP), and population projections in different age groups have been collected for this study using International Labour Organization (ILO) and World Bank Web-sites. Labour productivity (GDP per person in labour force) was estimated by dividing GDP at constant 2010 prices. A large number of indicators derived from the data bases are available up to the year 2017-18 or less. We used the 2017-18 as the base year for projecting the labour market outcomes for the future years up to 2050.

In addition, we also used a number of secondary literature. The types of interventions, their effectiveness and costs used in the VISES model are from one of the most comprehensive meta-analyses conducted by Conn (2016). In addition, we also included two additional interventions emerging from an extensive review of literature on experimental interventions in India: Banerjee e al. (2007) on 'Computer assisted learning programme' and Lakshminarayana et al. (2013) on 'supplementary teaching, learning material and material support'.. For estimating productivity gain on account of additional year of schooling we used Montenegro and Patrinos (2014). The study, using multicounty data bases, estimated that an extra year of schooling added to 5.25% in labour productivity. The study also estimated school quality and labour productivity elasticity as being 0.20.

The Economic Model

The economic model which estimates the effect of changes in educational outcomes (increased years of schooling and learning quality) on levels and types of employment (formal versus informal employment), value of GDP and GDP per worker (labour productivity) runs through two parallel tracks: i) base (unchanged policy) scenario and ii) an intervention scenario.

Base scenario: In the base scenario, the intervention variables were held constant at their estimated level in 2018 for the period of 2018–30. Holding the intervention level constant, the education model projects years of completed schooling, average school quality, the proportion of the population which has completed secondary school and associated costs of schooling for the period 2030.

Intervention scenario: In the intervention scenario, the education sector specific interventions were progressively scaled up from their 2018 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. This implies that the period from 2018 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.

The economic model uses these inputs from the education model and then combine population, GDP and labour force data to estimate labour productivity (GDP per person in labour force) and annual growth therein for the period 2018-2050 separately in the base and intervention case scenarios. The average productivity of the employed 20–24 year old age group, in each year of the base and intervention scenarios, is assumed to be equal to overall GDP per capita, set to 1. Labour productivity is projected with a declining rate of growth to match the productivity growth of developed nations by the end of the present century at the same rate both in the base and intervention scenarios. In addition, the model also allows variations in labour productivity for age groups using the single age year wage data for the population aged 20-80 years. Finally, the economic model estimated, worker population ratio (WPR), employment structure (categorized by formal, informal), labour productivity, change in GDP levels in intervention compared to the base scenario and BCR annually for the period 2018-2050.

With an assumed secularly declining rate of labour productivity (GDP/labour force) growth over a period of 2018-2100 from a level of approximately 5% in 2018 reaching to 1-2% in 2100 in real terms, the economic model predicts labour productivity and share of formal and informal employment for the projected 20-80 years aged population in general and by age cohorts in the subsequent years. The ratio of value added in the intervention case, relative to the base case, for a particular single-year age cohort in a particular year is assumed to be a function of both the average level of completed years of schooling for that cohort and of the average quality of the schooling which the cohort has received, both relative to base case values.

Projection of labour productivity

Using the econometric specifications mentioned in (Sheehan et al. 2017), the equation can be modified for India and separately for each of the four reference states as follows:

$$VA_{ik}^{I}/VA_{ik}^{B} = E_{ik}^{P} * \Delta S_i(1+\alpha) * \Delta Q_i(1+\beta) \qquad (1)$$

In equation (1) VA_{ik}^{I} and VA_{ik}^{B} are valued added per person in labour force for age cohort *i* in any year *k* in intervention and base case respectively. E_{ik}^{P} is the productivity weighted level of employment and ΔS_i is increase in the average completed years of schooling achieved by that cohort i . α is the return to an additional completed year of schooling, $\Delta Q_i$is the increase in the average quality of schooling in country, for the period relevant to cohort *i* and β is the elasticity of average productivity in employment with respect to school quality. For simplicity the parameters α and β are assumed to be invariant across formal and informal employment. Here it is important to note that the VISES adolescent model also discounts for effect of three risk factors, namely poverty rate, female sex and rural location on educational outcomes used in equation (1)

Further, since total employment in equation (1) can be divided into formal (E^{F}) and informal (E^{INF}) employment the level and share of these two forms of employment will change from the base level and share in relation to the increase in secondary school completions from the base level. The changes in level and share of formal and informal employment as a result of changes in school completion rates at the secondary level cab be defined as:

$$E_{ik}^{F} = f_0^{F} * E_{i0} + \gamma_F * \Delta SEC_{ik} * POP_{ik}^{NS} \quad \text{……………………………………………………………………….. (2.1); and}$$

$$E_{ik}^{INF} = f_0^{INF} * E_{i0} + \gamma_{INF} * \Delta SEC_{ik} * POP_{ik}^{NS} \quad \text{………………………………………………………………….. (2.2)}$$

Where, f_0^F and f_0^{INF} are defined as the base case shares of formal and informal employment respectively. POP_{ik}^{NS} is the population not in school in *i* cohort and in *k* year. γ_F and γ_{INF} are the coefficients relating the increase in secondary completions relative to the base case to the share of the non-school population in the cohort in question that is in the different types of employment.

Since increase secondary completion relative to base situation is likely to increase the share of formal employment rather than informal, we expect the signs of γ_F and γ_{INF} as positive and negative respectively. Further, for estimating productivity weighted average employment across the two employment types, average productivity in informal employment is assumed to be 50% of that in formal employment. Substituting the values of productivity weighted formal and informal employment in equation (1), we have

$$\frac{VA_{ik}^{I}}{VA_{ik}^{B}} = [(\gamma_F * \Delta SEC_{ik} * POP_{ik}^{NS}) + 0.5(\gamma_{INF} * \Delta SEC_{ik} * POP_{ik}^{NS})] * \Delta S_i(1+\alpha) * \Delta Q_i(1+\beta) \quad \text{……… (3)}$$

And an overall productivity index 'ΔVA_{ik}' is defined as follows:

$$\Delta VA_{ik} = \left(\frac{VA_{ik}^{I}}{VA_{ik}^{B}} - 1\right) * VA_{ik}^{B} \quad \text{……………………………………………………………………………………….. (4)}$$

Projection of change in GDP/SDP levels

For the calculation of changes in GDP/SDP over time the 20–24 year old group is assumed to be uniform, so that the same percentage changes apply to 20 year olds. The analysis of successive cohorts over time, up to year 2050, thus focuses on 20 year olds. The overall productivity effect index (combining together productivity effects from secondary completion, , school quality and employment levels and employment types as estimated in equation (5) is finally adjusted with age specific productivity estimated from wage data for the population 20-80 years old as follows:

$$GDP(SDP) = \Delta VA_{ik} * \frac{w_i}{\overline{W}} * LF \qquad (5)$$

In equation (6) $'w_i'$ is age specific wage, '$\overline{W}$' is mean wage of the workers aged 20-80 years and 'LF' is number of persons in labour force (not in school) in the age cohort of 20-24.

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Calculation of Benefit-cost Ratio

For estimating benefit cost ratio (BCR), we estimated ratio of net present value (NPV) of costs and benefits. NPV is is defined as the difference between the present value of cash inflows and the present value of cash outflows over a period of time. We estimated NPV of costs and GDP/SDP considering incremental costs and benefits (GDP/SDP) up to two points of time 2030 and 2050 using different discount rates during the same period. The alternative discount rates applied are 2%, 3%, 5% and 7%. NPV was estimated using formula as follows:

$$NPV = \sum_{t=1}^{n} \frac{R_t}{(1+i)^t} \qquad (7)$$

where, 'R_t' is net amount of costs and GDP/SDP inflow-outflows during a single period t, 'i' is the effective discount rate and 't' is the time period considered for estimating NPV.

Finally, BCR is estimated as the ratio of intervention to base scenario NPVs at two different points of time, with value of 't' being 12 years (up to 2030) and 23 years (up to 2050).

III. Discussions

Investment in the capabilities of adolescent, education and skill building is important to achieve sustained and inclusive economic growth (SDG 8). The findings in this study indicate that enhanced investment in education system (including improvements in quality of education) in India not only increases secondary school completion rates by adolescent but also it improves labour market outcomes of the adolescent in following years. Increased participation in secondary schooling along with enhanced learning quality, leads to increased labour productivity and finally increased levels of GDP. Overall, the increased benefits in terms of increased GDP could be many folds the investment in the education system. The effectiveness of types of interventions considered in this study are well established across different countries including India. A recent multi-country study reflected that if these interventions are implemented the BCR could be to the extent of 10-13 times the cost of interventions with a higher ratio in lower-middle income countries (Sheehan et al. 2017).

Using the education model as developed by the UN Education Commission and an economic model as developed by VISES we analysed Indian data (all India and four selected states) related to educational indicators, cost of intervention, GDP/SDP, labour productivity and share of formal and informal employment.

