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Abstract[1]

The increase in access to digital technologies is opening up opportunities for governments in Latin America and the Caribbean to offer digital public services. However, there is scarce evidence regarding the benefits and costs of potential projects, which makes it difficult for governments in the region to prioritize digital projects for implementation. As part of *Digitalizing Public Services: Opportunities for Latin America and the Caribbean*, a report produced by the Inter-American Development Bank, a set of cost-benefit analyses of digital public services was conducted. This document complements said report by presenting the methodology, assumptions, and results of these cost-benefit analyses. To increase the comparability of the results across digital public services evaluated, common assumptions and a standardized methodology were used. Moreover, contextual conditions were fixed across projects by estimating results for a base country, Peru. The robustness of the results was examined by replicating the analysis for Chile, El Salvador, and Jamaica. Digital public services were evaluated in three sectors: education, health and government administrative services (e.g. production of identity cards). For each sector, the benefits and costs of two digital projects were estimated. For some these digital projects, only one policy option was assessed but, in other cases, several policy options were analyzed. A total of 11 policy options were assessed as part of this exercise. Results indicate that, in general, the policy options analyzed produced positive net present values. However, there is wide variation in the net present value across policy options suggesting that governments should carefully evaluate which digital public services they should prioritize for implementation.

JEL classifications: D61, H51, H52, H59
Keywords: Cost-benefit analysis, Digital public services, Education, Health

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1. Introduction

Access and use of digital technologies in Latin America and the Caribbean has increased markedly in the last decade. This creates opportunities for governments to improve public service delivery through digitalization. In fact, the provision of digital public services can generate improvements in desired outcomes, expand access to services and, in many cases, can be implemented at low cost. These characteristics of digital programs provide a strong motivation for governments in the region seeking to improve the efficiency of public services provided with the final objective of addressing longstanding challenges that the region faces in key sectors.

However, governments have limited resources to invest in projects and need to prioritize those that generate the highest economic value for society considering existing constraints. Hence, producing cost-benefit analyses of potential digital projects can help to identify projects with high expected net present value and low implementation costs. This information is valuable for governments seeking to decide which digital projects to prioritize for implementation.

The objective of this technical note is to provide a detailed description of methodology, assumptions, and results of the cost-benefit analyses presented in the report titled "Digitalizing Public Services: Opportunities for Latin America and the Caribbean" and produced by the Inter-American Development Bank (Cristia and Vlaicu, 2022).[2] These cost-benefit analyses seek to provide estimates of the benefits and costs associated to implementing a range of digital projects that tackle important policy challenges for governments in Latin America and the Caribbean. They are conducted for four countries in the region (Chile, El Salvador, Jamaica, and Peru) which can be considered representative of different geographical areas in the region which differ in terms of economic development as well as cultural and social conditions. The projects selected for the analysis tackle challenges in three key sectors: education, health, and transactional services provided by governments (e.g., producing identification cards). This technical note covers the sectors in the same order as they are covered in the mentioned report: Section 2 covers education, Section 3 covers health, and Section 4 covers government transactional services.[3]

Each chapter includes the cost-benefit analyses of two digital projects. For education, the projects assessed include an intervention that seeks to reduce dropout by showing students videos

[2] For introductory references in cost-benefit analysis see Boardman et al. (2018) and Levin et al. (2017).

[3] As the time of the publication of this report and the present technical note, there were cost-benefit analyses in the process of being produced, but not ready for publication, for Chapter 5 of the report, which covers fiscal administration.

with information on the economic returns of education and an intervention that seeks to improve academic achievement by providing students access to a math learning platform. In the case of health, one project analyzed seeks to help depressed patients to accelerate their recovery from this condition by providing them with cognitive behavioral therapy treatment, and the other involves sending text messages to prediabetic patients to promote the adoption of healthy behaviors with the final objective of reducing the onset of diabetes. Finally, in terms of government transactional services, one project seeks to promote the timely renewal of identification cards by reminding citizens of the upcoming expiration of their current identity cards by sending them text messages, while the other project seeks to enhance the identification of beneficiaries of cash transfers by using devices that can read biometric information.

