The impact of COVID-19 on adult skills:
Estimation and projection of skills-adjusted human capital, 1970-2050

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1. Introduction

Over the last decades, many countries have made impressive progress in enrolling children in schools, hence improving the educational attainment of their populations. However, mere school enrolment or the attainment of a certain level of education does not necessarily guarantee the acquisition of skills. Particularly, in countries of the Global South, the gap between schooling and learning is acute (Angrist et al., 2021). Moreover, whereas educational attainment usually remains constant over an adult's life, the level of skills tends to change significantly as people grow older (Reiter, 2021), thus impacting the actual human capital of a population at a given time. To accommodate this, Lutz et al. (2021) have recently suggested a new human capital indicator, considering not only the educational attainment (measured in mean years of schooling), but also the qualitative dimension of human capital (measured in adult literacy test scores), the so-called Skills-in-Literacy Adjusted Mean Year of Schooling (SLAMYS).

This new measure was provided for the population aged 20 to 64 in 185 countries for the period 1970 to 2015. Results reveal considerable differences compared to conventional measures of human capital: While mean years of schooling increased massively over the past decades due to rapid educational expansion in virtually all countries of the world, literacy skills could not keep pace with this expansion. As a consequence, trends in SLAMYS exhibit a widening global skills gap between low and high performing countries. This means, in some countries, the expansion in quantity may have come at the expense of quality (Lutz et al., 2021) with significant impact on inequalities in socio-economic development between populations.

While this is already enough cause for concern, the on-going COVID-19 pandemic puts an additional burden on societies, often exacerbating existing social and economic disparities. With the world currently experiencing the most extensive school closures in human history, researchers become increasingly concerned with the impact COVID-19 has on students'

learning progress and their acquisition of skills. In this paper, we estimate future human capital by projecting SLAMYS until 2050, paying particular attention to the consequences of the pandemic. Based on recent estimates by Azevedo et al. (2020), who simulated the influence of COVID-19-related school closures on schooling and learning, as well as trend data from both international student assessments and adult skills tests, we develop a set of scenarios for the future human capital in 45 countries all over the world.

Our research contribution is twofold. On the one hand, we provide for the first time estimates of future human capital capturing not only the quantitative dimension (i.e. the educational attainment) but also the qualitative dimension (i.e. the actual skills people have) of human capital, with clear relevance for progress towards development goals. On the other hand, we try to quantify the mark that the COVID-19 pandemic is likely to leave on skills around the world. Focusing not only on immediate learning loss due to school closures but also on potential long-term effects of COVID-19 on the human capital of populations a few decades from now, this paper stresses the urgency to introduce mitigation and recovery strategies in response to the tremendous disruption to the global education system.

The remainder of this paper is structured as follows. Section 2 summarizes existing findings on the impact of COVID-19 on human capital, particularly focusing on established evidence for learning loss during school closures. In Section 3, we present the data sources used for the projections, followed by a detailed explanation of the methodology in Section 4. Finally, we present and discuss the results in Section 5, before we draw conclusions and discuss potential limitations in Section 6.

2. COVID-19 and human capital: existing evidence

The COVID-19 pandemic, which has been gripping the world for almost two years now, has not only killed millions of people and put pressure on health systems all around the world, but also has caused significant disruption to the global education system. Particularly, school closures have been a common tool in an effort to curb the spread of the virus. At its peak, 94% of the world's student population were affected by educational institution closures (United Nations, 2020) – with far-reaching consequences that are only slowly attracting attention. In order to balance the costs of school closures and public health benefits, it is crucial to understand the profound impact COVID-19 has on students' progress and overall human capital.

Studies on learning loss during school closures are only slowly emerging. Patrinos and Donnelly (2021) have recently systematically reviewed existing data and reports on the impact of COVID-19 on learning progress, concluding that seven out of the eight identified studies found evidence of learning loss among at least some of the students. These learning losses have been observed across a range of subjects, geographical regions, and grade levels, with strong indications that students in early grades tend to be more vulnerable than more advanced students. Moreover, several studies found instances of inequalities, with certain demographics of students (e.g. coming from less-educated households) experiencing losses more significant than others.