The findings reflect that an enhanced intervention in Indian education system up to the year 2030 has the potential to increase secondary completion rate by 33 percentage points from a present level of 45% in 2018 to 78% in 2050. The impacts are likely to be higher for the states of Assam and Madhya Pradesh where the current secondary completion rates are very low (33% and 29% respectively). This leads to a gain in labour productivity by 19% compared to school leavers in the base case scenario. Total employment in the country will be higher by 1.2% in 20303 and 2.6% in 2050 compared to the base scenario and informal employment will decline by 36 million by 2050 in favour of formal employment. This also results into 16% higher GDP compared to that in the base scenario. Since intervention in the school system involves range of costs the benefit in relation to the costs is in the rage of 4 times higher. However, once the intervention cease to happen by 2030, BCR increases very sharply in the range of 15 and 20 at different discount rates.

The BCR in all the four states considered in this study are lower compared to the BCR at the all India level. Among the four states the BCR is the highest in Tamilnadu followed by Madhya Pradesh, Uttar Pradesh and Assam. Sheehan et al. (2017) notes that the BCR (to 2030 at 3% discount rate) of investment in secondary education is generally higher in lo-middle income countries (12.8) compared to both low income (11.0) and high income countries (10.3). We find significantly lower BCR at 3% discount rate for the year 2030. Further, we also find that low income states like Assam, Uttar Pradesh and Madhya Pradesh reflected lower BCR compared to high income state Tamilnadu. This is maninly because in low income states the current secondary completion rates are far lower compared with that in Tamiladu. Although Assam and Madhya Pradesh reflected large jump in secondary completion in intervention scenario by approximately 30 percentage points in 2030 and 45 percentage points in 2050, this needed significantly higher cost of intervention compared to that in Tamilnadu. In both the states the current pupil-teacher ratio is very low and improving the same to reach the target required significant costs. This ultimately led to lower BCR in these states compared to that in Tamilnadu and all India.

The high BCRs for investment for adolescents reported in this study provide a strong support for large-scale investment in the secondary education. The benefits of such investment is not only limited to the school going adolescents in terms of educational attainments but also the benefits are spread over their life time staring with the time they enter into the labour markets at the 20-24 years. Accordingly, the country as a whole benefit in terms of enhanced GDP levels and economic growth.

Although the VISES Adolescent analytic model used in this study considers female sex as one of the risk factors, the present study doesn't change in labour productivity by gender. It is possible that that the labour productivity by ender may be different given the differential secondary completion rate by boys and girls and gender based wage differentials in the labour markets in India and across states in India. This is one of future research agenda. Another limitation of the study is related to the types of interventions suggested for achieving improved educational outcomes. Many of the referred to interventions may have differential effectiveness in India and across states. Owing to lack of evidence of studies on the effectiveness of these intervention we have considered international experiences (Conn 2006). However, the present study also considers two well demonstrated experiments in India conditions (Banerjee e al. 2007 and Lakshminarayana et al. 2008). Also the the productivity ratio across formal and informal employment as suggested in Montenegro and Patrinos (2014) (i.e informal sector productivity is 50% of that of formal sector) may not be true in Indian scenario.

In the light of emerging evidence, we conclude that there is strong case for investment in secondary education in India. Investment through a specified set of intervention has the potential to improve secondary school outcomes, labour force participation rates, labour productivity and GDP many folds compared to the cost involved.

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A4: Investment case for reducing Road Traffic Injuries for Adolescents

Introduction

For persons of all ages, road traffic accidents across the world are responsible for about 1.35 million deaths and a heavy burden of serious injuries every year, with a global fatality rate of about 18 persons per 100,000 population each year (IHME 2016). While the total number of road traffic deaths has plateaued in recent years, the global death rate has shown little decline, in spite of rapid falls in most developed countries, and road deaths and injuries are increasingly concentrated in developing countries. Deaths from road accidents in 75 developing countries accounted for nearly 80% of the global total in 2016, having increased by over 12% since 2000. Roads accidents thus constitute a major and continuing problem for developing countries as a whole, although there are divergent trends across countries. The Indian death toll from road accidents was about 254,000 per annum in 2016, with a fatality rate of over 19 persons per 100,000, although these figures are subject to data uncertainties discussed below. The total number of deaths rose by 35% between 2000 and 2012, but has plateaued over 2012–16. In terms of road deaths, India's experience is consistent with its global income position in terms of GDP per capita, as its fatality rate is in line with that of middle income countries as a whole, but significantly better than that of low income countries. Road deaths and injuries are a massive burden on India and her people.

In India, the concentration of deaths on vulnerable users is even greater that in developing countries as a whole, with these users accounting for a share of 73% of Indian road deaths in 2016. The central role of vulnerable road users must be an important element in any policy response. This paper sets out to provide an investment assessment of available interventions to substantially reduce this heavy burden of road injuries for young Indians. We describe the data and methods that we use in the next section, before providing results and discussion in subsequent sections.

Methods

Data

Like many other countries, India faces serious issues with the quality of its official road injury statistics. The official figures published by the Ministry of Road Transport and Highways (MoRTH) (MoRTH 2017) are primarily based on police reports, and it is widely accepted that data based on police reports tend to under estimate deaths and injuries. The limitations of the official data are analysed in some detail in the TRIPP report *Road Safety in India: Status Report 2016* (Mohan et al. 2017). They conclude that underreporting of road deaths is likely to be 10–20% on urban roads, but 50% or more in rural areas, and they are highly critical of the official data in other respects, such as the distribution of deaths by user type.

Other sources of information for India include those from the health sector (e.g. cause of death surveys and hospital databases) and the Million Deaths Study (MDS) (e.g. Hsaio et al. 2013). MDS is a national mortality survey, over 1998–2014, of about 14 million people from 2.4 million representative households, carried out in conjunction with the Register General of India.[2] The MDS survey relies heavily on the verbal autopsy method. The latest available results for road accidents from MDS are for 2005, finding that there were 183,600 road deaths in India in 2005, 55.2% higher than the official figures for that year (Hsaio et al. 2013). The World Health Organisation uses MDS data and other health sources, as part of its global mortality program, to estimate deaths from road accidents in India (WHO 2015). The latest estimate from the WHO data is that 208,000 people died on India's roads in 2015, 50.9% higher than the official estimate for that year.

However, the most comprehensive estimate of death and injuries from all sources in India is from the Global Burden of Disease – India project. This is a collaboration between the Institute of Health Metrics and Evaluation from the USA and the Indian Council of Medical Research, PHFI and other Indian experts. The GBD estimates are derived from a comparative analysis of several national health data systems, including cause of death reports, hospital data and the MDS, using analytical methods applied by the GBD team to virtually all countries. The latest GBD data shows road deaths in India of 254,000 in 2016, 68% above the official figure for this year. While undoubtedly the GBD data also have their limitations, they are compiled using all available data sources on an internationally comparable basis, and are used as our primary data source in this report. The GBD data on road deaths are available for individual years from 1990–2016 by age, gender and road user type, and for deaths only at the State level in 2016.

While in many respects this is a very rich data set, GBD is a health database focused on deaths and injuries and on the characteristics of the individuals involved. As a result, it contains no information

[2] Centre for Global Health Research at http://www.cghr.org/projects/million-death-study-project/

on the transport characteristics of road accidents. We need to go to other data sources for information on, for example, the location in which accidents occur and hence the factors that give rise to fatal accidents. Some of this information is available in the official data (e.g. MoRTH 2017) and in specific studies.

Road accidents in India occur in three main locations: urban areas[3], national and state highways and other areas (that is small towns, villages and rural areas away from the main highways). According to the UN[4], India has in 2018 an urban population of about 460 million, in over 50 cities with more than one million people and a vast number of smaller urban centres, but over 890 million people live outside these urban centres, in rural areas. Connecting these urban centres, and servicing rural areas, India has a large network of national and state highways. National highways, owned by the national government and managed by the National Highway Authority, currently cover in excess of 110,000 kilometres and rapid expansion is underway. State highways, owned and managed by State governments, cover an even greater length.

The official data based on police reports identify urban areas and highways as the main locations for road deaths, although the extent of the overlap between these two categories remains unclear. In particular, it is not clear to what extent deaths on national and state highways occur in urban rather than rural areas. The official data report a very high level of mortality on highways, with 94,142 persons killed on national and state highways in 2016, or 62% of total deaths recorded in the official data. This implies that 56,643 persons were killed in other areas. The MoRTH data also report that 38.4% of deaths in 2016 (57,840 deaths) occurred in urban areas and 61.6% (92,945 deaths) in rural areas. Consistent with the likely underreporting of deaths in rural areas, the more complete MDS survey has a 23.8%/76.2% urban/rural split in 2005 (Hsiao et al. 2013). MoRTH also provide data on accidents and deaths for 50 Indian cities with a population of one million or more, reporting 17,797 deaths in these cities in 2016. As these cities cover about 40% of India's urban population, if fatality rates were the same in other areas, this implies total urban deaths of about 44,000.

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[3] "Currently, the Indian Census defines urban areas as (a) all settlements with a local urban body and (b) settlements with a population of at least 5,000 persons, density of at least 400 persons per sq. km. and at least 75% of the male main working population engaged in non-agricultural activities." (Tumbe 2016)

[4] United Nations 2018 World Urbanization Prospects: the 2018 Revision, Population of Urban and Rural Areas at Mid-Year (thousands) and Percentage Urban, United Nations Population Division, Department of Economic and Social Affairs.