For each of these digital projects, in some cases, several policy options were explored. For example, the benefits and costs of four different policy options were assessed in the case of the program seeking to improve academic achievement by providing access to a math learning platform. The options differed in terms of whether or not new devices were provided to schools, and in how teachers were supported to promote the adoption of this technology. In other cases, only one policy option was analyzed for a digital public program. This was the case of a program that entailed sending SMS to pre-diabetic patients to promote the adoption of healthy behavior to delay the onset of diabetes.

Regarding the selection of the projects analyzed, three conditions had to be met: i) rigorous causal evidence was available to quantify their impact, ii) impact evaluations found positive effects on intended outcomes, and iii) sufficient data were available to estimate cost parameters. Additionally, selected projects had to tackle some important challenge in the sector discussed (i.e., education, health, and government transactional services).[4] Beyond these conditions, the teams in charge of implementing the analysis for each sector had flexibility to select projects. That is, there was no systematic procedure in place to choose among projects that fulfill the mentioned criteria. Consequently, the set of projects evaluated here cannot be interpreted as a representative sample

[4] Though it was not a stringent condition, teams were advised to look for projects that had low implementation costs because they mostly use existing infrastructure and did not involve hiring much personnel for service delivery. The goal was to select projects that showcase to governments which type of digital interventions should receive special attention because their capacity to produce high value added with limited government investments. Additionally, teams were advised to choose digital projects that did not require having reliable access to Internet provision because access to this technology is more limited in the region especially in low-income populations. In contrast, projects that require only access to basic phones or smartphones with sporadic internet access were preferred.

of a clearly defined universe of projects. At the same time, because the number of projects in the sectors selected that fulfilled the described conditions was not large, there was little latitude in choosing among a large set of potential projects. In future work, it would be relevant to specify a systematic procedure for the selection of projects to be analyzed.

As mentioned, one important goal of this technical note is presenting the methodology and assumptions underlying the cost-benefit analyses presented in the mentioned report. An additional goal in the production of these analyses was to facilitate and reduce the costs involved in producing additional cost-benefit analyses of digital projects. Because there are many important critical inputs in the development of a cost-benefit analysis that are presented here (e.g., estimates of the relationship between increasing math test scores in a broad standardized examination and future earnings), this can reduce the time and cost necessary to produce additional cost-benefit analyses in the future. Moreover, if future cost-benefit analysis uses assumptions and procedures similar to those used here, then this would facilitate making sound comparisons of the benefits and costs of alternative projects. Of course, the frameworks, procedures, and estimates presented here have substantial room for improvement, and hence, they could also be updated and refined to produce more precise estimates of costs and benefits in the future.[5] In particular, because these are ex ante analyses that seek to inform policy decisions, by definition they should be updated and refined as new evidence is uncovered or as contextual conditions change in the countries under analysis.

Turning to practical considerations, it is important to note that the cost-benefit analyses presented focus on Peru as the base country. This allows us to discuss the framework used and specific estimates with greater clarity. Still, for robustness, we present the results for the other three countries (Chile, El Salvador, and Jamaica) and explicitly mention any changes in the procedure for these other countries. In general, the analysis seeks to presents the average costs and benefits per person and then arrive at aggregated measures multiplying the mentioned variables by the population targeted in the intervention. We then produce standard summary measures such as the net present value and the benefit-cost ratio.

[5] In particular, it would be relevant to try to adjust the cost-benefit analysis presented here so as to follow recent guidelines that have been produced to motivate more consistency in how cost-benefit analysis of social programs is implemented (Cost Analysis Standards Project, 2021). Although the teams collaborating in the production of these cost-benefit analyses tried to standardize procedures as much as possible, it would be also important to try to align the procedures with respect to emerging practices that are becoming standard in the field.

