The burden of childhood pneumonia, effects of amoxicillin use, and the associated impacts on future productivity and output

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List of Abbreviations

LMIC low- and middle-income-countries

ARI acute respiratory infection

URI upper respiratory infection

LRI lower respiratory infection

Hib Haemophilus influenzae type b

PERCH Pneumonia Etiology Research for Child Health

PCV pneumococcal conjugate vaccine

SGDs Sustainable Development Goals

GAPPD Integrated Global Action Plan for Pneumonia and Diarrhoea

Contents

1 INTRODUCTION

Pneumonia is a form of acute respiratory infection (ARI) affecting the lungs. ARIs are classified as upper and lower respiratory infections (URI and LRI) according to the affected anatomical part of the respiratory system. Pneumonia is mainly caused by bacteria, viruses, or fungi. A scan of the current literature suggests a lack of consensus on what proportions (of pneumonia) are viral versus bacterial.[1,2,3,4] Pneumonia is a common LRI in children, which affects the continuation of the airways from the trachea to the bronchioles and the alveoli.[5] The alveoli of affected individuals are filled with pus and fluid, leading to painful breathing and limited oxygen intake.[6] Other symptoms can include intense coughing, high fever, and chills. As pneumonia progresses, children can experience convulsions, unconsciousness, feeding problems, and without timely treatment, often death.[7] Severe pneumonia may result in long-term complications like bronchiectasis which persist to adulthood and present as chronic obstructive pulmonary disease.[2]

Pneumonia incidence is estimated to be about 0.29 episodes per child year in the developing world and 0.05 episodes per child year in the developed world.[8] Even though progress in the overall child survival was made since 1990, pneumonia remains the major single cause of death in children under five (U5) years old and consequently a global health problem.[9,10] Since 2000, the total number of under-five deaths due to pneumonia has declined by 54% (from 1,755,000 in 2000 to 802,000 in 2018), but still more than 2,000 lives are lost every day.[11] In 2018, globally, there were over 1,400 cases of pneumonia per 100,000 children, with the highest incidence occurring in South Asia (2,500 cases per 100,000) and West and Central Africa (1,620 cases per 100,000).[11] Five countries account for more than half of child pneumonia deaths in 2018: Nigeria (162,000), India (127,000), Pakistan (58,000), the Democratic Republic of Congo (40,000), and Ethiopia (32,000).[11] The highest total number of pneumonia-related deaths is found in Nigeria, where it corresponds to approximately 19% of all child deaths or 443 deaths per day, or 18 deaths every hour.[12]

The disease burden is unevenly distributed between developed and developing countries. There is a strong correlation between death rates due to pneumonia and a country's GDP per capita (see Figure 1). The underlying reasons for the negative correlation between both are twofold. Suboptimal living and healthcare conditions in low- and middle-income countries (LMICs) reinforce the disease burden of pneumonia. In turn, the high disease burden negatively affects economic development and growth. That is why some have called pneumonia the "ultimate disease of poverty".[9]

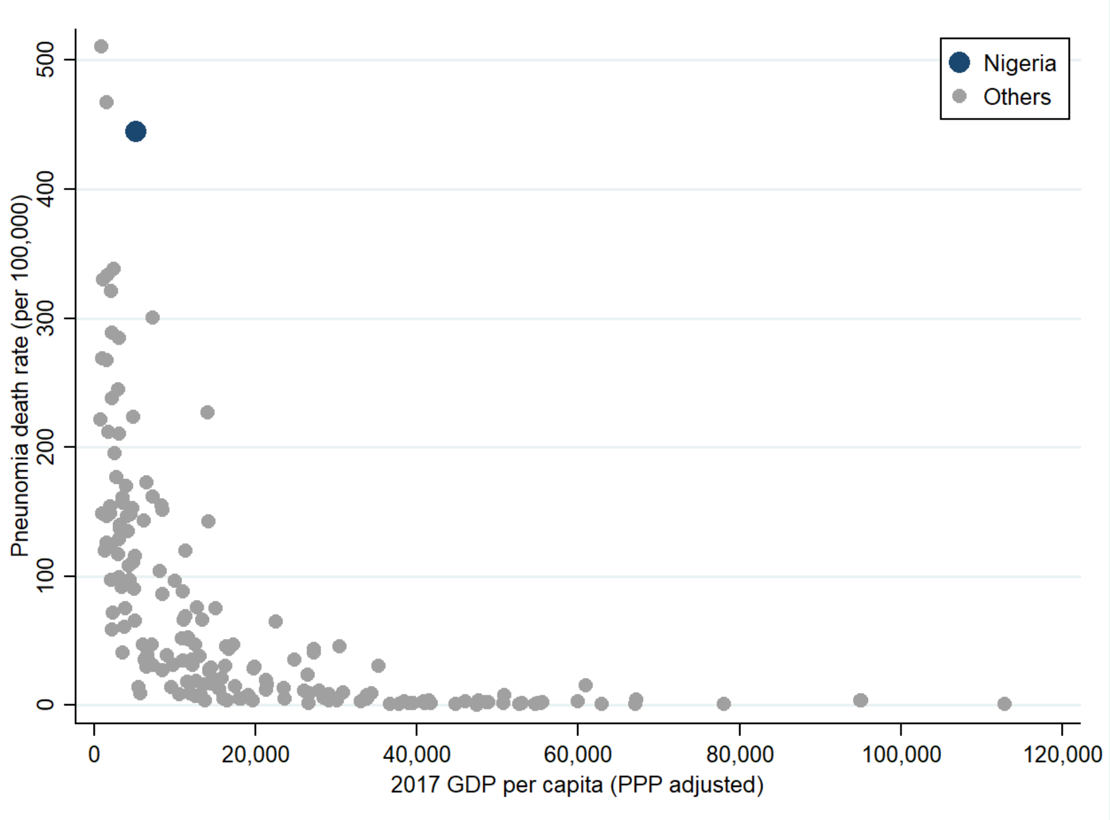

Figure 1: Death rate from pneumonia for children vs. GDP per capita, 2017. Source: World Development Indicators / Our World in Data

Risk factors for pneumonia include undernutrition (child wasting), in- and outdoor air pollution, second-hand smoke, low vaccine rates and no or suboptimal access to health care and treatment. Further, overcrowding facilities exacerbate pneumonia spread. This is especially an issue in developing countries, where almost half of children live in overcrowded households.[13] Nevertheless, access to pneumonia interventions, and use of antibiotics in children have increased over the past decade. According to Allwell-Brown and colleagues (2020), the antibiotic use across all LMICs increased from 36.8% in 2005 to 43.1% in 2017 (UI: 28.8-44.7 and 33.2-50.5, respectively).[14] However, instead of excessively using antibiotics, the usage should be targeted for an efficient treatment and avoiding antimicrobial resitence.[15]

The UNICEF Child Health Coverage Database shows that the percentage of children under-five years with ARI, who consult medical experts is low. While the share of children with pneumonia symptoms visiting a health facility was 73.2% in India, it was only 23.7% in Nigeria.[16]