To provide a sound base for our modelling exercise we have drawn on these and other sources to estimate the structure of road accident deaths in India in 2016, consistent with GDB total deaths (254,000 deaths; see Table A4.1). The key assumptions are that there is little underreporting in the MoRTH highways data, but that this is significant in the urban areas data and very high in the rural data. The share of urban areas in total road deaths is based on Hsiao et al. 2013, while highway deaths are set close to the MoRTH estimate, and rural deaths are the residual. The share of types of road users in urban deaths is based on a study of six cities (Mohan et al. 2016) which found that, for each of the cities, over 80% of road accident fatalities were of vulnerable users, mainly pedestrians and motor cyclists. The user share of deaths on highways is based on two studies, Tiwari et al. 2000 and Tiwari 2015. These studies show that even on highways, the share of vulnerable users in total deaths is very high.

Table A4.1 Estimated structure of total road accident deaths (all ages), India, 2016

	Urban areas excluding highways	**National and state highways**	**Villages and rural roads excluding highways**	**Total**
Share of total deaths (%)	25%	40%	35%	100%
Share of deaths in each location by road user type				
Pedestrians	37	27	37.0	82,500
Motor cyclists/riders	40	33	30.3	85,000
Bicyclists	5	3	10.5	15,000
Car occupants	5	9	6.2	17,500
Truck and bus occupants	7	26	8.2	37,500
Other (including TSR)	6	2	7.8	12,500
Number of total deaths	67,500	100,000	97,500	250,000
Death in each location by road user type				
Pedestrians	24,975	27,000	30,525	82,500
Motor cyclists/riders	27,000	33,000	25,000	85,000
Bicyclists	3,375	3,000	8,625	15,000
Car occupants	3,375	9,000	5,125	17,500

Truck and bus occupants	4,725	26,000	6,775	37,500
Other (including TSR)	4,050	2,000	6,450	12,500
Number of total deaths	67,500	100,000	82,500	250,000
			Residual	GBD (revise)

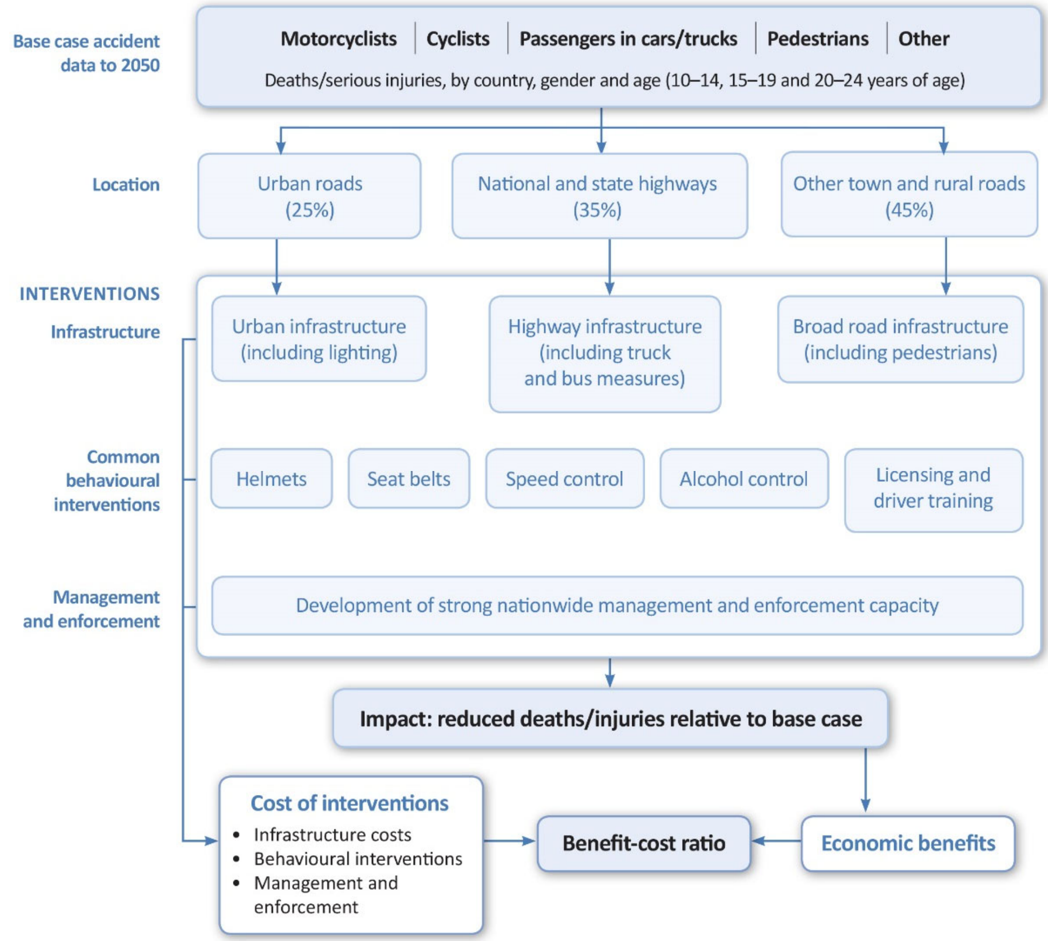
Sources: Estimates of the authors, drawing on the sources described in the text.

The structure of road accident deaths in India in 2016 shown in Table 1 provides the foundation of our modelling.

Modelling

This paper builds on earlier studies (such as Chisholm and Naci 2008, 2012; Sheehan et al. 2017; Symons et al. 2018), to develop and apply an investment model for interventions to reduce roads deaths and injuries in India. In applying such an approach to the Indian case we give particular attention to the distinctive locational and user type characteristics of Indian road accidents, as covered in Table 1. We start from the path of deaths and serious injuries from road accidents—by age, gender and vehicle type—in an unchanged policy base case, and compare that path with one achieved through systematic implementation of a range of interventions. After identifying key interventions, we estimate the cost of these interventions and their effectiveness in reducing deaths and serious injuries for adolescents in India. We then incorporate these estimates in a modelling framework to calculate the reduction in deaths and serious injuries achieved relative to the base case. Finally, we estimate the economic and social benefits arising from these reductions, and hence calculate benefit-cost ratios (BCRs). This methodology is summarised in Figure A4.1 and we outline the various elements of it below.

Figure A4.1 Summary of the benefit/cost model applied to Indian road accidents



The base case

Deaths

The base case projection is the unchanged policy one. That is, it is the projected path of road deaths and injuries if current policies affecting road accidents remain unchanged out to 2050. Many factors might influence this unchanged policy path, as the economy grows and changes. For example, different transport modes have different accident rates (e.g. motor cars are safer than motor cycles), and the relative importance of transport modes varies over the development path. Some authors have argued that the incidence of road accidents follows a Kuznets curve (an inverted U curve), rising rapidly as GDP per capita rises from low levels, but then falling after per capita income passes a threshold level (McManus 2007; Kopits and Cropper 2005). Here we abstract from these complexities, recognising that our central interest is in the difference between the policy case and the base case paths, rather than the characteristics of the base case itself.

Following McManus (2007), the starting point for the base case is that the matrix of fatality rates (deaths per 100,000 population) in 2016—by age, gender and road user type—is held fixed out to 2050. The level and structure of the population varies over time, in line with the International Labour Organization (ILO) population projections, but this matrix of fatality rates remains fixed for each group. The base case data of fatality rates by age, gender and vehicle or injury type are from the Global Burden of Disease (GBD) 2016 data (IHME 2016). Two age cohorts (10–14 and 15–19 years of age) are used, for the following types of injured persons: pedestrian, cyclist, motorcyclist, motor vehicle occupant and other categories. This produces 20 baselines (age cohort × gender × user type) for India.

Serious injuries

For each death from road accidents there are a large number of people injured, with the figure of 16 persons sent to hospital for every death often quoted. Many of these injuries are minor, or of limited duration or with limited impact on employment, so we need an estimate of serious injuries. For the first time, the GBD 2016 data provide estimates of the incidence of injuries from road accidents, in addition to estimates of mortality. These estimates— again by age, gender and vehicle accident type for each country—provide our starting point.

In the benefits model, we take account only of injuries causing severe and profound limitations such as to preclude the person's ability to work at all in the future, assumed to be those with greater than

80% permanent impairment on standard impairment scales. There is very little data on the distribution of injuries by severity, but there are a number of country studies. We rely here on a detailed study (BITRE 2009), which found that in Australia in 2006, 4.1% or about 1 in 24 of those hospitalised had severe or profound limitation (i.e. impairment of 80 to 100%). In the absence of any other data, we assume that 4.1% of injury incidences as measured in the GBD data lead to a disability with severe or profound limitation. Such injuries we here call serious injuries.