In one case study by Engzell et al. (2021), the authors analyzed the impact of school closures on primary school performance, using exceptionally rich data from the Netherlands[1] – a country which was in many regards a best-case scenario due to comparably short school closures, equitable school funding, and world-leading rates of broadband access. Still, results revealed a learning loss of about 3 percentile points, equivalent to one-fifth of a school year, with losses being up to 60% larger among students from less-educated households. These results anticipate the massive impact COVID-19 is likely to have on human capital formation in less prepared countries. In Sub-Saharan Africa, for example, classrooms have been fully or partly closed for longer than the global average, with remote learning being hardly possible considering that half of all Africans live without electricity. Many children, particularly girls, are likely to never go back to school - with profound consequences, not only economically, but also demographically, given the strong link between female education and family size (The Economist, 2021).

In an attempt to quantify the potential impacts of COVID-19 school closures on schooling and learning, Azevedo et al. (2021) recently developed a set of global estimates. The results of this simulation study (which also inform the projections presented in this paper) suggest that COVID-19 could result in an average loss of 0.3 to 0.9 learning-adjusted years of schooling, or, in economic terms, in an average reduction between USD 355 and USD 1,408 in yearly earnings for everyone of today's cohort of students, depending on the scenario considered. With poorer countries facing worse starting conditions, the most pessimistic scenario is more likely in low- and middle-income countries, further exacerbating global disparities. Similarly,

[1] The study used data from a natural experiment: national student examinations in the Netherlands took place just before and after the period of lockdown (n ≈ 350,000).

the European Commission estimated the likely impact of COVID-19 on education for a set of European countries. The "conservative estimates" consistently indicate a decline in students' knowledge and skills, with weekly learning losses estimated to be between 0.82 and 2.3% of a standard deviation. The study also highlights potential long-term effects, stating that "[s]uch loss will translate into a reduction of available human capital, with negative effects on productivity growth, innovation and employment, including future lower earnings for the student cohorts directly affected by the lockdown" (Di Pietro et al., 2020, p. 5).

While most of these studies focus on test scores, the impact on children's psychosocial development and emotional well-being is likely to be equally important. Particularly, for students from less advantaged backgrounds, COVID-19 and the resulting lockdowns may have reinforced feelings of isolation, loneliness, and emotional stress – all likely to further adversely impact human capital formation. There is not yet enough data available to fully understand the long-term consequences of the COVID-19 impact on children's cognitive and socio-emotional skills. Dynamic models of learning, however, have shown that small losses can accumulate into large disadvantages with time (DiPrete & Eirich, 2006; Fuchs-Schündeln et al., 2020; Kaffenberger, 2021).

Finally, it is not only children's human capital that is impacted by the pandemic. In an attempt to contain the spread of the virus, governments around the globe introduced radical social distancing measures, including complete shutdowns of economic activities. As a consequence, adult non-formal learning (e.g. workshops, employer-provided trainings, etc.) decreased by an average of 18% and by even 25% in informal learning (e.g. learning from others, learning by doing, learning new things at work, etc.), as estimated in a recent OECD report (OECD, 2021). Moreover, the economic crisis caused by COVID-19 is likely to raise global unemployment rates – particularly once immediate government support such as publicly financed short-time work is eased. The latest International Labour Organization forecast predicts that global unemployment will reach 205 million people in 2022, with women and youth workers being among the worst-hit (International Labour Organization, 2021). More research is needed, however, to understand how home office regulations, short-time work, or job loss may affect adult skills in the longer run. Given the lack of reliable and quantifiable estimates of the impact of COVID-19 on adults' skills development, our current projection refrains from any assumptions in this regard.