Lastly, the main common assumptions that all the cost-benefit analyses presented in this publication share are the following: i) the analysis is conducted from the perspective of society and includes costs and benefits irrespective of whether the government or individuals are going to experience them, ii) the implementer of the programs is the government, iii) there is a 20 percent additional cost for all governmental expenses to incorporate the deadweight loss of tax-related distortions based on Harberger (1997), iv) the discount rate is 3 percent, and v) all monetary values are expressed in US$ of April 2022 using inflation rates since the year that a benefit or cost is experienced and using the exchange rate (from country currency to US$) for April 2022.

2. Cost-Benefit Analysis of Digital Interventions in Education

This section presents the methodology and assumptions of the two cost-benefit analyses presented in Chapter 2 of the report, entitled "Let's Get Smarter: Using Smart Technological Investments to Improve Learning and High School Completion." The present section of this technical note has two parts. The first part presents the cost-benefit analysis of a program that uses videos to reduce dropout, which is discussed in Section 2.3.2 of the chapter mentioned above. The second part describes the cost-benefit analysis of different policy options to increase students' academic achievement in math by promoting student practice, which is presented in Section 2.4.2 of the aforementioned chapter.[6]

2.1. Cost-Benefit Analysis of a Digital Intervention to Reduce Dropout Rates

This subsection presents the methodology and assumptions of the cost-benefit analysis presented in Section 2.3.2 of Chapter 2 of the report. Common assumptions presented in Section 1 of this technical note apply to this analysis. All the data sources used to provide estimates for the different parameters in this analysis are included in the Annex 2.1 of this technical note.

2.1.1. Background

One of the critical educational challenges in Latin America and the Caribbean (LAC) is low secondary school completion rates. In fact, one third of students do not graduate from secondary school. And these low completion rates are mainly driven by high dropout rates during secondary

[6] For more information on technical details, please contact Julián Cristia (jcristia@iadb.org), the corresponding author for this section of this technical note.

education. There is evidence suggesting that providing information to students regarding the economic returns of education can reduce dropout rates (see Section 2.3.1 of the report).

2.1.2. Program and Evaluation

The cost-benefit analysis presented in this section estimates the potential social returns of a digital program providing information about educational returns through videos to reduce dropout rates, and it is based on the results from the evaluation of the program "Decidiendo por un Futuro Mejor" reported in Neilson et al. (2018). The program consists of showing four 15-minute videos to students in urban schools in grades 5 to 9 for two consecutive years. The evaluation of this program showed a reduction of 1.8 percentage points in the two-year dropout rate.

2.1.3. Overview of the Approach Followed to Estimate Benefits and Costs

We conduct a cost-benefit analysis of implementing the program "Decidiendo por un Futuro Mejor" and assume that this program will be targeted to students in grades 5 to 9 in urban public schools of Peru with adequate infrastructure for showing the videos.[7] The benefits of implementing the program are estimated as the increase in adult earnings of each student targeted by the program as well as the increase in labor taxes collected by the government.[8] This increase in adult earnings is the result of two mechanisms: additional schooling and improved academic achievement. Also, there are two types of costs this program generates. First, there are implementation costs of the program (including management costs and costs of the informational packages that are distributed to schools). Second, because the program will induce students to continue their studies, there are

[7] The program could also cover students in grades 10 and 11 (i.e., fourth and fifth years secondary school in Peru). However, we do not include these students in this cost-benefit analysis because the experimental evaluation on which we base this analysis only reported effects for students in grades 5 to 9.

[8] The program could also generate positive effects in other areas for targeted individuals as well as positive and negative externalities on non-targeted individuals. For example, for targeted individuals, the program can generate improvements in health and increases in life expectancy. The program can also produce increases in targeted individuals' productivity in market activities as well as at home. home. Regarding spillovers, if students targeted by the program improve their human capital, this can also induce improvements in productivity of other workers (Acemoglu and Angrist, 2000). Also, the program can generate positive effects on society such as increases in prosocial behavior and reductions in crime. Additionally, the program could generate positive effects on the children of targeted individuals. On the other hand, the program could generate negative spillovers due to increases in congestion or changes in peer effects among students. We do not incorporate into the cost-benefit analysis the potential effects for targeted individuals in non-economic dimensions (e.g., health) or spillover effects of the program on non-targeted populations in our calculation because: i) there exists limited evidence that can be directly used to project these indirect effects, and ii) in general, we expect that these indirect effects are going to produce mostly increases in benefits, and hence, the baseline estimates that we present can be considered conservative.