These new estimates of injuries from GBD 2016 (IHME 2016) provide insight into the incidence of deaths and serious injuries for adolescents in accidents involving different types of vehicle and across countries. They imply an average ratio of 0.45 deaths per serious injury. The data for the 75 developing countries show that the death/serious injury ratio is highest for accidents involving cars and trucks (0.71 for males, 0.46 for females), for pedestrian accidents (0.72, 0.47) and for motor cycle accidents (0.62, 0.22). For cyclists the ratio is low (0.07, 0.05). These differences may relate significantly to speed, with many car/truck and motor cycle accidents involving vehicles travelling at high speed, often in non-urban areas, while pedestrians are in grave danger of being killed if struck by a rapidly moving vehicle.

It is also notable that across all vehicle types death/serious injury ratios are about twice as high in developing countries than in the OECD. This presumably reflects the many differences between developing countries and the OECD in road conditions, vehicle technology, safety programs and injury treatment. It also suggests that the assumption drawn from the Australian study (that 4.1% of GBD injuries are serious) may underestimate the extent of serious injury in the 75 countries.

India shows a similar pattern across road user types in death/injury ratios, although these ratios are somewhat lower in India. The serious injury (calculated using the 4.1% measure)/death ratios are higher in India than in the 74 countries as a whole, and particularly high for bicycle accidents. To avoid overestimating serious injuries we here measure serious injuries as the lower of 4.1% of all injuries or 4 times deaths, for all relevant age, gender and road user groups.

For base case projections of serious injuries for each year, we hold the serious injury rate per 100,000 constant for each age cohort, gender and country over the time-period being modelled, and apply this rate to the projected number of deaths for each age cohort, gender and country, to obtain the level of serious injury for each category.

Interventions: Impact and cost

Building safer infrastructure

The limitations of India's road transport safety infrastructure are well documented (e.g. Srinivasan 2017). Major issues in urban areas include lack of separation of pedestrians and motor cyclists from other traffic (footpaths and motor cycle lanes), many dangerous intersections and poor visibility at night. While behavioural issues are also involved, these limitations partly explain the high level (over 80%) of vulnerable users in road deaths in Indian cities. In terms of highways, India has seen the construction of new, faster roads with inadequate safety provision, with a large number of deaths. A 2015 study (Tiwari 2015) of sections of 2 lane, 4 lane and 6 lane highways found that about 30% of deaths were pedestrians and a similar proportion were motor cyclists, with truck drivers being the dominant source on 6 lane highways.

Major crash risks arise in developing countries from poor infrastructure and from the construction of new, faster roads with inadequate safety provision. Modelling by the International Road Assessment Programme (iRAP) for the UN Sustainable Development Goals project estimated that bringing the 10% of roads where 50% of fatalities occur in all countries to a three star iRAP standard or better would reduce fatalities (and serious injuries) in those countries by more than 15% (iRAP 2014). These estimates are supported by recent demonstration projects in India and other countries. In India, for example, a project in Karnataka state involved traffic calming, better delineation, pedestrian, bus and truck parking facilities, leading to nearly 60% reduction in road fatalities in the year following the completion of the project (van der Horst et al. 2017). Another demonstration project on the 139 km Renigunta-Kapada Rd in Andhra Pradesh, India, led to a 43% reduction in injuries and 22% reduction in fatalities (van der Horst et al. 2017).

It is clear that India requires massive investment in safe infrastructure – in cities, on national and state highways and on rural roads – and that this investment will be both costly and highly effective in reducing deaths and serious injuries on India's road. Quantifying the cost and the impact is more difficult. Here we rely on work conducted by the World Bank in conjunction with Indian partners and the Bloomberg Foundation, using the iRAP star rating system noted above (with ratings from 1 – poor to 5-excellent) and summarised in Srinivasan (2017). This study surveyed 10,500 km of road in India and found that almost all roads were 2-star or less and that, from the viewpoint of vulnerable road users, the majority of roads surveyed were only 1-star. Their estimates imply that an intensive program to bring most Indian road up to 3-star standard or better would require annual expenditure, when peak investment activity is reached, of about 0.124% of GDP. We assume that such an investment program is put in place, that it is phased in to reach its peak by 2024, and that it remains at that level until 2030 before being gradually reduced out to 2050. Estimates of the impact of such an investment on road deaths can only be based of existing pilot programs, such as those noted above. On this basis we assume that higher quality infrastructure reduces road deaths by 50% for pedestrians, cyclists and motor vehicle occupants by 2050 and reduces deaths of motor cyclists by 25% (see Table 3).

Behavioural interventions

There is broad agreement, internationally and within India, about the main behavioural interventions that need to be put in place to reduce road accidents and deaths. Table A4.2 summarises the findings about the effectiveness of these various interventions from the main studies identified as having such information. Table 3 shows the effectiveness measures actually used in the modelling, together with our assumptions about the extent to which these measures are in place in the base case for India. As noted, the estimates of the effectiveness of the interventions vary widely in the literature and these variations may reflect the intensity with which the interventions are applied.

Table A4.2 Measures of the effectiveness of behavioural interventions: the international literature

Intervention	Measure of effectiveness	Effectiveness summary range (%)	Effectiveness (% reduction)
Seat belts	Wearing seat	Fatalities 7–65	65 (Peden 2005) 7–9 (Dellinger et al. 2007) 11 (Chisholm & Naci 2008) 11 (Chisholm & Naci 2012 11 (Elvik & Vaa 2004)
Helmets	Wearing helmet	Fatalities 20–48	36 (Chisholm & Naci 2008) 20 (Bishai & Hyder 2006) 42 (Liu et al. 2008) 29 (Olson et al. 2016) 36 (Chisholm & Naci 2012)
Alcohol	Modern constraints on alcohol use on roads	Fatalities 3–48	10 (Bishai et al. 2008) 25 (Chisholm & Naci 2008) 22 (IQR 14–35) (Elder et al. 2002) 20 (18–22) (WHO 2006) 25 (Chisholm & Naci 2012)

Speed enforcement	Systematic speed limit enforcement	Fatalities 17–25	17 (Bishai et al. 2008) 25 (Bishai & Hyder 2006)
Graduated licensing schemes	Implementation of GLS scheme	Fatalities 31–57	57 (Williams et al. 2012) 20 (VicRoads 2017)

Note: IQR is interquartile range.

Drawing on many studies shown in Table 2, the Global Research Safety Partnership (GRSP) Seat Belt Manual (FAS 2009) sets out the benefits of wearing a seat belt compared to not wearing one (in a 4-wheel vehicle) as follows: 50% fatality reduction for drivers, 45% reduction for front seat passengers and 25% reduction for rear seat passengers. We represent these results by a 40% average reduction in fatalities from seat belt use.

Several studies have examined the benefit of helmet wearing, with a strong and repeated finding of significant reductions in the risk of death and serious injury, as summarised in Table A4.2.

In relation to alcohol, Bishai et al. (2008) among others, examined the effect of alcohol enforcement to reduce deaths and found a 17% reduction, whereas Chisholm and Naci (2012) use a figure of 25%. Table 2 provides the results of other studies. These effects are the estimated effects of putting in place an integrated system for the prevention of driving with excessive alcohol levels, as applies in many developed countries, relative to no alcohol controls.

There is a long literature on the effect of reduction in speed levels on deaths and injuries from a given level of accidents, which centres around the percentage change in these outcomes for a given percentage reduction in average speed levels on different types of road. For example, Cameron and Elvik (2008) find, on the basis of an extensive meta-analysis, that a mean speed reduction of 3 km per hour (e.g. from 65 km/hr to 62 km/hr on a 60 km/hr road) generates a 15% reduction in deaths on urban arterial roads, 20% on residential roads and 24% for rural highways, for all road users. As well as varying across road types, the reduction in deaths from a given reduction in speed also varies with the initial speed level.

The literature around graduated licensing systems (GLS) shows that these systems provide a safer learning environment, with robust license testing before solo driving and safer novice driving years. As shown in Table 2 several studies show that GLS delivers a reduction of more than 20% in novice driver and rider deaths and crashes when compared with a control group, although there is considerable variation in results across the different cases studies. These studies are all for the developed countries, although GLS are being considered in several low- and middle-income countries in view of high fatality rates for young drivers and riders.

Table A4.3 Summary of assumptions about effectiveness of interventions by 2050, India

Intervention	**Assumed level in base case**	**Intervention effectiveness by 2050**	**Level of deaths by 2050, other things being equal (relative to base case)**
Seat belt usage	27%	40% (motor vehicles/trucks)	70.8%
Helmet usage	50%	36% (motor cyclists)	82%
Enforcement of alcohol limits	0	25% (all categories)	75%
Enforcement of speed limits	0	14% (all categories)	86%
Better preparation of novice drivers (e.g. GLS)	0	20% (drivers 15-19 years)	80%
Building safe infrastructure – Urban/rural	0	20% (motor vehicles/trucks) 25% (motor cycles) 50% (pedestrians) 50% (cyclists)	80% 75% 50% 50%
Building safe infrastructure – Highways	0	50% (motor vehicles/trucks) 25% (motor cycles) 50% (pedestrians) 50% (cyclists)	20% 25% 50% 50%

In an earlier study (Symons et al. 2018), we have reviewed the literature on the cost of the five behavioural interventions covered in Table A4.3, concluding that annual expenditure equal to about 0.03% of is required to implement these measures seriously and with strong coverage. That finding is adopted here for India.