If treatment is sought in time with an accurate diagnosis, most cases of bacterial pneumonia can be treated effectively and at a low cost with the available antibiotics. Two previous articles indicate a reduction of 35 to 36 percent in childhood pneumonia-related mortality due to community case management approaches, including the one proposed by the WHO.[17,18] Adjusting for the suboptimal antibiotic availability, these studies suggest an effectiveness of pneumonia disease management including antibiotics of up to 70%.[18]

Despite a growing awareness of pneumonia prevention and treatment options as well as increases in care-seeking and antibiotic use, the burden of childhood pneumonia due to preventable child death is still high. Ending all preventable child deaths by 2030, as set in the Sustainable Development Goals (SGDs), or even reducing deaths to less than 3 per 1,000 births, as outlined in the Integrated Global Action Plan for Pneumonia and Diarrhea (GAPPD), seems unattainable. At current rate of progress, Nigeria is not expected to achieve the GAPPD target by 2025 or even by 2050.[19]

Not only are childhood pneumonia deaths negatively associated with emotional well-being of affected families and communities, but they also have a negative impact on future human capital accumulation and a country's output. They lead to attrition of future labor and productivity and decrease investments in human and physical capital formation.[20] Child deaths are potentially associated with reductions in future consumption; size of the labor force; household savings, investments and tax revenues. In other words, deaths from pneumonia could considerably impact the future wealth of a nation, which in turn might have an adverse impact on population health. However, there is an absence of evidence on the extent of the economic impact associated with pneumonia-related childhood mortality. In this study, we aim to estimate the impact of pneumonia-related child deaths on the future non-health components of GDP (per capita) in Nigeria. We simulate the pneumonia-related impact on future GDP (per capita) if the current trend in childhood-pneumonia death continues (baseline scenario), compared to the pneumonia related impact on future GDP (per capita) if availability and access to antibiotics are improved (intervention scenario) and the current trends are pushed down further as a result.

2 METHODOLOGICAL APPROACH

2.1 Components channels

In our analysis, we consider deviations of the path of fertility from what would occur along some baseline in Nigeria. Our modeling assumes that the changes in fertility are associated with changes in the overall childhood mortality. That is, there is a movement from medium (baseline) to low variant fertility as increased number of children survive childhood diseases such as pneumonia. Our model can be easily tailored to consider different baseline and alternative scenarios (and for other disease areas with relatively high mortality). For the analysis, we tailor the model to fit Nigeria. We take the UN (2010) medium-fertility population projection as our baseline population forecast[21], and the UN low-fertility variant as our alternative scenario (with further intervention). Figure 2 shows the paths of the total fertility rate (TFR) in the two scenarios. If fertility replacement happens immediately, the fertility path in the low variant is the same as that in the medium variant prior to 2020 (first year of intervention) but then differs by about 0.5 thereafter. However, generally, fertility shifts take time, and a 25-year replacement occurs around 2045 (blue dotted line) where we see a shift towards the low variant from medium variant. Within this report we assume a shift in fertility after 25 years. Because of the long-term nature of fertility shifts, we show the forecasted evolution of relevant outcomes till the end of the lifetime horizon (2079). As these lie up to 60 years in the future caution is warranted in their interpretation. Therefore, we discuss the results at a 15-, 25- and 60-year time horizon but concentrate on the first two where the uncertainty about future developments remains moderate. In the following, we display the effect of the fertility shift on population channels of our modelling and especially describe the economic model.

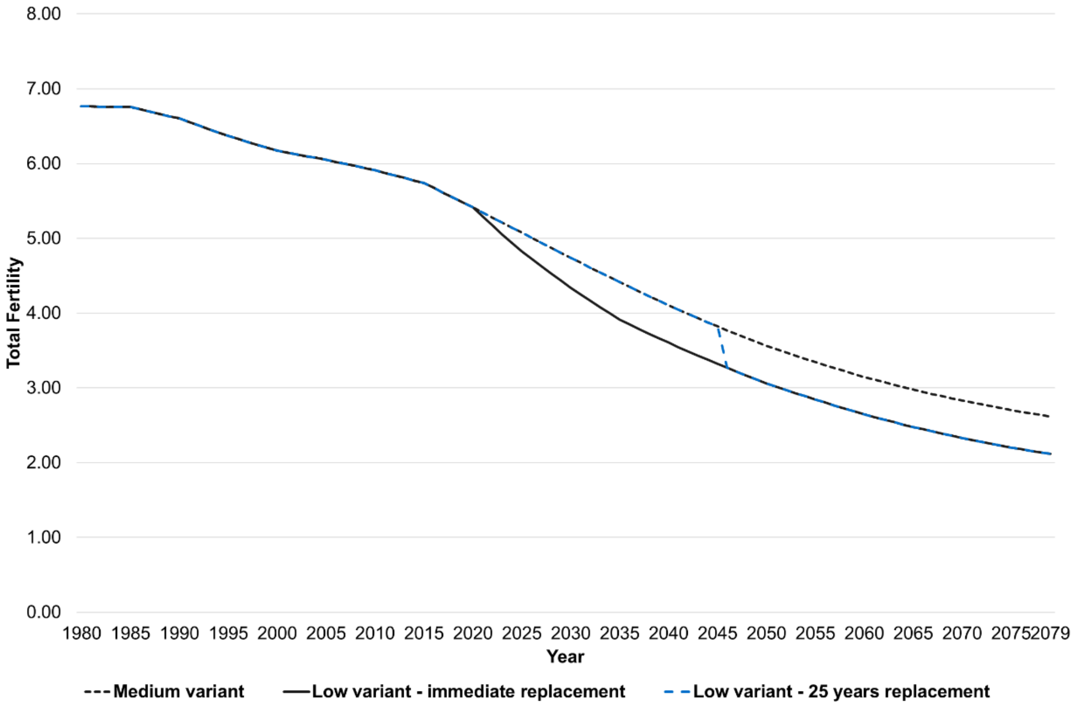

Figure 2: The time paths of the total fertility rate by demographic scenario

Figure 3 shows the paths of total population in the two scenarios. Population in the low variant (both immediate and delayed shifts) is lower than the medium variant. Such deviations are associated with changes in fertility.