costs associated with this additional schooling. The costs associated with additional schooling include tuition covered by the government and families, and opportunities costs borne by families because beneficiary students will spend more time at school. In addition, we are performing the cost-benefit analysis for the representative targeted student who would be in grade 7 in 2022 (because targeted students are in grades 5 to 9 and the share of students in each grade is quite similar) and over the length of the intervention which is two years.

2.1.4. Estimation of Costs Benefits and Costs for the Base Country

This section describes how we estimate the benefits and costs of the program studied for our base country: Peru. For other countries for which we estimate this cost-benefit analysis (Chile, El Salvador, and Jamaica), we follow a similar procedure though in some cases, which we explicitly mention, we take advantage of the estimates generated for Peru and introduce adjustments to extrapolate the estimates to these other countries. Here we present the modifications and additional assumptions to calculate costs and benefits costs for the other countries.

Target Population

The beneficiaries of the program include students in grades 5 to 9 in urban public schools that report having at least 10 computers in the 2019 school census. We assume that schools with at least 10 computers could also have projectors to play the videos, or in the absence of these projectors, students could watch videos in shared computers. For example, three students could watch a video on the same computer at the same time. The number of students targeted by this program is 1,574,817, and the number of schools is 11,194.

Average Benefit per Person

We estimate the benefits of the program as the expected increase in adult earnings for students targeted by the program.[9] To that end, we first estimate the discounted lifetime earnings that students would accumulate in the absence of the intervention. To make this estimation, we use data from the "Encuesta Nacional de Hogares (ENAHO)" for 2019 and obtain annual net labor income expressed in current dollars (we use the inflation rate between 2019 and 2022 to express income to the present and the exchange rate for April 2022 to convert the amount from Peruvian

[9] As will be explained below, we also incorporate the benefits associated to increases in revenue of labor taxes that are induced by the increase in gross salaries that the program is expected to produce.

soles to dollars) for individuals ages 18 to 65 years old (including all individuals, those working and not working). We then run a regression of this amount on a constant, age and age squared as regressors. Using the estimated coefficients of this regression, we predict annual labor income for ages 18 to 65. That is, we assume that the average student enters the labor market at age 18 and exits at age 65.[10] We also incorporate the fact that wages are expected to continue growing in the future and, hence, current students are going to receive higher wages (in real terms) compared to current workers. To incorporate this, we consider that the average annual growth of real labor income between 2006-2019 was 2.1 percent, and we reduce this rate by 50 percent to provide a conservative estimate, especially considering that the region grew rapidly during the mentioned period.[11] Under these assumptions, we can estimate the annual labor income earnings for the average student and discount them to present. Based on this calculation, we estimate that baseline discounted lifetime earnings amount to US$ 94,827.

Second, we calculate the increase in lifetime earnings due to additional schooling. For this, we compute the increase in total years of education that the program will produce based on the evidence presented in the evaluation of the "Decidiendo por un Futuro Mejor" program (Neilson et al., 2018) and the evaluation presented in Jensen (2010). The experimental evaluation in Neilson et al. (2018) reported that the program reduced the dropout rate by 1.8 percentage points in urban schools one year after the end of the program. In Jensen (2010), a program providing information on educational returns in the Dominican Republic recorded a 4.1 percentage points effect in enrollment in the year after the intervention took place. Moreover, this evaluation also reports an effect in years of schooling of 0.2 at the end of the fourth academic year after the intervention took place.[12] We assume that a similar ratio of completed years of education after four years to short-term effects on enrollment will take place in the program in Peru. Under this assumption, we estimate an effect on years of education of 0.09 years (1.8/4.1*0.2). Assuming a return to an

[10] Because we compute average annual labor income by age using information on all the population aged 18 to 65 (irrespective of whether they work or not), we are implicitly incorporating into the calculation changes in the employment rate as people age.
[11] We calculate this average growth rate as the weighted average of the growth rates of real labor income between 2006 and the year of the last available household survey of the four countries in the analysis.
[12] Note that the program can generate increases in years of education even after the fourth year of program implementation. However, to be conservative, and considering the difficulties of extrapolating effects for a longer horizon, we only focus on effects on years of education that can be generated during the first four years after program implementation.

additional year of education of 8.1 percent, the increase in earnings will be 0.71 percent, equivalent to US$ 674 per student (see Table 2.1).