Management and enforcement capacity

In addition to this period of capacity building, the authorities will require an allocation of funding for ongoing adequate maintenance and governance of legislative processes, enforcement systems, data assembly and management (crash, offence, licensing and vehicle registration), infringement management and court systems. There have been several studies examining the cost of building and maintaining such capacity, such as Bliss and Breen (2009) and Breen 2017. Drawing on these and other sources we estimate that building a high quality road safety management and enforcement capacity in India would require annual expenditure (after a phase-in period) of 0.04% of GDP out to

2030. We also assume that the ongoing operation and maintenance of these capacities, once established, would require about half those funds (0.02% of GDP) after 2030.

The total cost estimated in this study to implementing the various interventions, reaches a peak level of 0.194% of GDP (0.03+0.124+0.04) over 2019–30. This expenditure is phased in over 2019–25, as plans are developed and implemented, and two of the three elements are phased down after 2030, as better infrastructure and enhanced management capacity are in place by that date. These cost figures relate to initiatives to reduce road deaths for the whole population, not just adolescents. To estimate what proportion of these costs should be ascribed to adolescents is a difficult matter, and one which is significant for the overall BCR results reported. One natural approach is to allocate costs across age groups in line with population shares, but it can also be argued that both the propensity to use the road system and to engage in risky behaviour should be relevant to the cost allocation process. Here we take account of both of these dimensions by using an average of the adolescent population share and the adolescent share of road deaths as our allocation measures. As a result, 12.78% of these full system costs are considered to be the cost of the interventions for adolescents.

Economic and Social Benefits

The costs discussed above are the costs of implementing the various measures outlined. The benefits arising from the interventions are the economic and social costs of road accidents avoided because of the reduction in accidents. The analysis here focuses only on the avoided deaths and serious injuries, involving severe and profound impairment such as to preclude employment. Two types of benefits arise from fewer deaths and serious injuries: increased employment and productivity leading to higher GDP and the social benefits of each healthy life, over and above the benefits of higher GDP. This methodology is explained in Stenberg et al. (2014) and in Sheehan et al. (2017).

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A5. Investment case for interventions to reduce child marriage in India

Child marriage is defined as a legal or customary union that occurs before the age of 18. In India, the age of consent for girls is 18 and 21 for boys. The *Child Marriage Act, 2006* has closed various loopholes which allowed child marriage. It is also an offence to arrange a child marriage (Center for Child Rights 2009). India is also party to a range of international conventions outlawing child marriages, such as a number UN human rights conventions.[5]

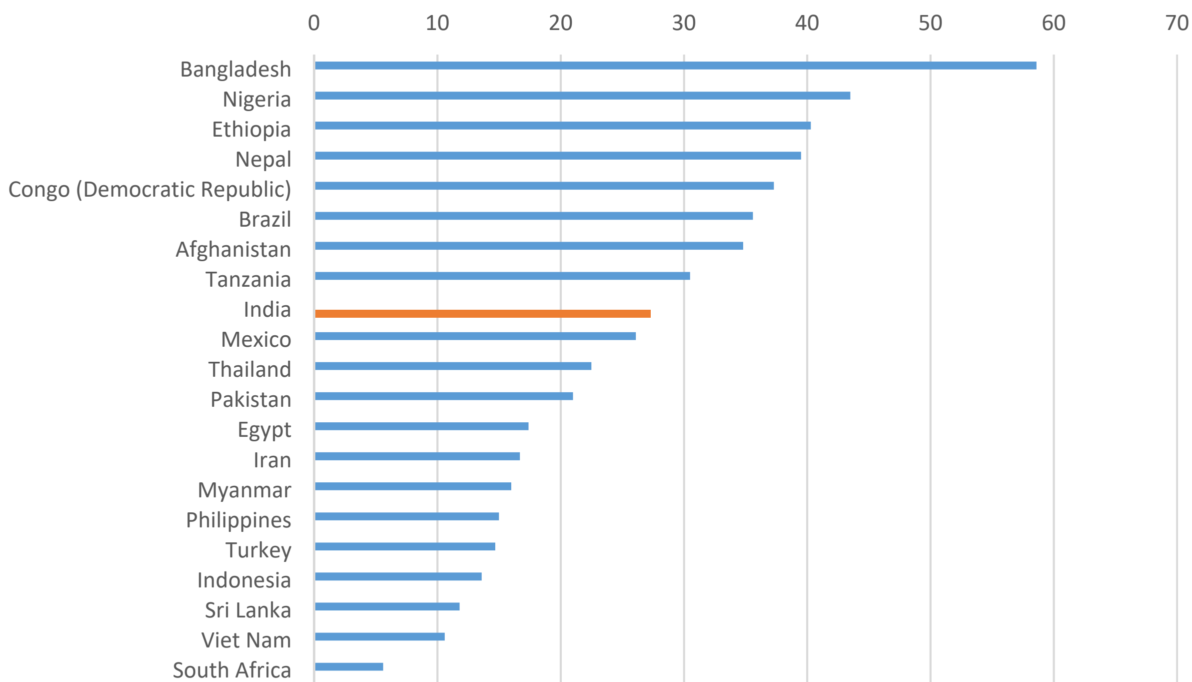
Despite these laws and conventions, child marriage remains high in India by international standards. Of the 125 countries listed in the UNICEF database (2018) with reported child marriage, India ranks 43rd with a child marriage rate of 27% for 2015–16, although this is a substantial decline since the previous *National Health and Family Survey, 2005–06* (IIPS 2007), when it was reported as being 47%. Some of this decline may be due to the large number of intervention programs (including cash transfer programs and a range of government programs for empowering girls) implemented in India (see Appendix) to reduce child marriage rates, even though few of these programs have not been subjected to appropriate evaluations to provide the necessary evidence to substantiate this statement. The accepted measure of the child marriage rate is the proportion of those women aged 20–24 who were married prior to 18. This measure is generally higher than the proportion of girls aged 17 or under married at a particular point in time for two reasons. Firstly, some of these girls may be married later but before 18, and secondly, that there is a tendency to under report marriage for girls yet to reach the legal age of marriage (Sachdev 2018). The modelling in is paper is based on the accepted measure.

Figure A5.1 shows the child marriage rate for India, its neighbours and other selected large countries (population over 50 million). Those with higher rates include neighbours, such as Bangladesh (59%) and Nepal (40%), and large African countries such as Nigeria (44%) and Ethiopia (40%). In Latin America, Brazil (36%) is higher but Mexico is about the same (26%). However in other parts of Asia, Indonesia, Sri Lanka and Vietnam have much lower levels.

[5] The Universal Declaration of Human Rights (1948), The Convention on Consent to Marriage, Minimum Age for Marriage, and Registration of Marriages (1962), The Convention on the Elimination of All Forms of Discrimination against Women (1979), The Convention on the Rights of the Child (1989) and The International Conference on Population and Development Programme of Action (1994) (3:2).

Child marriage varies significantly across states and regions of India, and between rural and urban areas. In Bihar with a rate of 42.5%, the district of Jamui has a rate of 85.3%, while in the relatively urban Gurjarat district of Jamnagar the rate is only 16.9%.

Figure A5.1 Child marriage, India and other selected countries, %



Note: Proportion of women aged 20–24 married before 18 (2010–2017)*
Source: UNICEF (2018).

This paper reports on the results of a simulation study of the benefits and costs of education and child marriage interventions for girls aged 15–19 for India. The results are dependent on models developed for the broader study of investments in education and employment to improve outcomes for adolescents (Sheehan et al. 2017). This paper focuses on the evidence used to establish the costs and effectiveness of specific child marriage interventions, which with other education interventions, determine the modelled marriage rates. The reduction in marriage rates leads to employment and productivity benefits. After an outline of the methodology, the results of the analysis are presented and discussed.

Factors contributing to child marriage

A complex range of factors contribute to child marriage. One of the most significant is prevailing social and cultural norms (UNFPA 2012; Mathur et al. 2003; UNICEF 2005; Save the Children 2004), often arising from the complex relationship between religious beliefs and socio-cultural practices (Gemignani and Wodon 2015). In India, these include marriages to a maternal uncle or elder sister's husband, multiple sibling marriages and marriages in loan settlements which tend to lead to child marriages. In some Muslim regions, the *Child Marriage Act 2006* is seen as contrary to Muslim personal law (Centre for Reproductive Rights 2018; Jha 2016).

Poverty further significantly disadvantages girls, as is attested by higher prevalence rates in the poorest regions (Wodon et al. 2017). For India, 63% of girls in the poorest quintile are married by 18, whereas this is less than 10% for the richest quintile. However this varies between districts. In the previously mentioned Bihar district of Jumui, 81% of child marriage occurs in the poorest quintile, although in the affluent district of Hyderabad in which child marriage is low, 97.5% occurs in the richest quintile (Jha 2016).