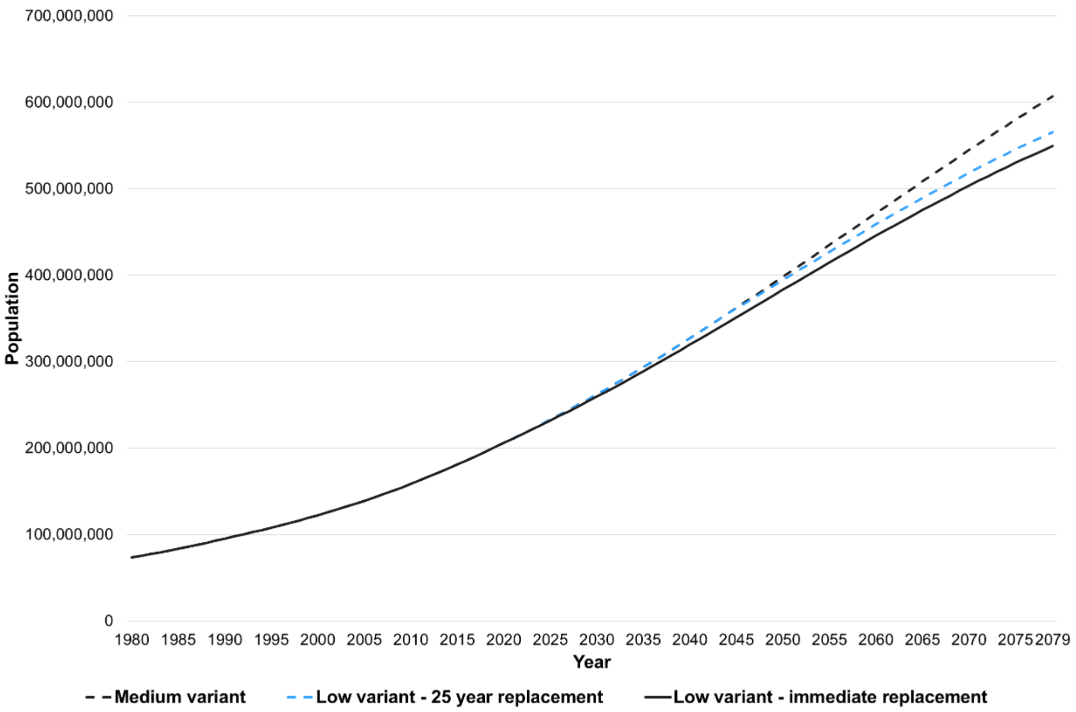

Figure 3: The time paths of population by demographic scenario

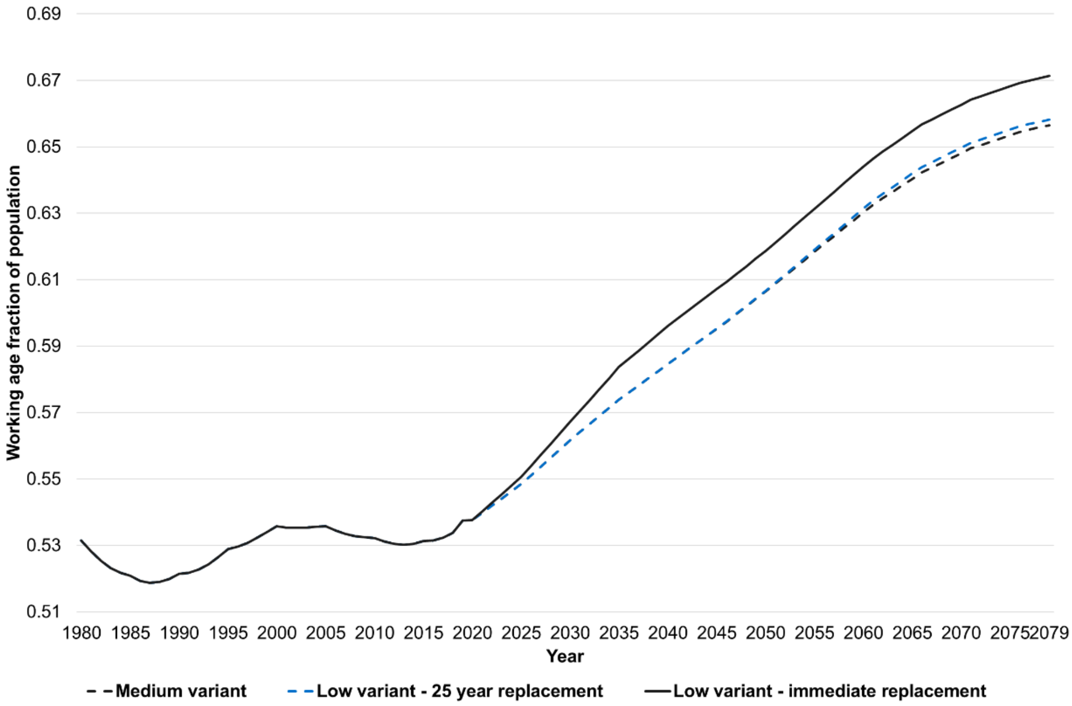

Figure 4: The time paths of the working age fraction of the population by demographic scenario

Figure 4 shows the working-age (15-64) fraction of the population in our baseline (medium variant) and alternative scenarios (low variant). Previously, Bloom and Williamson (1998)[22] have emphasized the demographic dividend from lower dependency that results from reduced fertility. In all scenarios we examine, there is a significant rise in the working-age fraction of the population over the next several decades, but the increase is slightly larger in the low-fertility scenario (both delayed and immediate replacement). For example, following our projections, in 2050, the working-age fraction is 60.6 percent in the medium-fertility (baseline) scenario, 61.9 percent in the (immediate replacement) low-fertility scenario, and 60.7 percent in the (delayed replacement) low-fertility scenario (relative to 53.7 percent in 2020, first year of the intervention). The gap between the two variants is highest when the surviving children are in their 40s in the 2060s.

2.2 Economic modelling and its parametrization

Production function

We use an augmented Solow growth model that includes physical capital, human capital, health through human capital, labor and technology as the determining factors of output.[23–25] The augmented model is an extended form of the original Solow growth model which gave output (Y) as a Cobb-Douglas function of physical capital (K), labor (L), and technology (A). The original Solow growth model looks as follows:

$$Y(t) = K(t)^{\alpha} (A(t)L(t))^{1-\alpha}$$

The augmented model includes the human capital component and looks as follows:

$$Y(t) = A(t)K(t)^{\alpha} (H(t)L(t))^{1-\alpha}$$

Using information from the Penn World Table, version 9.1[1], we assume a standard elasticity for $\alpha = 0.51$ and $1 - \alpha = 0.49$.

Information on initial physical capital stock (K) (from 1980 through 2017) was retrieved from the Penn World Table, version 9.1. We handle capital accumulation by assuming that a fixed share of national income is saved in each period. Accordingly, the stock of capital in period *t, K(t)*, evolves over time according to:

$$K(t+1) = sY(t) + (1 - \delta)K(t)$$

where *s* is fixed saving, and δ is depreciation rate. We assume that the annual savings rate in the future is 8.55 percent, which corresponds to the investment share of real GDP for Nigeria. We assign a standard value to the depreciation rate of five percent.

We model an individual's human capital as a function of his or her labor force participation rate and level of human capital. Human capital, in turn, is a function of his or her schooling, experience, and health. We apply similar methodology as in the Human Capital Index (HCI), developed by the World Bank.[2] The HCI incorporates data on school attendance rates, test scores, and health (combining adult health, as measured by adult survival rates, with child stunting and under-5 mortality rates). The weightings of the different components of the HCI are based on evidence of effects of schooling and health on wages. Although not part of the HCI, we augment the HCI with effects of gained work experience over time. The following sections describe the different components.