Table 2.1. Benefit per Student from Additional Schooling of a Digital Intervention to Reduce Dropout Rates in Peru

Increase in lifetime earnings (%)	0.71
Total effect on schooling (years of education)	0.09
Return to another year of schooling (%)	8.10
Lifetime earnings (US$)	94,827
Benefit per student from additional schooling (US$)	674

Source: Authors' calculations.

Third, we calculate the increase in lifetime earnings due to improved academic achievement. We compute the effect on learning as the average of the effect on the verbal and math sections of the national standardized test in Peru (3 percent and 4 percent of a standard deviation, respectively, as reported in Neilson et al., 2018). We then estimate the expected increase in earnings due to an increase in academic achievement. Based on existing studies, we assume that a one standard deviation increase in average academic achievement generates an increase in adult earnings of 10.6 percent (see Annex 2.2).

Now, as we are considering the effects on adult earnings induced by both additional schooling and improved academic achievement, it is possible that we are double-counting part of the effects. That is, the studies that have estimated the effect of increasing academic achievement on earnings seek to measure the total effect of the former variable on the latter without keeping constant the number of years of education. To tackle this issue, and to avoid over-estimating the effects due to double-counting, we use data from a representative longitudinal survey from the United States and regress a measure of adult earnings on average academic achievement in adolescence under two specifications: in one we do not control for number of years of education, and in the second we do control for number of years of education.[13] Based on this analysis, we find that once we control for years of education, the effect of academic achievement on earnings is

[13] The regression uses data from the National Longitudinal Survey of Youth 1997 (NLSY97). From these data, we select students born in 1984. The dependent variable is the income at age 35. The test score variable is the Peabody Individual Achievement Test (PIAT) taken at age 12. The schooling variable is the highest grade completed at age 35. We include student demographic, household composition, household income, age and schooling of parents, and information about student childhood as controls.

reduced by 51 percent. This suggests that about half of the effect of improved academic achievement on earnings is due to an increase in educational attainment (which we have already accounted for). Consequently, we reduce the estimated effect on earnings due to improved academic achievement by 51 percent to avoid double-counting benefits due to increases in educational attainment and improved academic achievement. Under these assumptions, we expect that earnings will rise an additional 0.19 percent, equivalent to US$ 180 per student (see Table 2.2).

Table 2.2. Benefit per Student from Improved Academic Achievement of a Digital Intervention to Reduce Dropout Rates in Peru

Increase in lifetime earnings (%)	0.19
Total effect on learning (% of standard deviation)	3.5
Effect of increasing test scores by one standard deviation on earnings (%)	10.6
Reduction in the increase in earnings to avoid double counting benefits (%)	51.3
Lifetime earnings (US$)	94,827
Benefit per student from improved academic achievement (US$)	180

Source: Authors' calculations.

The increase in earnings presented above implies that the average benefit per student will amount to US$ 854 dollars (674+180). Because we base our estimate of lifetime earnings on *net* labor income, we are not yet considering that increases in productivity and wages are also going to produce an increase in labor taxes that the government receives to fund social security and other programs. To incorporate this, we consider that labor deductions correspond to 13 percent of gross salary and hence estimate the expected increases in government revenues due to labor taxes. This is equivalent to US$ 128, and, hence, the total average benefit per student will be US$ 982 (see Table 2.3).

Table 2.3. Benefit per Student of a Digital Intervention to Reduce Dropout Rates in Peru

Average benefit per student (US$)	854
Labor deductions of salary (%)	13
Increase in taxes per student (US$)	128
Total benefit per student (US$)	982

Source: Authors' calculations.