In an environment where resources are limited, girls suffer more from truncated educational opportunities. In India over 50% of girls marrying before 18 are illiterate compared with about 20% for those marrying 18 and over. Few marrying early have completed secondary education (Jha 2016). Girls are married early as a safeguard against premarital sex (UNFPA 2012). Poor parents justify marrying girls early to 'secure' their economic future (Parsons et al. 2015), or regard them as an economic commodity and a way of settling familial debts or disputes (Amin 2011). Hence, addressing social norms is paramount in reducing child marriage rates and improving girls' educational levels so they can be more economically independent.

Impact of child marriage

Child marriage has a range of inter-related health, education and economic impacts.

There is a strong correlation between child marriage, lower educational outcomes and reduced levels of literacy (10–14). Child marriage is highest among the least educated (UNFPA 2012). It is also an important reason for early dropout from school (Wils and Shi 2018. Although estimates vary by country, child marriage and pregnancies typically account for 15–33% of dropouts (Lloyd and Mensch

2008; Wils and Shi 2018). Similarly, delayed marriage leads to higher skill levels (Nguyen and Wodon 2012a, 2012b; Field and Ambrus 2008).

Low education outcomes lead to reduced economic participation (Chaaban and Cunningham 2011), including the exclusion from paid employment (Mathur et al. 2003; Vogelstein 2013). The ability to complete secondary education increases girls' learning and their earnings potential, generating better employment outcomes and productivity gains (Sheehan and Shi 2018).

Health impacts include a range of risks from elevated child and maternal deaths and disabilities, including sexually transmitted infections, obstetric fistula, complications of unsafe abortion, and still and premature births (UNFPA 2013). Early marriage can lead to social isolation, hampering access to support networks and increasing depressive disorders (Duflo 2011).

Child marriage is associated with high fertility rates (Wodon et al. 2017; Raj et al. 2009), leading to population growth and casting families into a self-perpetuating cycle of poverty (UNFPA 2012, 2013; Parsons et al. 2015; Erulkar and Muthengi 2009). In contrast, educated mothers who are less likely to marry young are more likely to use contraception (UNFPA 2012; Lloyd and Young 2009). Children of less-educated mothers are less likely to be well nourished and immunized against diseases, and more likely to die (Schäferhoff et al. 2015; Pfeiffer et al. 2001; Smith and Haddad 2015). Not only is the education of early-married mothers poor, but also that of their children (Schäferhoff et al. 2015; Delprato et al. 2017; Patton et al. 2018).

This suggests that interventions which address social norms and provide incentives for girls to stay at school could help reduce child marriage rates. population growth by 2030 (p. 9).

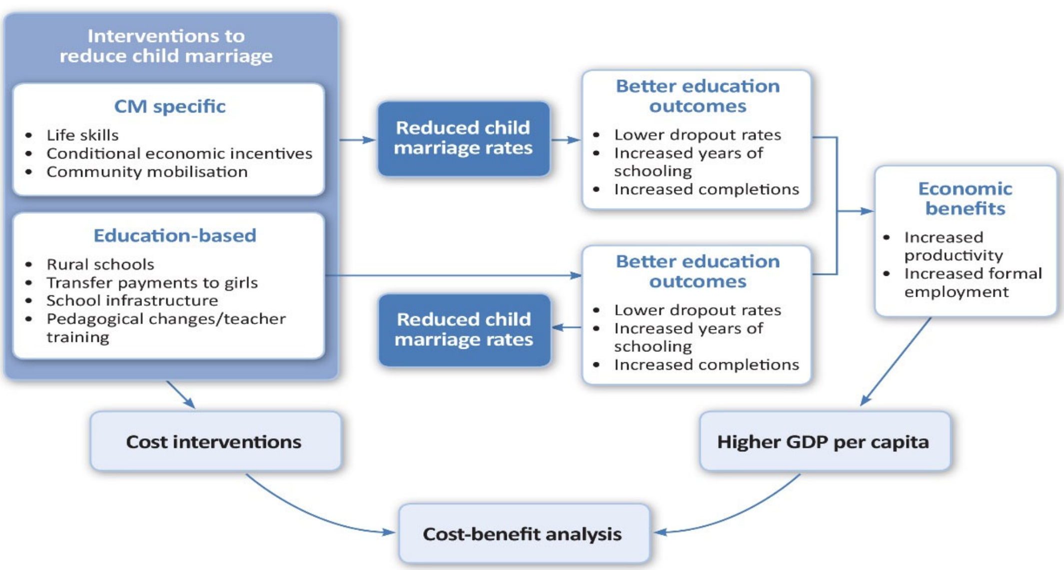
Methodology

Modelling framework

The benefit-cost ratios estimated in this paper draws on the results of two closely related models, namely: education (Wils and Shi 2018), and employment (Sheehan and Shi 2018) and developed further for this project (Anup, Rajeev Sheehan and Rasmussen). We modelled the relationship between interventions to reduce child marriage and the economic benefits from better education outcomes, by linking the results derived from these existing models.

Figure A5.2 provides a schematic of the relationships between the child marriage interventions, improved education outcomes, and economic benefits. First, we use parameters derived from the literature to estimate the impact of interventions on the child marriage rate, as well as their costs. As shown in Figure 1, three of those interventions have direct impacts on the child marriage rate, while four have indirect impacts through the effect of educational interventions on school attendance, and hence on child marriage rates. The second step is to estimate, for the direct interventions, the impact of reduced child marriage on educational outcomes, notably early dropout, years of schooling and extent of completion of secondary schooling. The third step is to estimate one key element of the economic benefit of the better educational outcomes for the girls concerned: higher productivity and access to better employment, leading to higher levels of GDP per capita. The results of these analyses are brought together in a cost-benefit analysis.

Figure A5.2. Modelling framework: Estimating the benefit-cost ratios for the interventions to reduce child marriage



There was no direct data to apportion the intervention costs and benefits between the primarily education outcomes and the reduction in marriage rates. Instead, we apportioned the costs and benefits based on the country-cross section relationship between the proportion of married girls completing secondary school and the effectiveness in the education interventions in reducing child marriage. We made the assumption that those countries achieving higher proportionate reductions in the number of otherwise married girls, were devoting a greater proportion of resources to the objective of reducing child marriage. For India, this assumption results in 67% of the total education costs of the selected child marriage related education interventions being allocated to reducing child marriage.

Choice of interventions

For evidence of the costs and effectiveness of specific child marriage interventions, we conducted a thorough literature search of both peer reviewed and grey literature.

In the peer reviewed literature search, PUB MED and Web of Science were searched from 2006 onwards and only from English language sources. The initial search for ("child marriage" or "early marriage") produced 502 results in Web of Science and 547 in PUB MED. These results were refined to the terms (impact* or intervention* or trial* or evaluation*) resulting in 172 results in Web of Science and 244 in PUB MED. These two sets were combined (416 articles) and 80 duplicates were removed leaving 336 possibly relevant articles. The abstracts of this set were reviewed and 62 were identified (30 in Web of Science and 32 in PUB MED). A final set of 14 articles was chosen. The range of reasons for excluding articles included: being related to prevalence and not interventions or being focused on the determinants of child marriage rather than interventions to prevent child marriage.

The grey literature was searched on Google Scholar, university library catalogues, and by visiting relevant websites of national and international agencies, such as the UNFPA, and the UN, international NGOs, research institutes and networks on violence against women and girls (as child marriage is a form of violence against girls), such as the International Center for Research on Women (ICRW) and the Population Council. We specifically concentrated on seeking additional evidence from the Indian sub-continent where child marriage rates are high. We then hand-searched the literature based on citations in the identified articles in both the peer reviewed and grey literature. We excluded articles which focussed primarily on education, as the education interventions used in this paper are sourced from Wils and Shi (2018).

Two of the papers identified in the literature search were review articles of interventions (Malhotra et al. 2011; Kalamar et al. 2016).

Malhotra et al. (2011) identified 23 evaluated child marriage prevention programs. They identified five main effective strategies (often combining multiple strategies) for delaying marriage or preventing child marriage. The strategies identified were: (1) empowering girls with information, skills and support networks (generally termed life skills); (2) educating and mobilizing parents and community members to change social norms (community mobilisation); (3) enhancing the accessibility and quality of formal schooling for girls (education incentives); (4) offering economic support and incentives for girls and their families (conditional economic incentives); and (5) fostering and enabling legal and policy framework (p. 11).

Kalamar et al. (2016) assessed and ranked the interventions according to a comprehensive criteria. High quality interventions were those that were detailed, rigorous and well-designed, including intervention impact measurement, employed randomization, and pre-post comparisons.

These two reviews provided a framework for selecting interventions. Malhotra et al. (2011) identified the main effective strategies and Kalamar et al. (2016) provided an evaluation benchmark for each study. The most relevant literature closest to meeting these criteria was extracted from the formal search process and is presented in Table A5.1. The table is divided between studies conducted in India and those of other countries. Where available, the table includes the costs and outcomes of the interventions.