3. Data

To project SLAMYS to the future, we use several data sources. First of all, we build our projections on existing SLAMYS data, calculated for five-year-periods between 1970 and 2015 (Lutz et al., 2021). SLAMYS has two main dimensions. The first one is quantity of schooling which is measured by mean years of schooling (MYS). The Wittgenstein Centre (WIC) Human Capital Data Explorer (2018) provides MYS projections for 201 countries until 2100. These projections are built on the so-called Shared Socioeconomic Pathways (SSPs), a set of scenarios representing alternative socioeconomic development routes[2]. These include three main scenarios. The SSP1 scenario, which is also named rapid development scenario, assumes both low fertility and low mortality, resulting in a rapid increase in life expectancy. Moreover, educational expansion is assumed to reach the levels set by the Sustainable Development Goals (SDGs) in this scenario. The SSP2 scenario, which is the medium scenario, assumes moderate fertility and mortality rates. Educational expansion is also assumed to be at moderate levels. Finally, the SSP3 scenario is the stalled development scenario, assuming both high fertility and mortality as well as a stalled educational expansion in developing countries (Lutz et al., 2018). We used MYS data by five-year-age groups and five-year-periods for all three scenarios from the WIC Data Explorer.

The second dimension of SLAMYS is the quality of education, i.e. the skills of a population, which is calculated by a Skills Adjustment Factor (SAF). As a quality benchmark we used the literacy skills data of 15-year-olds from OECD's Programme for International Student Assessment (PISA) from 2000 to 2018 (OECD, 2021).

Finally, since we also aim to integrate the potential learning loss due to school closures during the Covid-19 pandemic, we additionally used school closure data reported by UNESCO Institute for Statistics (UNESCO, 2021).

4. Methods

Since MYS were already projected by WIC, we only need to project the SAF in order to develop projections of SLAMYS until 2050. When reconstructing SLAMYS back to 1970, Lutz et al. (2021) showed that adult skills considerably change over one's lifetime. They calculated an age pattern by two broad education groups (lower secondary or less, and upper secondary or higher). We applied this age pattern to project the SAF of every age group in 45

[2] For further details on SSPs see O'Neill et al. (2014) and Riahi et al. (2017).

countries[3]. In this way, we were able to project the SAF to the future for all cohorts who are between the ages of 15-60 in 2015.

As a next step, we projected the SAF for every emerging 15-19-year-old age group starting from 2020. To do this, we decided that the PISA reading test, which is conducted with 15-year-old students around the world, is the most suitable indicator to estimate literacy skills of 15-19 year-olds. Using PISA data from 2000 to 2018, we calculated a 5-year-average change in PISA reading scores of 15-year-old students in 45 countries[4], which varies between ±3% depending on the country. For example, if the PISA reading score in a country has been increasing 1% on average every five years, we assumed that the literacy skills of 15-19-year-olds in 2020 would be 1% higher compared to 15-19-year-olds in 2015.

Finally, we also incorporated the potential learning loss due to school closures during the pandemic. Azevedo et al. (2021) simulated the effects of school closures on learning for countries with different economic development. They estimated the change in Learning-Adjusted Years of Schooling (LAYS). LAYS is an indicator of quality adjusted educational attainment for countries. It was suggested by Angrist, et al. (2021) and uses a similar approach as SLAMYS but focuses on student assessments instead of adult skills. In addition to learning loss expected due to the length of school closure, Azevedo et al. (2021) also take into account the potential drop-outs of students after the pandemic, and the effectiveness of online teaching regarding the availability of material sources such as broadband internet or personal computers. As summarized in Table 1, they estimated varying levels of learning loss for different sets of countries and different length of school closures. Since LAYS is conceptually quite similar to SLAMYS, we used the percentage drop in LAYS, estimated separately for different income groups and school closure duration groups, in our SLAMYS projections.

[3] These countries are the 45 countries that have participated in PIAAC or STEP. An empirical SAF could be calculated by 5-year-age groups and education levels for these countries.