Average Cost per Person

The costs generated by the program include both implementation costs and costs associated with additional schooling. We divide the implementation costs into management costs and informational packages costs. To estimate the management costs, we consider that the team in charge of implementing the "Decidiendo por un Futuro Mejor" program in 2015-2016 obtained a grant of US$ 977,690 to cover the implementation and evaluation of the program. We assume that 67 percent of this initial grant was allocated to the implementation of the program in urban schools (the project also included an evaluation component and the implementation of a different version of the program in rural schools). From that amount, we assume that 30 percent represented fixed costs and 70 percent variable costs distributed into 1,393 schools that received the treatment. This implies that the fixed management cost of the program will be US$ 456,255, and the variable management cost will be US$ 1,571,323 (this takes into account that there are 11,194 schools that are expected to be covered in this analysis compared with the 1,393 schools covered in the evaluation reported in Neilson et al., 2018). Consequently, the total management cost will be US$ 2,027,578 and translate into a management cost per student of US$ 1.29.[14]

In addition, the cost of the informational package containing the instructions and DVDs is set to US$ 0.05 based on the marginal per-student cost reported in Neilson et al. (2018). Because these packages are sent twice, the total cost of informational packages will be US$ 0.10. Therefore, the total implementation cost for the program will be US$ 1.39 per student (see Table 2.4).

Table 2.4. Implementation Cost per Student of a Digital Intervention to Reduce Dropout Rates in Peru

Management cost per individual (US$)	1.29
Informational package cost (US$)	0.10
Implementation cost per student (US$)	1.39

Source: Authors' calculations.

[14] Our assumptions regarding the management costs of the program have considerable uncertainty because we have limited empirical data to make these estimates. However, it is important to note that these assumptions should have only a minor effect on the estimates of the benefit-cost ratio or on the net present value of the program because management costs represent a small share of total costs.

The cost associated with additional schooling includes tuition costs and opportunity costs. We calculate the tuition costs for four years after the program has ended because we have projected effects on dropout during this time horizon. To estimate tuition costs, we first obtained the government expenditure per student in secondary and tertiary education from the "Instituto Nacional de Estadística e Informática (INEI)" for 2019 and express these expenditures in current dollars (following the procedure described above considering inflation rate and exchange rate). Then, for each year in which there are effects on dropout, we take into account the proportion of targeted students who will be in secondary and in tertiary education, and how much of the cost incurred in that year will be covered by the government and how much by families. To do this, we assume that the tuition of all students in secondary education is funded by the government, and that the tuition of students in tertiary education is distributed between the government and families according to the percentage of tertiary students in public institutions (34 percent). Then, we can estimate the tuition cost per year and discount them to the present using the 3 percent discount rate. This results in a tuition cost for the government of 99 dollars per student and for families of US$ 35 per student (see Table 2.5).

The opportunity costs borne by families are also calculated for four years after the program has ended. First, we assume that when a targeted student continues studying because of the program, she will devote six hours per school day to going to school and studying that she cannot allocate to other activity (such as labor market work, household chores, or leisure). Considering that the students will attend school five days in a week, 4.3 weeks in a month and nine months in the year, we expect that the targeted student that continues going to school due to the intervention will forgo a total of 1,161 hours per year. Then, we value these hours according to the average hourly wage for full-time workers in the age groups 14-17 (for the proportion of students that will be in secondary education) and 18-24 (for the proportion of students that will be in tertiary education) using data from ENAHO 2019 expressed in current dollars (following the same procedure described above considering inflation rate and exchange rate). For this type of cost, we also take into account the proportion of targeted students who will be in secondary and in tertiary education each year and estimate the opportunity cost per year and discount them to the present using the 3 percent discount rate. This results in an opportunity cost of 126 dollars (see Table 2.5).

Table 2.5. Additional Schooling Cost per Student of a Digital Intervention to Reduce Dropout Rates in Peru

Tuition cost for government (US$)	99
Tuition cost for families (US$)	35
Opportunity cost for families (US$)	126

Source: Authors' calculations.