Pneumonia-related and overall under-5 mortality rates

We model total under-5 mortality using data from UN Inter-agency Group for Child Mortality Estimation[26] using the available years (1980 to 2018). In the baseline scenario, we assume that the current trend in death per 1,000 birth (-1.7% per annum) continues and the proportion of pneumonia-related deaths is constant at 18.2 percent. In the intervention scenario the number of pneumonia-related deaths decreases according to the increase in coverage from 35.5 to 85.5 percent within the first 15 years of intervention. As a result, the current trend in deaths per 1,000 births is pushed further down and survival rates increase. The higher survival rates then positively influence human capital

[1] Feenstra, Robert C., Robert Inklaar and Marcel P. Timmer (2015), "The Next Generation of the Penn World Table" American Economic Review, 105(10), 3150-3182

[2] Kraay A. Methodology for a World Bank Human Capital Index. The World Bank Group: Washington DC 2019

accumulation due to return to schooling or work experience and higher working age to population ratio. The modelled under 5 mortality rates for the baseline and intervention scenario are displayed in figure 5.

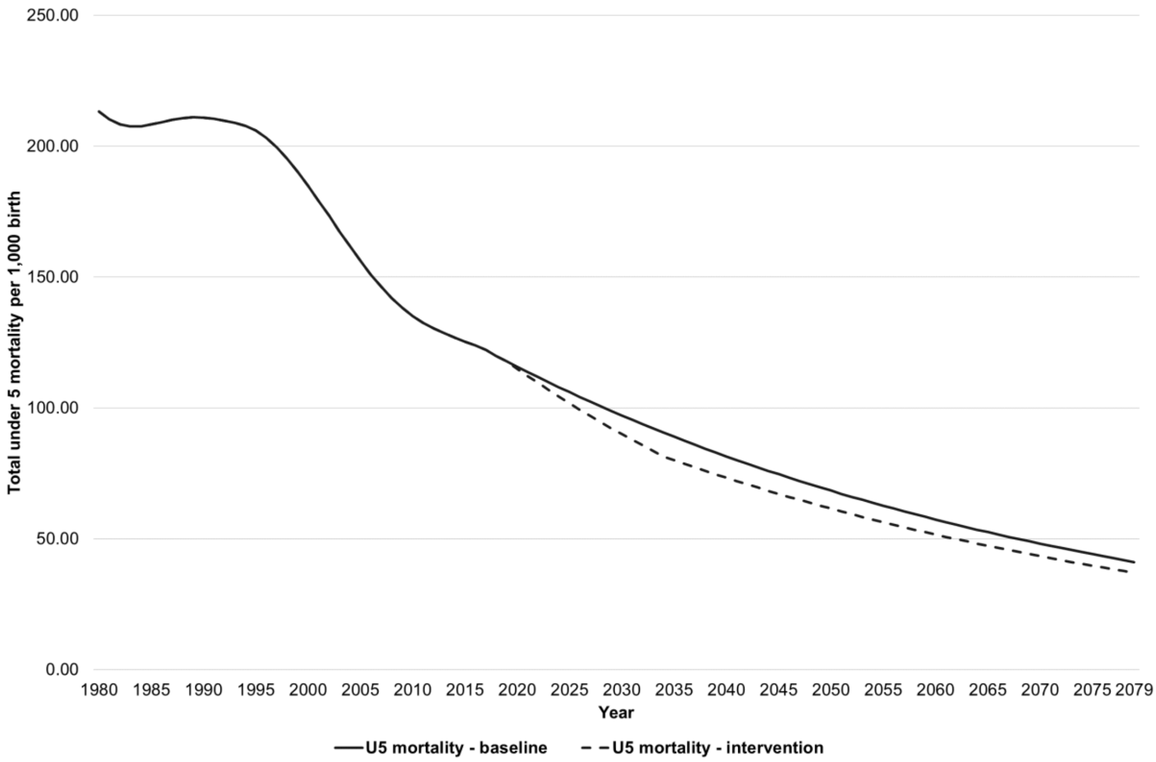

Figure 5: The time paths of the total U5-mortality per 1,000 birth by model scenario

Returns to schooling

Years of schooling are aggregated into human capital from schooling using a log-linear specification,

$$h^{s}_{(i,t)} = exp[\Theta S]$$

where ϴ is the return to an additional year of schooling (S). The return to schooling will be relevant for the exercises we conduct because reductions in fertility will raise the average level of schooling.

In their seminal work, Psacharopoulos (1985; 1994) and Psacharopoulos and Patrinos (2004)[27–29], found that the returns to schooling in Sub-Saharan Africa range from 4.1 to 20.1 percent, with an average return of 11.7 percent. These results, however, have been criticized for being driven by data of poor quality. Banerjee and Duflo (2005)[30] improve on the quality of these estimates and find a range of 3.3 to 19.1 percent, with an average return of 9.75 percent. In general, these estimates have been criticized as they measure the average return to education in a country and do not account for the level of education of the worker. In other words, if the change in fertility occurs mostly among low educated workers, and the returns to education differ with the level of education, using an average return to schooling for all workers could be misleading. Psacharopoulos and Patrinos (2004) calculated the returns to education by the level of education and found that the returns fall as the level of education rises. However, Schultz (2004)[31] indicates the opposite. He finds that in Nigeria, the return to primary education is approximately 2.5 percent per year, while the return to university education is in the 10-12 percent range. Moreover, the returns to primary education vary between 2 and 17 percent over a sample of six African countries, with an average of approximately 8 percent. Another concern with these estimates is that they are obtained by running simple OLS regressions and are prone to endogeneity and omitted variable bias. Exploiting a quasi-natural experiment in Indonesia, Duflo (2001)[32] estimated the returns to education between 6.8 and 10.6 percent. Oyelere (2010)[33] used a similar research design and found a return of only 2.8 percent, consistently with Schultz (2004). And finally, Aromoralan (2007)[34] finds a return of 2.5 percent for primary education and 4 percent for secondary education in Nigeria.

For our model, we chose the conservative and recent value of $\Theta = 2.5$ percent for primary education and $\Theta = 4$ percent for secondary education (from Aromoralan 2007)[34], which we consider the standard value applied in much of the growth literature (albeit in developing nations) and represents a rough average of the estimates discussed above.

Returns to experience

Human capital from on-the-job experience for a worker of age i in period t, is computed as

$$h^{e}_{(i,t)} = exp[\Phi(i - 15) + \psi(i - 15)^{2}].$$

Experience plays a role in our simulations because declines in mortality and fertility lead to a population with higher median age and a slightly higher average experience. The formula reflects a diminishing marginal product of work experience. That means, the first years of experience yield high returns which increase at a decreasing rate thereafter.

As with the literature on the returns to education, labor economists have been estimating the returns to experience in the United States for quite some time. Internationally, there are many studies with conflicting results. Estimates of the Mincerian returns to experience[3] in African nations are highly unreliable due to poor data quality. Psacharopoulos (1994)[28] (implicitly) estimated the returns to experience across a set of 45 different countries, in addition to estimating the returns to education. Unfortunately, Psacharopoulos (1994)[28] does not directly report these estimates. Bils and Klenow (2000)[35] complimented the work by Psacharopoulos (1994) by adding seven additional countries to their analysis. For our model, we use values of 0.052 for Φ and -0.0009875 for ψ, corresponding to the average of the estimates for each of these coefficients across the sub-Saharan African countries in Bils and Klenow (2000)[35].