[4] Among the 45 countries with an empirical SAF score, 6 have not participated in PISA or participated only once. So, it was not possible to see the trends in PISA reading scores for the following countries: Armenia, Bolivia, Ecuador, Ghana, Kenya and Ukraine. For these countries, 1% increase in literacy skills for 5 years is assumed since countries with similar socio-economic development levels have experienced such an increase.

Table 1.

The effect of school school closures on Learning-Adjusted Years of Schooling (LAYS)

Income Level	Baseline	School closure scenarios			
		Optimistic	Intermediate	Pessimistic	Very pessimistic
High	10.3	10.0	9.6	9.2	8.9
Upper middle	7.8	7.5	7.2	6.9	6.7
Lower middle	6.6	6.3	6.0	5.8	5.6
Low	4.3	4.1	3.9	3.8	3.6

Adapted from Azevedo et al., 2021:45

More specifically, we categorized the countries in our data by their income level classes defined by the World Bank (2021) and their length of school closures. Azevedo et al. (2021) defined four different school closure scenarios. They assumed a school closure of 3 months in the optimistic scenario, 5 months in the intermediate scenario, 7 months in the pessimistic scenario and 9 months in the very pessimistic scenario. Using Covid-19 school closure data from UIS (2021), we could assign each country to one of the school closure scenarios.

Table 2.

Length of school closures and corresponding scenarios

Length of school closure	Countries
More than 40 weeks *(very pessimistic scenario)*	Mexico, Bolivia, Ecuador, Turkey, Peru, Colombia
31-40 weeks *(pessimistic scenario)*	Korea, Chile, Poland, Slovenia, Czechia, Kenya, Canada, Ghana
22-30 weeks *(intermediate scenario)*	Hungary, Slovakia, United States, Greece, Austria, Kazakhstan, Germany, Italy, Israel, Georgia, Lithuania, Ireland, Ukraine
6-21 weeks *(optimistic scenario)*	Netherlands, Denmark, United Kingdom, Finland, Estonia, Cyprus, Belgium, Norway, Australia, Spain, Sweden, Viet Nam, Armenia, Singapore, France, Japan, Russia, New Zealand

Constructed using school closure data from https://en.unesco.org/covid19/educationresponse

5. Results

Using the above-mentioned steps, we extend SLAMYS by 5-year-age groups and quinquennial time periods until 2050, including the effect of learning loss due to school closures during the Covid-19 pandemic.

The school closures affected only those who have been in school during the pandemic, namely the birth cohorts of 2005-09 and 2010-14. Hence, we expect the effect of learning loss during the pandemic to be rather limited on the overall SLAMYS of a country. However, if we look closely at the amount of learning loss among those affected cohorts, the severity of human capital loss is striking. Figure 1 shows SLAMYS projections at the age of 40 by birth cohorts in six selected countries. The projections using the SSP2 scenario and ignoring the effect of Covid-19 (red dots) show that SLAMYS tend to increase in all countries, with increases being faster in developing countries. However, when the effect of Covid-19 learning loss is taken into account, one can see that the birth cohorts who are in school during the pandemic suffer a lot in countries where the length of school closure has been longer. In some countries, like Armenia or Australia, where schools have been shut down only for a limited time, differences are not immense; in countries like Ecuador, Turkey or Peru, however, the cohorts affected from Covid-19 are projected to drop to the SLAMYS levels of a few cohorts older than themselves.

Figure 1.
SLAMYS projections at the age of 40, by birth cohorts in selected countries