Table A5.1 Results of literature search: Interventions to delay marriage and reduce child marriage rates

Study; program; country	Targeting	Main intervention components	Costs	Method	Impact/Outcomes
India					
Pande et al. (2006) Pande et al. (n.d.) Life skills course, rural Maharashtra, India	Girls aged 12–18 not in school or working	1-year program with life skills as one-hour sessions each weekday evening		Logistic regression analysis of data collected from program & control (randomly selected) villages	Steady decrease in proportion of marriage in girls 11–17 yrs between 1997 & 2001 in intervention. No significant change in control. Randomly selected control 4 times more likely married before 18 than those on full program. Pre-18 marriage rate only 9% for full participants & almost a third for control group.
Acharya et al. (2009) Better Life Options programme, model group-based empowerment program by CEDPA, Uttar Pradesh, India	Unmarried adolescent girls 13–17 over a 6-month period	Life skills Community mobilisation		Quasi-experimental research to evaluate effectiveness. Baseline surveys of all 13–17 yrs old unmarried girls in intervention & matched control site pre-intervention. Panel survey 9–15 months later. 1,038 girls interviewed in baseline & endline surveys.	Percentage of girls preferring to delay marriage beyond adolescence increased from 48–55% to 62–75% at endline.
Mehra et al. (2018) EU funded Youth Information Centres, Uttar Pradesh and Bihar, India	Young girls and boys 10–14,15–19, 20–24	Life skill-based educational sessions, focusing on SRH, early marriage and early pregnancy		Cross-sectional (post-test study) with a mixed method approach. Multi-stage sampling was adopted for the selection of a sample of 10- and 24-year olds.	Intervention strategy showed a significant effect towards decrease in the number of early marriages (Adjusted Odd Ratios (Adj) 2.25, CI 1.28–3.94), of early pregnancies (Adj 3.00, CI 1.06–8.43) and increase in the number of school retentions (Adj 2.96, CI 2.02–4.34).
CEDPA (2001) BLP – Better Life Options Program, peri-urban slums in Delhi, rural Madhya Pradesh	Adolescent girls	Life skills educational program		Cross-sectional impact study	37% of BLP girls married after age 18 compared to 26% in control group. Control group girls were 35% more likely to marry before age 18 compared to BLP girls. Quality of the evaluation unlikely to meet Kalamar et al. (2016) standards.

and rural Gujrat, India					
Pathfinder International (2013) PRACHAR – Promoting Change in Reproductive Behavior, Bihar, India	Young couples and adolescents	Tackling social norms that pressure young people to marry and have children before they are ready		960 villages with 10 million people	Young women who took part in the program got married 2.6 years later than those who did not and had first babies 1.5 years later.
Centre on Gender Equity and Health (2017) RISHTA – Regional Initiative Supporting Healthy Adolescents, Jharkhand, India	Boys and girls	SRH education and youth empowerment		In-depth quality interviews with girls aged 13–24	Changed social norms with later marriage being more acceptable and improved gender equity.
Nanda et al. (2014) ABAD – Apni Beti Apna Dhan (Our Daughter, Our Wealth), Haryana, India	Poor households and disadvantaged caste groups	Cash disbursement for registering birth of girl; and on enrolment at school and saving bond for daughter redeemable if girl unmarried at 18	Savings bond Rs 2500 redeemable at maturity of Rs 25,000	Data from beneficiaries and comparable non-beneficiaries	Study found that that the program did not affect the probability of being ever-married or the probability of marriage before the age of 18. And while the research did not find that the program had any effect on delaying age of marriage for girls who participated in the program, ICRW did find that beneficiaries were more likely to get married exactly at age 18. Positive effect on educational attainment
Sen & Dutta (2018) Kanyashree Prakalpa (KP), West Bengal, India	Girls aged 13–18 years	Conditional cash transfers	For unmarried girls aged 13–18 enrolled in an educational institution (KP1) annual grant Rs750 and a onetime grant of Rs 25,000 on reaching age 18,	Independent primary survey of 1,050 households from six blocks in three districts of West Bengal	Preliminary results: Dropout rate reduced by 20.6% points; marriage rate by 12.3% points or a 32.9% reduction

			providing both unmarried and at educ. inst. (KP2)		
Sambodhi (2014) Maharashtra, India	Adolescent girls 12–18	Life Skills Project – Deepshika, empowering girls State Gender resource centre – network of support	Per participant cost ranged from INR267 to INR455 (US$4–6.50)	Large program reaching 64,360 girls. Study results based on interviews with girls, parents, service providers and frontline workers – sample for the endline covered 583 girls in project and 324 in comparison areas.	Impact on gender knowledge and attitudes strongly evident within communities –a number of young women elected into local self-governance bodies, some heading their gram panchayats, now active at village level and active part family level decision making process. Changes within families evident, especially attitudes towards girls. However the reduction in the number of child marriages (280) small compared with the large program size.
Other Countries					
Zibani (2012) in Sewall-Menon & Bruce (2012) Ishraq (Sunrise) Program, Upper Egypt	Disadvantaged out-of-school, rural adolescent girls aged 12–15	Life skills Community mobilisation	Life skills costs per girl $17.99 Admin costs pro rata $13.50 Total costs $31.50	Monitored & evaluated with surveys of intervention villages & control villages with no intervention	No results at time of study but indicators developed & program scaled-up.
Brady et al. (2007) Ishraq (Sunrise) Program, Upper Egypt	Disadvantaged out-of-school, rural adolescent girls in 4 rural villages – 2 in Ishraq, 2 control	Social norms Safe spaces		Longitudinal surveys of girls aged 13–15	Marriage rates at endline among non-participants in program villages are higher than in control villages (22% vs 16%). Rate of 13–29 months participating 12 %, with full-time participants 5%.
Erulkar & Methungi (2009) Berhane Hewan, Ethiopia	Married & unmarried girls aged 10–19.	Community mobilisation Girls' education incentives Conditional economic incentives, e.g. chickens or goat	Cost of materials such as pencils, notebooks $US4 Provision of goat/pregnant ewe (at cost of $US20) if girl unmarried at age 18	Baseline & endline (2 years later) of 2 villages with similar SES profiles – 1 program & other control; Chi-square tests, proportional hazards models & logistic regressions	Improvements in girls' school enrolment, age at marriage, etc. Particularly for girls 10–14 in program rather than in control area, more likely to be in school (odds ratio, 3.0) & less likely to have ever been married (0.1). But, girls aged 15–19 in intervention, elevated likelihood of having been married by endline (2.4).
Erulkar (2014) Berhane Hewan,	Girls aged 10–14	Community mobilisation	Full model costs in Ethiopia $44 per girl	Quasi-experimental research design, with population-based surveys before & after	*In Ethiopia:* Education support, 94% less likely to get married at endline.

Sub-Saharan Africa		Girls' education incentives Conditional economic incentives, e.g. chickens or goat	Full model costs in Tanzania $117 per girl	implementation, in intervention & control sites	2 chickens for every year unmarried, girls 15–17yrs were 50% likely. Full model, girls aged 15–17 yrs, were two-thirds less likely to be married. *In Tanzania:* With goats, girls 5–17 yrs, two thirds less likely to be married. Full model positive effect among both groups of girls.
Erulkar et al. (2017) Berhane Hewan, Burkina Faso, Ethiopia & Tanzania	Cross section of men, women adolescent males & females	Community mobilisation Girls' education incentives Conditional economic incentives	Conditional cash transfer cost in: Ethiopia $32 Tanzania $107 Average $69.50	Population-based base line & endline surveys of girls aged 12–17 & parents of girls	*In Ethiopia*: among girls aged 15–17, with conditional asset transfer half the risk of being married at endline compared to baseline RR = 0.57 *In Tanzania*: RR = 0.52
Catino et al. (2012) in Sewall-Menon & Bruce (2012) Abriendo Oportunidas, Guatemala	Disadvantaged rural girls aged 8–24	Life skills Safe spaces for girls Building social networks		Project monitoring with feedback throughout the project cycle to adjust project strategies, & evaluation to assess project effectiveness as measured against outcome indicators	Core outcome indicators for beneficiaries during pilot: • Continuation of education • Delayed age at marriage & first birth • Retention of health & economic assets after program • Leadership & teaming capacity

As the evidence source to model the interventions, we gave preference to the studies of cost and effectiveness for India from Table 1, which met the criteria suggested by Kalamar et al. (2016) and conformed to the framework of interventions provided by Malhotra et al. (2011). However, we also drew on evidence from studies conducted in other countries where the necessary data was lacking for India. Table A5.2 provides details of the sources for the intervention programs considered for inclusion in the child marriage modelling.

Table A5.2 Sources of evidence for intervention programs considered for modelling

Intervention programs	Source of evidence
Life Skills	Youth Information Centres (Mehra et al. 2018), Ishraq (Sewall-Menon & Bruce 2012; Brady et al. 2007); Maharashtra Life Skills (Pande et al. 2006; Pande et al. n.d.)
Community Mobilisation	Berhane Hewan (Erulkar et al. 2017; Erulkar and Methungi 2009).
Conditional Economic Incentives	Kanyashree Prakalpa (Sen & Dutta 2018) Berhane Hewan (Erulkar et al. 2017; Erulkar 2014; Erulkar & Methungi 2007)
Education Incentives	Provided by the education interventions identified by Wils & Shi (2018)
Legal & Policy Framework	Outside the domain of this study

The life skills, community mobilisation and conditional economic incentives form part of the specific child marriage interventions, and together with the education incentives are discussed below. While recognising the importance of the legal and policy framework, it is not considered in this study. The evidence for the Community Mobilisation program (Erulkar et al. 2017) indicated a relatively low level of effectiveness, and accordingly we selected the Life Skills and the Conditional Economic Incentives programs to include in the model.