Effect of fertility on education

We expect that lower fertility will raise the average level of schooling. Models of the fertility transition stress the movement of households along a quality-quantity frontier in which investment per child in health and education rises as the number of children falls. Previously, Rosenzweig and Wolpin (1980)[36] and Rosenzweig and Schultz (1987)[37] found that an exogenous increase in fertility due to the birth of twins decreases the level of schooling for all children in a household. This work was criticized due to the imprecision of estimates arising from a small sample size and methodological problems such as not controlling for birth order. Lee (2008)[38], finds that higher fertility decreases educational investment per child in Korea, but the effect is somewhat small. Using Norwegian data, Black, Devereux, and Salvanes (2005)[39] find a negative effect of family size (using twins as a natural experiment) on educational attainment, but the effect disappears once birth order is controlled for.

In our modeling, we use results from Joshi and Schultz (2007)[40], who analyzed a randomized intervention in Matlab, Bangladesh. They found that a total fertility rate (TFR) reduction of 15 percent, resulting from the intervention, led to an increase of 0.52 years of schooling for males aged 9-14. We incorporate this estimate in our model by using changes in TFR in UN fertility tables. In the UN medium-fertility variant, the TFR falls from 5.42 in 2015-2020 to 5.08 in 2020-2025, a reduction of 0.34. Since this corresponds to a reduction of 6.27 percent in the TFR for Nigeria in 2020, the relevant increase in schooling over this period is 0.52 x (6.27/15) = 0.22 years of schooling. In the UN low-fertility variant, however, the TFR falls to 4.83 or a reduction by 11 percent in the TFR. Using a similar calculation, the increase in years of schooling under the low-fertility variant is 0.38 (using immediate replacement as an example). As fertility continues to fall over time in the two scenarios, years of schooling increases, with the increase being

[3] Mincerien earning functions explain wages as a function of income and work experience.

larger for the UN low-fertility scenario because it features a larger decline in fertility (Figure 6). We adjust this calculation to reflect the 25-year fertility replacement. However, differences are marginal.

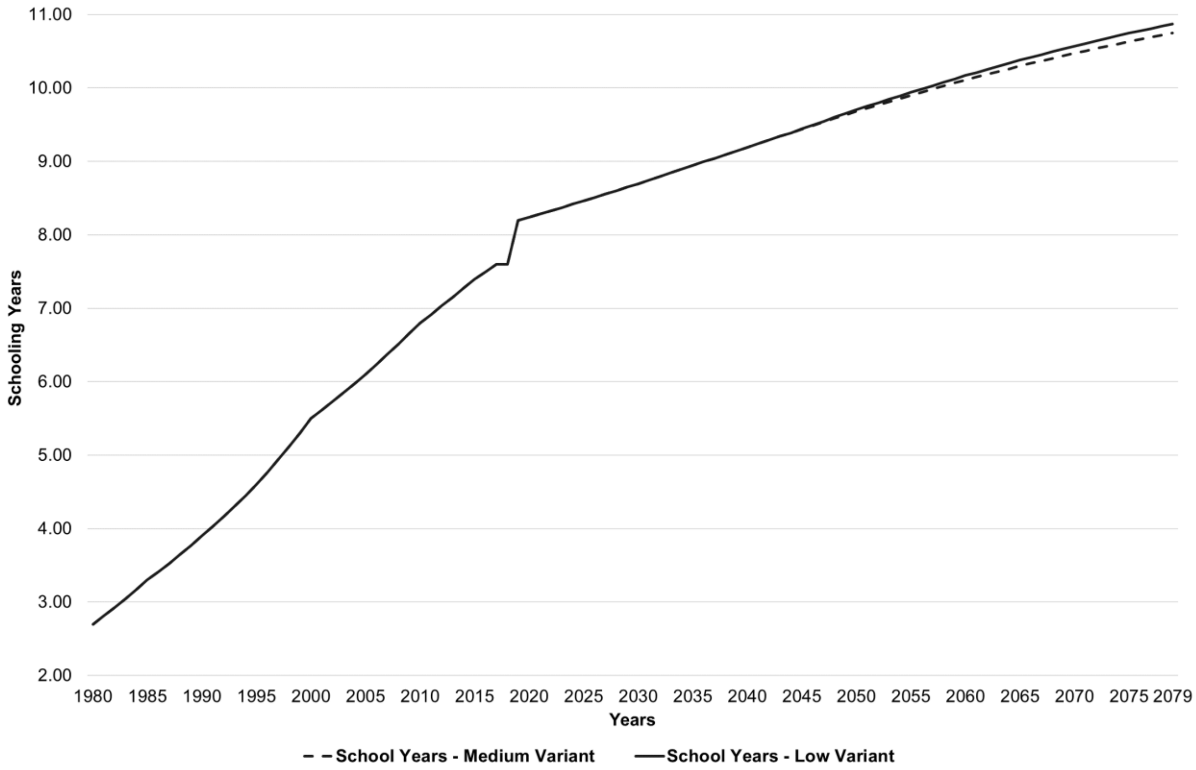

Figure 6: The time paths of schooling years by demographic scenario

Childcare effect of labor supply

Raising children requires a good deal of labor. That labor is spread over many years and is divided among many individuals, but the largest piece usually comes from the child's mother. Reduced fertility should thus potentially increase the labor supply of women. A large literature has examined the effect of fertility on female labor supply in developed countries. Generally, these studies find a moderate to large negative effect. However, surprisingly little research has been done to assess the effect of fertility on female labor supply outside of Europe and the United States. Among studies focusing on non-Western countries, Chun and Oh (2002)[41] find that having an additional child reduces labor force participation by 40 percent. Bloom et al. (2007)[42] finds that an additional birth reduces lifetime labor supply by about two years. However, neither of these papers estimate the effect of fertility on female labor force participation strictly in a developing country, where one would expect the effect of fertility on female labor force participation to be lower since child-rearing is often combined with productive activities. Beyond the general lack of research in this area, assigning a quantitative magnitude to the effect of fertility on female labor supply is difficult. Mechanically, we implement the childcare effect by increasing female labor force participation (5.3 percent of 48 percent) in each year by the hypothesized change in age-specific fertility multiplied by the labor market time cost (in years) of a marginal child.

3 RESULTS

Lives saved

Our model projects total U5 mortality and death cases in Nigeria from 2020 (first year of intervention) over the next 60 years (figure 7). In this and all following figures, we assume a 100 percent market share (total coverage not company specific coverage), a 50 percent affected fraction (bacterial versus viral infection) and an increase in coverage from about 36 percent to 86 percent in the next 15 years.

Without further intervention, we expect the total U5 death cases to decrease from about 890,000 cases per year to 846,000 (2035), 793,000 (2045) and 514,000 (2079) cases. Assuming a coverage rate increase from 35.5 to 85.5% till 2035 pushes the figures down to 762,000 (2035), 714,000 (2045) and 463,000 (2079) cases. With about 86,000 death cases avoided the difference between both scenarios is highest after 15 years, when the coverage rate reaches 85.5 percent. Within the 15 years of intervention cumulatively about 770,000 death cases could potentially be avoided. This figure even increases to 1.6 million in 2045 and 3.8 million in 2079.