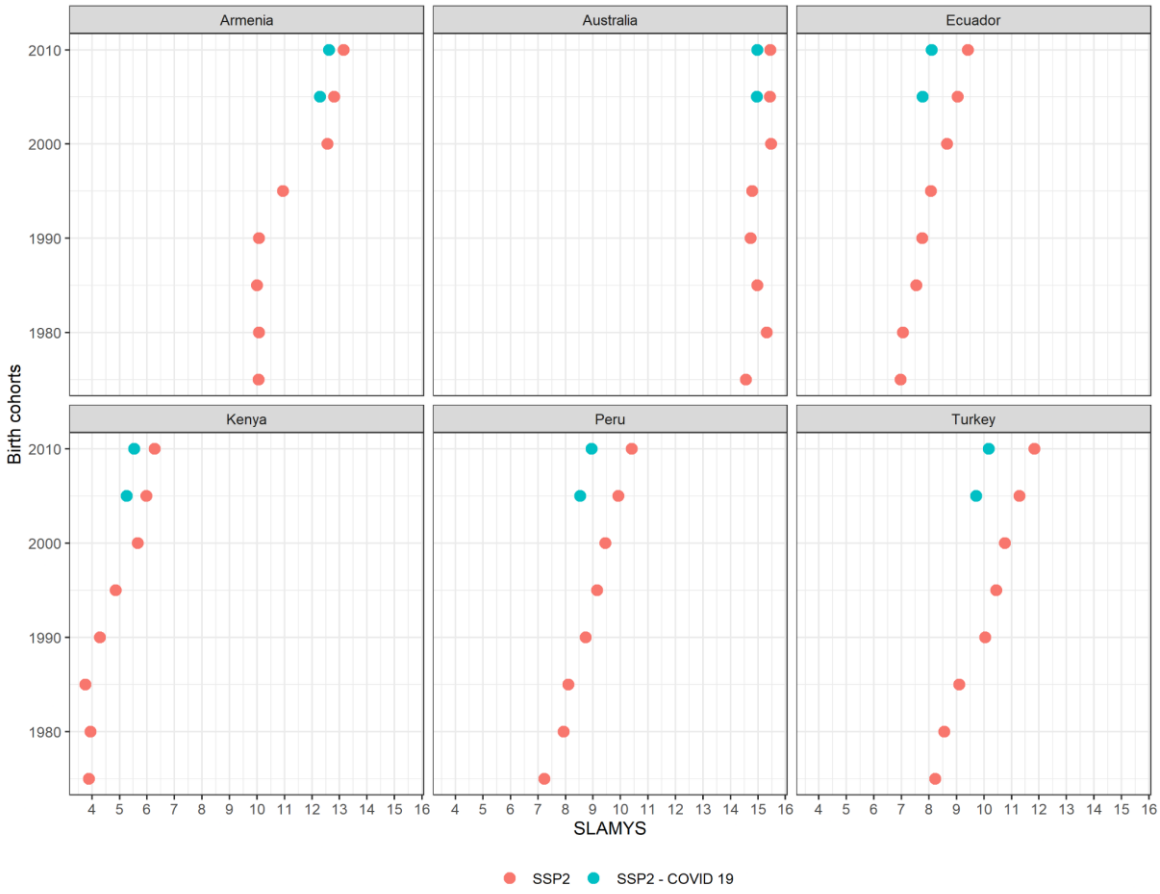


Figure 2 shows more scenarios for all countries in our dataset. This time, SLAMYS projections for 45-year-olds in 2050 are visualized. In the SSP3 (stalled development) scenario, countries are expected to experience bigger losses in SLAMYS, with higher gaps between developing and developed countries. On the other hand, SLAMYS of developing countries are projected to converge to the ones of developed economies under the SSP1 (rapid development) scenario.