Specific child marriage interventions

The *'Life Skills'* programs were represented by the Maharashtra program (Pande et al. 2006; Pande et al. n.d.) and the Youth Information Centres program (Mehra et al. 2018) conducted in Bihar and Uttar Pradesh. The most detailed information for conditional economic incentives was available for the Berhane Hewan program (Erulkar and Muthengi 2009; Erulkar et al. 2017). A study of

Kanyashree Prakalpa (Sen and Dutta 2018) is still preliminary, but indicates a positive impact of an Indian conditional cash transfer program.

In the Maharashtra *Life Skills* program, the pre-18 marriage rate for those girls who participated fully in the life skills program was only 9%, compared with the control group of almost one-third, a reduction of over 70% (Pande et al. n.d.). Moreover, the odds ratio of the control group to marry before 18 was 4.0, compared with those who fully attended the life skills course (Pande et al. 2006). However, Pande et al. (2006) acknowledged the likelihood of selection bias in these comparisons and other unobserved variables.

Exposure to the Youth Information Centres program was found (Mehra et al. 2018) to reduce early marriage compared with the control group (Adj. OR 2.25, CI 1.28–3.94). This implied a reduction due the intervention of 56%. Given the cross sectional (post-test) nature of the methodology, in which only end line interviews of household members were conducted selection bias was less of an issue. For females, 47.1% of those interviewed had an exposure to the life skills program. The life skills CEDPA (2001) program also showed positive results, with the early marriage rate for the intervention group lower than the control group (35% more likely to marry before 18), the published study lacks the detail to meet the Kalamar et al. (2016) criteria. On balance, we adopted a conservative approach and used in the model an effectiveness rate of 40%, together with two sensitivity rates of 30% and 50%.

The only costings we had on costs for an Indian evaluation of a Life Skills program was for the Deepshika program in Maharashtra (Sambodhi 2014), about $4-6.50 per girl. This was much lower than those based on the Egyptian Ishraq program of $31.50 per girl ($17.99 plus pro-rata administrative costs of $13.50) (Sewall-Menon and Bruce 2012). The costs for the Deepshika program may reflect the economies of a large program. However the evaluation study recorded only a modest impact on child marriage which may suggest that greater resources were required. For modelling purposes we have used the average of the two costs $21.50 per girl.

There are a large number of *Conditional Economic Incentives* programs conducted in India (see Appendix Table 1A). However, the only evaluation we found was the preliminary but positive results for the Kanyashree Prakalpa program (Sen and Dutta 2018), which showed a reduction of 32.9%. An analysis of detailed cost data indicated that the average cost per enrolled girl was the equivalent of $11.55. A more detailed study by Erulkar et al. (2017) of the effectiveness in delaying marriage for girls aged 15–17 in sub-Saharan Africa, Burkina Faso, Ethiopia and Tanzania (Erulkar et al. 2017) showed that for Ethiopia and Tanzania (more reliable data), the odds ratio for was 0.57 (0.35, 0.90)[6] and 0.52 (0.30, 0.91),[3] respectively, an average reduction of 45%. The nature of the reward structure of the intervention left it less open to selection bias than the Life Skills programs considered above. The cost of these programs per girl was $32 in Ethiopia and $107 in Tanzania (Erulkar et al. 2017), higher than the Kanyashree Prakalpa program. We used the Kanyashree cost of $11.55 and a lower effectiveness of 30%.

The educational interventions

The education interventions, which also reduced child marriage rates, were derived from the meta-analysis undertaken as part of the development of the education model (Wils and Shi 2018, Table 2). The meta-analysis measured the impact of education interventions to reduce secondary school dropout rates in terms of standard deviations. The authors selected those that show an effect size in excess of 0.1 standard deviations for either learning improvement or dropout reduction. Those which the evidence suggested had a significant impact on child marriage (Nguyen and Wodon 2012c) were (with their standard deviations in brackets):

1. Increase the provision of school in rural areas to give rural girls greater access to schools. (S.D. 0.38 (ϱ=.27))
2. Improve educational infrastructure such as the provision of girl's latrines. (SD =.12 (ϱ =00))
3. Pedagogical changes (SD = 0.13)
4. Private public partnerships (SD = 0.10)

The costs of the educational interventions are derived from Wils and Shi (2018). These are expressed as percentages of the base cost of the education programs for each country. They are respectively 10%, 5% and 10% for the above interventions (Wils and Shi 2018, Table 2; Karan et al. 2018).

[6] $\rho<0.05$.

Discussion

While child marriage represents a serious personal problem for girls, it is symptomatic of society-wide attitudes to young women in communities where girls are systematically excluded from participation in social, economic and political life. This has 'implications not only for the young women themselves, but also for society as a whole, exacerbating poverty and perpetuating disparities in health, education, and economic achievement' (Hallman and Roca 2007, p. 1). In particular, for a number of Indian regions, fertility rates remain very high for early married young women (Raj et al. 2009). The low status of women exacerbates difficulties with adolescent employment, and the poor outcomes for young women carries through to the next generation in the form of lower education levels and poorer health (Delprato et al. 2017). The study suggests that interventions which reduce child marriage through increased attendance at school and changing social attitudes to child marriage, are both important in reducing child marriage and should be pursued jointly.

As with all modelling exercises, the results produced in this paper depend on the assumptions made in specifying the relationships between the relevant variables. Some causes of child marriage are not modelled. Moreover, the relationships between child marriage, education and employment outcomes are complex, and the direction of causation in many cases highly interdependent. It is not possible, given the limited evidence, to capture all these relationships. Accordingly, the modelling attempts to incorporate the most important of the relationships based on the best understanding we have from the available evidence. Nonetheless, this analysis relies on a small number of studies, not all of them Indian, to evaluate these relationships. This is particularly true of the specific child marriage programs. The results of these evaluation studies are broadly applied to contexts which may be very different from those where the results were produced.

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APPENDIX

Table 1A Select conditional cash transfer schemes in India

Name of Scheme	2007–2008	2008–2009	2009–2010
Balika Samriddhi Yojana (Gujarat)	26,031	30,263	132,684
Balika Samridhi Yojana (Himachal Pradesh)	7,955	13,031	17,038
Balri Rakshak Yojana (Punjab)	62	52	62
Bhagyalakshmi scheme (Karnataka)	123,789	297,764	144,749
Dhan Lakshmi scheme (Government of India)		79,555	42,077
Girl Child Protection scheme (Andhra Pradesh)	96,487	72,046	70,302
Indira Gandhi Balika Suraksha Yojana (Himachal Pradesh)	152	318	233
Kunwarbainu Mameru scheme (Gujarat)	8,762	6,775	7,628
Ladli Lakshmi scheme (Madhya Pradesh)	214,134	209,848	40,854
Ladli scheme (Delhi)		135,645	140,006
Ladlischeme (Haryana)	49,558	72,624	105,113
Mukhya Mantri Kanya Suraksha Yojana (Bihar)		475,220*	
Mukhya Mantri Kanya Vivah Yojana (Bihar)		157,256*	
Mukhya Mantri Kanyadan (Yojana(Madhya Pradesh)	32,621	43,297	19,579

Note: *Total number of beneficiaries since inception.

Source: Jha (2016, p. 36).

Table 2A Key government programmes for empowering girls and their limitations

Ministry of Health and Family Welfare	Ministry of Human Resource Development	Ministry of Labour and Employment	Ministry of Youth Affairs and Sports	Ministry of Women and Child Development
The Reproductive and Child Health Programme provides maternal care, including pre-and post-natal care, prevention of unwanted pregnancies and safe abortion facilities.	Mahila Samakhya aims to ensure equal access to education for young women but is not implemented uniformly across the country.	Facility for registration in employment exchanges for job placements, career counselling and vocational guidance for adolescents. Industrial training institutes provide vocational training after class 8 & 10.	Nehru Yuva Kendras undertake youth activities for: health awareness to educate and adopt health and family welfare programmes; youth awareness drives to address issues such as HIV/AIDS; self employment projects to equip youth with income generating vocational skills.	Three flagship programmes aimed at adolescent girls: Apni Beti Apni Daulat; Kishori Shakti Yojana and SABLA.
Adolescents are included under the target population of women, without any specific programmes or provision of services.	Sarva Shiksha Abhiyan provides quality education to children up to 14 years of age.	These opportunities are quite limited due to inadequate provision.	There is significant variation in the implementation of this programme amongst states.	SABLA is the first multi-sectoral approach targeted specifically at adolescent girls with an outlay of INR7.5 billion and poised to roll out across all states.
Unwritten code denying services to unmarried adolescents.				
A number of HIV/AIDS related programmes, including school education and through radio and TV.				

Source: Jha (2016, p. 16).