Under the current trends, we expect the total under 5 mortality rates to reach 89, 75 and 41 per 1,000 births by 2035, 2045 and 2079, respectively. With further interventions, these figures can be reduced to 80, 67 and 37 per 1,000 births, respectively (see figure 5).

However, these figures are up to 60 years in the future and should be interpreted with caution as future external shocks could change the trends in any direction.

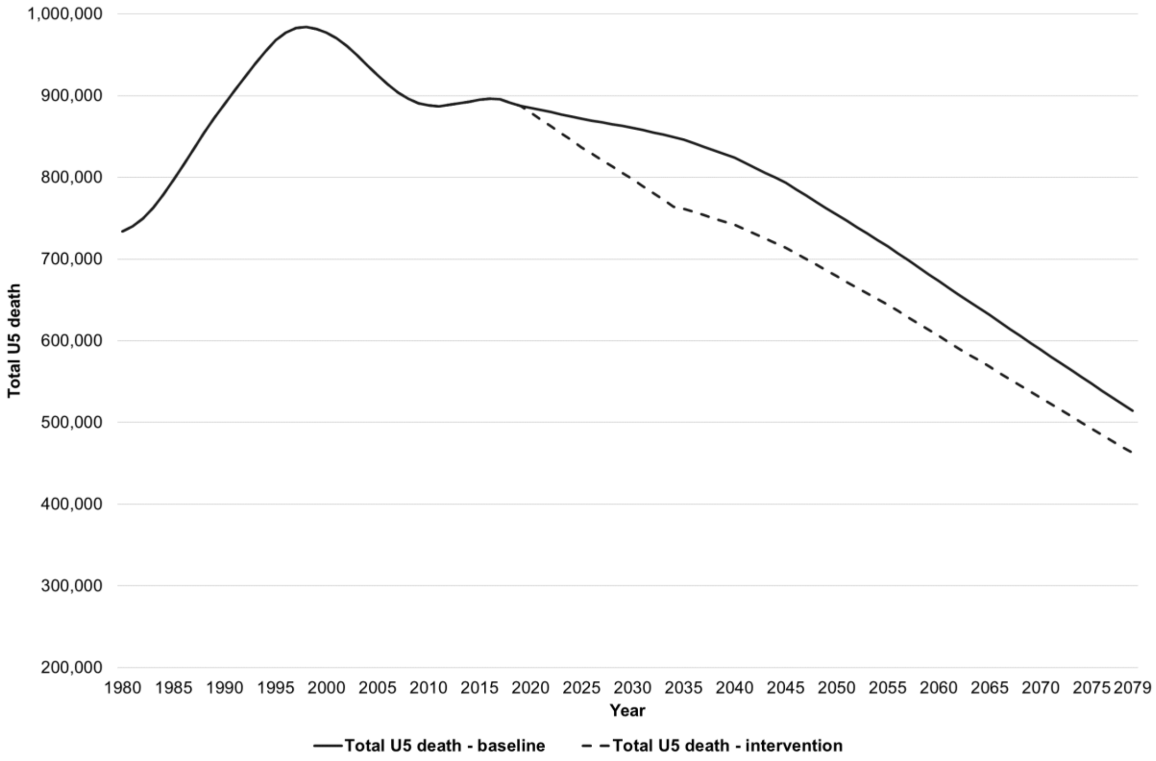

Figure 7: The time paths of total U5 death by modelling scenario

Output/Gross Domestic Product - overall

Figure 8 shows the paths of physical capital per worker, human capital per worker, GDP per worker, and GDP per capita in our model, using the parameters discussed above. The path of GDP per worker (capita) reflects the dynamics of human and physical capital per worker. As in all the figures that follow, we show the ratio of outcomes in the intervention scenario (increase in antibiotic coverage from 35 to 85.5% over 15 years) to outcomes in the baseline scenario (current trends). Further, in discussing our results below, we refer to the year 2020 as the start of our simulation with a 25-year fertility replacement (year 2045). So, references to time horizons in our simulation should be interpreted with respect to these years.

Figure 8 shows that, in our base case setup, the long-run effect of increasing coverage, reducing childhood mortality, and thus reducing fertility from the UN medium variant to the low variant is to increase GDP per capita by 6.5 percent at a horizon of almost 60 years. At a 25-year horizon (year 2045), the increase in GDP per capita is 2.3 percent and at a 15-year horizon (year 2035) the increase in GDP per capita is 1.5 percent. The GDP per capita increase amounts to $64, $105 and $391 in 2035, 2045 and 2079 respectively. Human capital per worker is expected to increase steeply during the first years of intervention, and the ratio between both scenarios flattens out at about 4 percent. After 2045, the capital stock per worker is expected to increase further as the fertility effect starts.

Because fertility in the intervention scenario is lower than in the baseline scenario for the entire period we examine, income in the two scenarios continue to (eventually) diverge. In the scenario presented here with 100 percent market-share and half of the children needing antibiotics, the narrative describes the effects of raising antibiotic coverage in general and not specific to the Novartis impact in Nigeria.