Figure 2.
SLAMYS projections for 45-year-olds in 45 countries in 2050

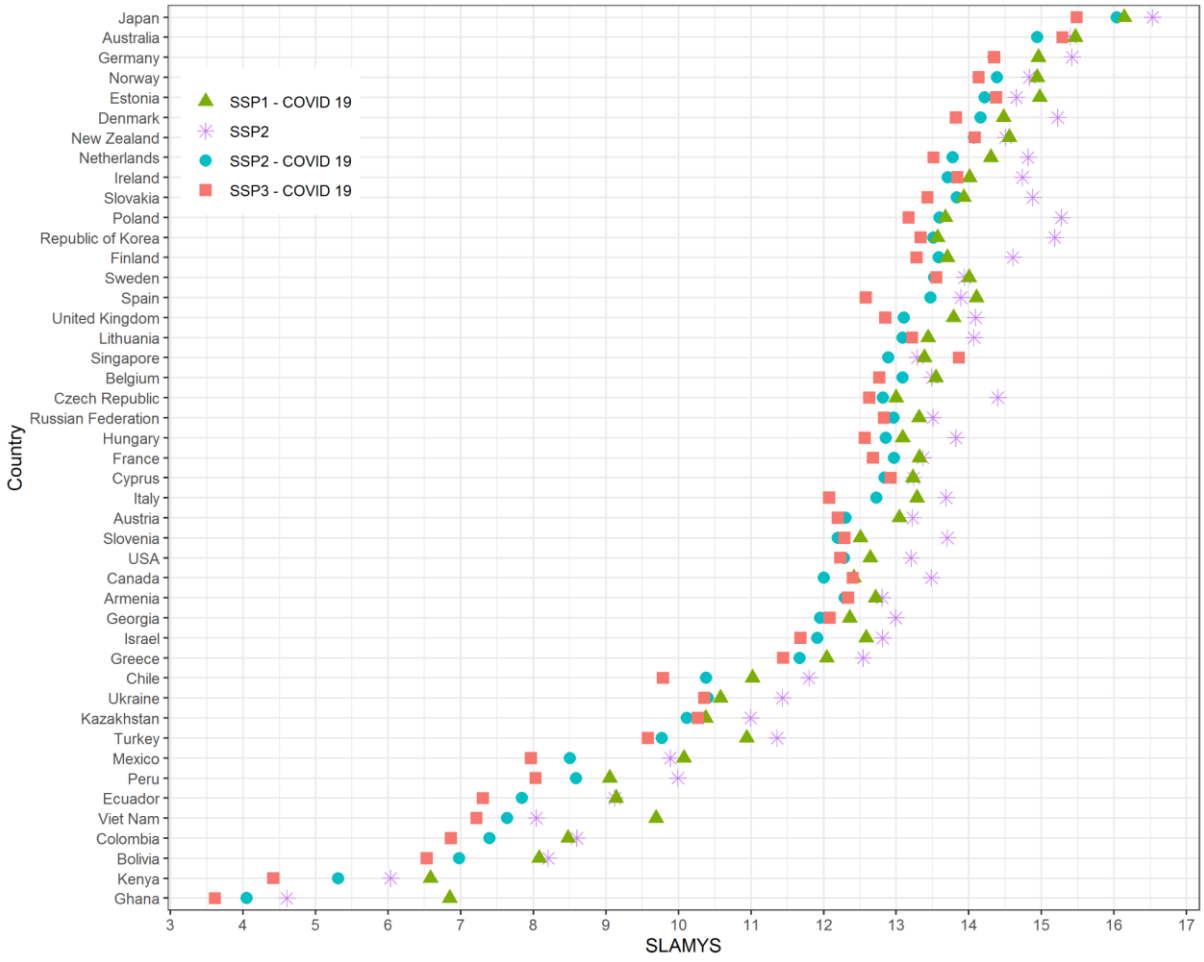
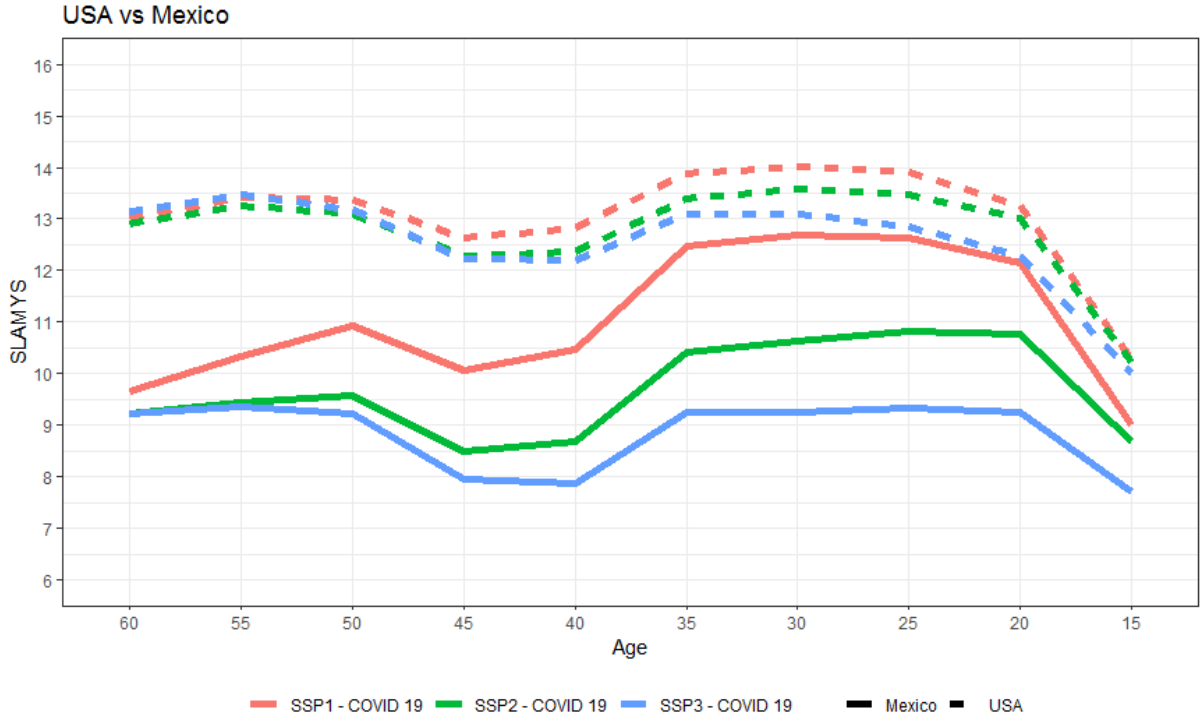