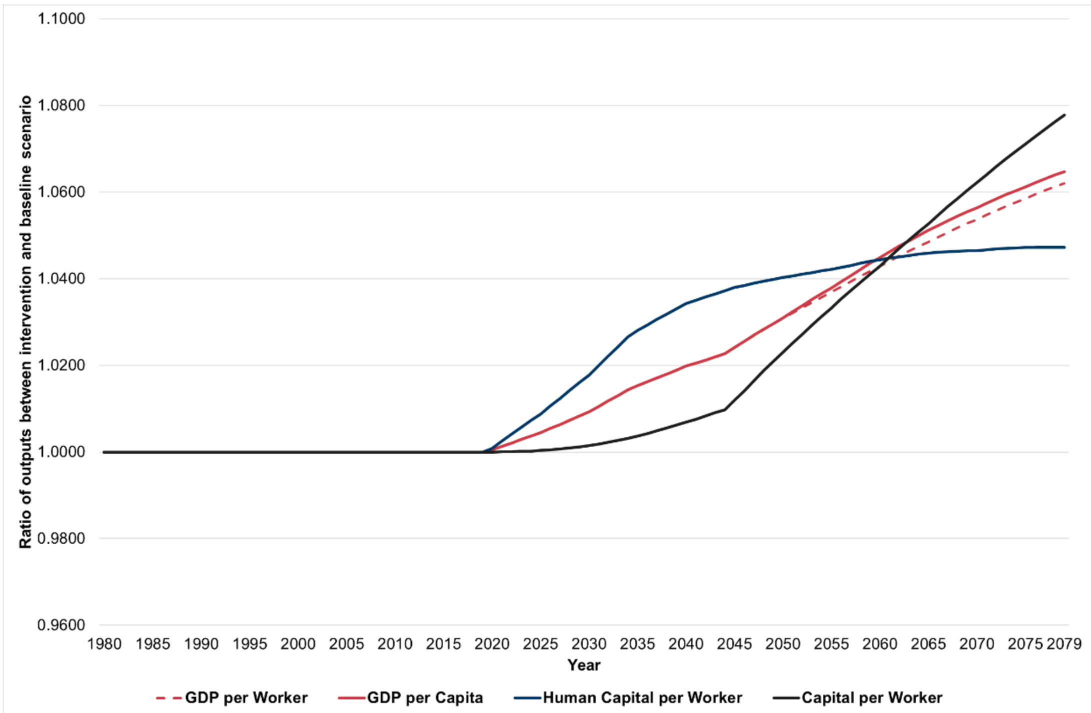

Figure 8: The base case economic projections

Returns to Novartis market-share

Figure 9 accounts for the expected impact specific to Novartis. As expected, a lower market-share (30 percent) yields fewer gains in output (GDP) compared to the total increase in coverage (previous chart). Based on internal data from Novartis, the market-share is likely between 25 to 40 percent, therefore estimates below 50 percent are plausible. We simulate the base case projections by changing the market share to 30 percent. As a result, the GDP per capita effect is 1.9 percent at a horizon of almost 60 years. At a 25-year horizon (year 2045), the increase in GDP per capita is 0.7 percent and at a 15-year horizon (year 2035), the increase in GDP per capita is 0.5 percent.

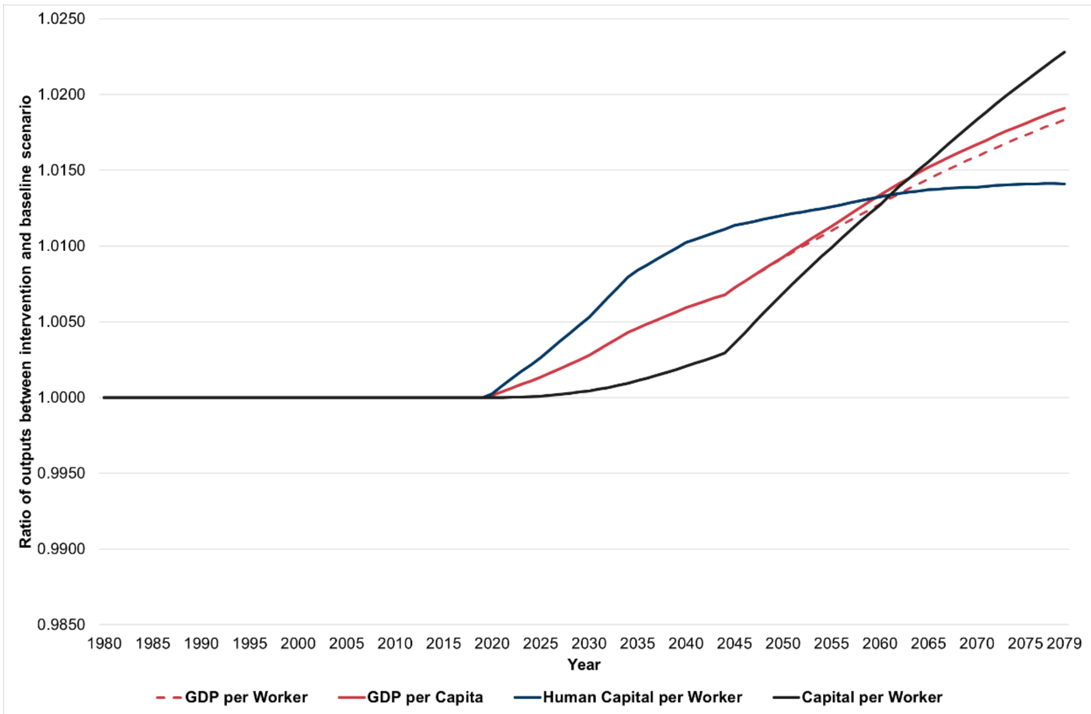

Figure 9: The base case economic projections with modified market share (30%)

4 DISCUSSION

For years, researchers have been exploring the impact of diseases on future productivity. We have shown here that by increasing antibiotic coverage in Nigeria, the impact on future GDP is significant. We apply our simulation model to data from Nigeria. The reduction in fertility that we consider is the difference between the medium- and low-fertility variants of the UN (2010) population forecasts. This is a difference in the TFR phased in over a period of 25 years, relative to a baseline of declining fertility. This reduction seems reasonable as something that could result from some exogenous intervention. That is, in our case, reduction in childhood mortality because of improvement in antibiotic coverage for pneumonia. For a base case set of parameters, we find that this reduction in fertility will raise GDP per capita by 6.5 percent at a horizon of 60 years, and by 2.3 (1.5) percent at a horizon of 25 (15) years.

Applying the plausible market share of Novartis in Nigeria (30 percent), we see a rise in GDP per capita by 1.9 percent at a horizon of 60 years, and by 0.7 (0,5) percent at a horizon of 25 (15) years. That is, the nominal GDP in 2045 is expected to be $10.7 billion higher with the further intervention scenario compared to the baseline scenario. With a 100% market share (not Novartis-specific scenario) the nominal GDP is expected to be $36 billion higher. The increase in nominal GDP stays mostly constant till 2065 at this level and then decreases as population size in the intervention scenario shrinks relative to the baseline scenario. However, the per capita GDP and thus economic wealth further increase.

The effects that we find suggest that a reduction in the TFR by one lead to roughly 1.3 percent increase in GDP per capita. The labor effect (experience) and to a lesser extent, the schooling, are the dominant channels by which reduced fertility affects GDP per capita in the time-period. We discuss these channels below.

As discussed above, demographic change affects economic outcomes through several channels, which may operate at different relative intensities at different time horizons. It is of interest to decompose the overall effect of fertility reduction into the parts that run through these different channels. Some caution is necessary, however, because there are clearly interactions among the different effects. In particular, the effect of fertility through any one channel will depend on which other channels are operative. For example, the effect of increased labor force participation of working-age adults will be larger or smaller, depending on the fraction of the population made up of such adults. To address this problem, we do all our analysis of the effects of fertility through each of the different channels under the assumption that all the other channels are operative. That is, we consider the results in our full model relative to the case where one channel is controlled (an alternative would be to assume that no other channels are operative).

We start by looking at several channels individually. This allows us to perform an analysis of the sensitivity of our results to assumptions about key parameters. The following assumes a 100 percent market share and thus shows the non-company specific effects.

Impact of changes to antibiotic coverage

As our main objective, we start by examining the **effect of antibiotic coverage changes *only***. That is, we (conservatively) assume no change in fertility and as a result, the education and experience effects remain fixed. As expected, we see a modest rise in GDP per capita by 0.45 percent at a horizon of almost 60 years. At a 15-year (25-year) horizon (a point at which the coverage increase is maximum), the increase in GDP per capita is 0.56 (0.56) percent (figure 10). We also notice that the intervention effects eventually start to decay and the income in the two scenarios will (eventually) diverge. The decay is faster for the human capital effect as schooling and experience are kept fixed and the effect of increased coverage stays at about 86 percent after rising during the first 15 years.

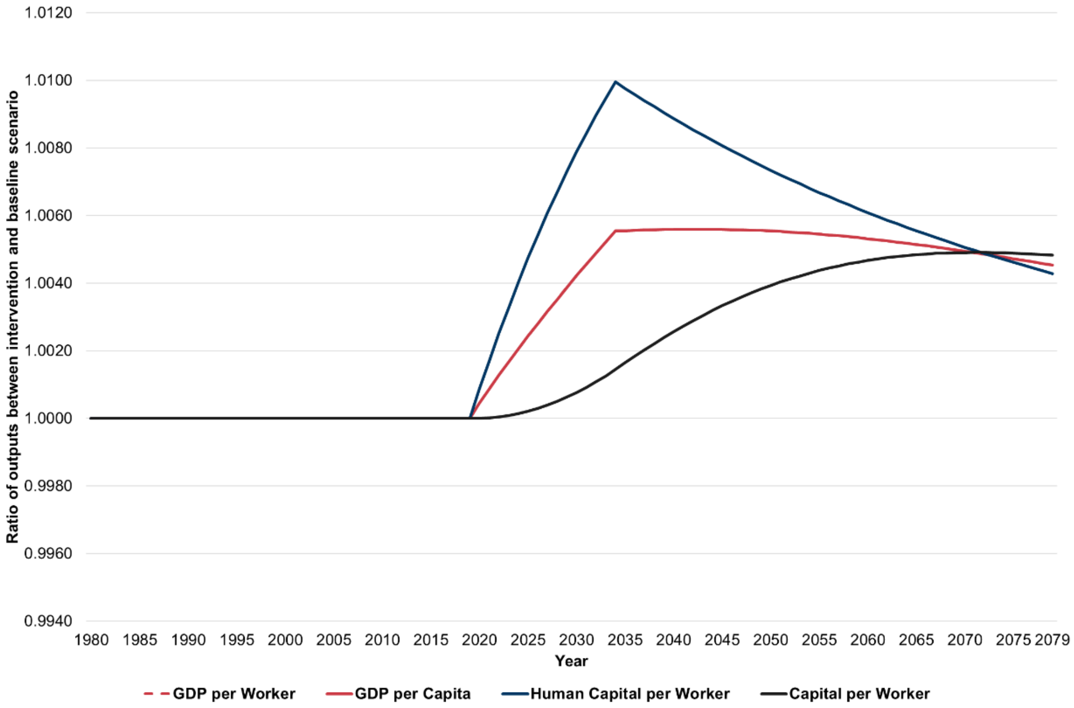

Figure 10: Effect of antibiotic coverage only on economic projections

The returns to schooling

Figure 11 shows the returns to increased schooling as more children survive and the resultant increased human capital investments. The figure shows that schooling plays an appreciable role in determining the economic effects from interventions that are likely to reduced child mortality. At a horizon of 60 years, for example, GDP per capita is 3.1 percent above the baseline. At a 25-year (15-year) time horizon the effect is about 0.8 (0.55) percent. As would be expected, the effect of higher schooling due to lower fertility phases in as the cohorts that received the additional schooling enter the labor force and replace those that did not. Thus, initially, this channel contributes little to higher income. Additionally, the human capital remains higher than the baseline instead of converging back towards the baseline as seen previously.

Figure 11: Returns through increased schooling

The returns to experience

Figure 11 accounts for the human capital acquired through experience, and it somewhat increases the amplitude of the changes following the intervention. The output gain (GDP per capita) is 6 percent higher than the baseline at a 60-year horizon and output per worker is at par. Over a 25-year (15-year) time horizon the increase in output is 2.3 (1.7) percent. We also notice a deviation from human capital gains and output gains. In other words, this shows that the returns to work experience gains have a societal benefit that goes beyond what is captured in GDP.

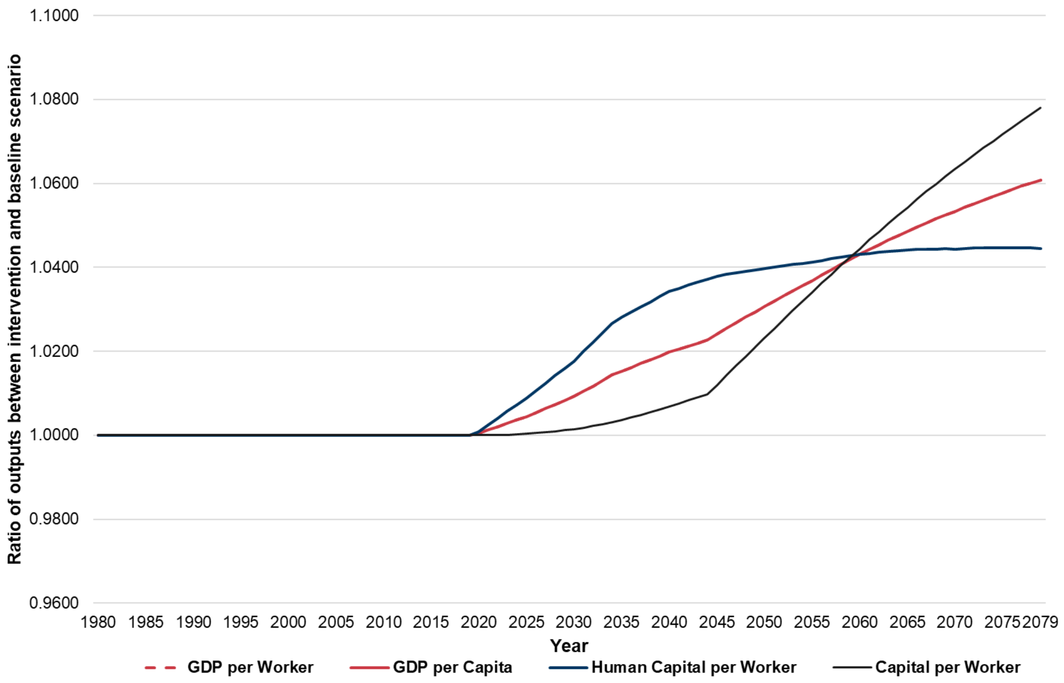

Figure 11: Returns through increased experience

5 Conclusion

Progress has been made in accessibility of childhood pneumonia treatment and mortality rates in the developing world have consequently dropped over the last decades. However, the burden and the mortality are still at a high level. We have shown here that by increasing antibiotic coverage in Nigeria, over the next 15 years the impact on future mortality rates and GDP per capita is non-trivial. However, even an increase of the coverage rate to 86 percent will not be enough and the SDG and GAPPD goals will not be reached in the next 60 years, neither under the current trend nor with further intervention. Pneumonia-related mortality in 2045 is expected to range between 12 and 14 per 1,000 births depending on coverage increase. By2060, it could reach 7 percent. However, these long-term estimations are subject to high uncertainty.

Our results further suggest, that reducing childhood mortality will have sustainable effects on future productivity and GDP of a nation. In the case of Nigeria, we expect that further decrease in under-5 mortality has the potential to increase GDP per capita by a medium single digit percent within the next decades.

This clearly shows that further medical and non-medical interventions are necessary to eliminate avoidable child deaths in the near future. This will not only prevent health and emotional burden for the affected families but additionally contribute to economic and social development.

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