Figure 3 shows a vivid example of the closing or widening skills gaps between developed and developing countries. The graph visualizes SLAMYS projections for the USA and Mexico by age groups in 2050. Our projections show smaller differences across different scenarios for the USA. Moreover, the effect of Covid-19 school closures are also smaller in the USA on the age groups that were in school during the pandemic. On the other hand, in addition to a much bigger SLAMYS drop, population scenarios for Mexico indicate a bigger margin for SLAMYS projections. The rapid development scenario suggests that future cohorts in Mexico may have similar SLAMYS like their peers in the USA. On the contrary, the skills gap may widen between the two countries under the stalled development scenario.

Figure 3.
SLAMYS projections by age groups in 2050 for USA and Mexico



6. Conclusion

In this study we extend the SLAMYS dataset from 2015 to 2050, by projecting SLAMYS for 5-year age groups, quinquennial time periods and for 45 countries. Our projections of SLAMYS are calculated according to three distinct SSP scenarios presented in Lutz et al. (2018). Moreover, we also take into account the potential effects of the learning loss due to the school closures during the Covid-19 pandemic on adult skills.

SLAMYS projections by different SSP scenarios show that the skills gap between developed countries and developing ones may widen or shrink depending on their demographic development trajectories. For example, if developing countries can expand their education up to the levels set by SDGs and reduce their mortality and fertility ratios as expected in the SSP1 scenario, younger cohorts in these countries may reach the SLAMYS of their peers in the developed countries. On the other hand, projections of SLAMYS by SSP3 scenario indicate much bigger gaps in terms of adult skills.

Moreover, learning loss due to school closures during the pandemic may exacerbate the inequalities due to adult skills between countries. The cohorts who are in school during the pandemic are hit hardest by these closures in countries where these closures were quite long. The fact that the length of school closures has been longer in many developing countries is a

serious concern for global equality of human capital. These closures may erase the gains of a few decades in adult skills for the affected cohorts unless policies to mitigate the learning losses are implemented immediately.

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