The costs presented above imply that the government will incur an average cost per student of US$ 99, and families will incur an average cost per student of US$ 161. As we are including 20 percent to account for deadweight losses, which apply to implementation costs and schooling costs funded by the government, the total government costs will be US$ 119, and the total average cost per student will be US$ 280 (see Table 2.6).

Table 2.6. Cost per Student of a Digital Intervention to Reduce Dropout Rates in Peru

Government cost with deadweight loss (US$)	119
Initial government cost	99
Deadweight loss	20
Families cost (US$)	161
Cost per student (US$)	280

Source: Authors' calculations.

2.1.5. Estimation of Benefits and Costs for Other Countries

For the other countries for which we estimate this cost-benefit analysis (Chile, El Salvador, and Jamaica), we follow a similar procedure with the following modifications. First, the target population is calculated using data from the ministries of education of each country and the percentage of students in urban public schools with at least 10 computers from the 2018 Programme for International Student Assessment (PISA).[15] For Chile, this results in 1,033,971 students and 7,983 schools. For El Salvador, this results in 171,752 students and 1,349 schools, and for Jamaica, this results in 158,795 students and 457 schools.

Next, the average benefit per person includes two modifications: the estimation of the baseline discounted lifetime earnings uses the information from the household surveys of each

[15] PISA 2018 does not include El Salvador or Jamaica. For these countries we run a regression on the percentage of students in urban public schools with at least 10 computers for all available countries in the PISA survey and use the logarithm of the GDP per capita as regressor. We then predict this percentage for El Salvador and Jamaica.

country, and the increase in taxes uses the labor deductions of salary of each country. Then, the average cost per person changes as follows. For the management cost, the value for Peru is adjusted by the ratio between the average hourly labor income of each country and the average hourly labor income of Peru and considers the number of schools covered in each country. For tuition costs, the estimate considers the government expenditure per student in secondary and tertiary education and the percentage of tertiary students in public institutions for each country.[16] For opportunity costs, we value the hours according to the average wage for full-time workers in the age groups considered obtained from the household survey of each country (see Annex 2.2 for data sources).[17]

2.1.6. Results

Table 2.7 summarizes the main components of the cost-benefit analysis for all countries and presents results on key indicators such as the net present value. For example, for Peru, the total benefit per student is US$ 982. This benefit comes from additional schooling (US$ 674), improved academic performance (US$ 180), and the increase in taxes (US$ 128). The total cost per student is US$ 280, of which US$ 119 is borne by the government and US$ 161 by families. Based on these estimates, we calculate the net present value per student subtracting the cost per student to the benefit per student.[18] Finally, considering that the target population for this program is 1.57 million students, the total net present value of the program for Peru is estimated at US$ 1,106 million.

Now consider Chile. We estimate that the total benefit per student is US$ 2,800. This value results from the addition of the benefits of increasing schooling (US$ 1,941), improved academic achievement (US$ 341) and the increase in taxes (US$ 518). This value is almost three times that of Peru, but consider that the average hourly earnings of a Chilean employee is 2.27 times that of a Peruvian employee. Regarding the total cost, we estimate it at US$ 672 per student. This amount includes costs borne by the government (US$ 204) and by families (US$ 468). Hence, for Chile,

[16] Government expenditure per student in tertiary education for El Salvador and the percentage of tertiary students in public institutions for Jamaica was not available. For these cases, we assume an average of the other countries.

[17] For Jamaica the sample was small, and, hence, we could not compute representative hourly wage for the selected age groups. To predict the wages for the selected age groups, we use the relationship between wages for the overall population and the selected age groups (14-17 and 18-24) for Peru and apply these ratios to the overall wage mean for Jamaica.

[18] There are two alternatives to compute the benefit-cost ratio regarding whether the additional educational expenses and the deadweight loss are incorporated as a reduction in the benefits or an increase in costs. If they are included as a reduction in benefits, the benefit-cost ratio is higher compared to when they are included as an increase in costs.

the net present value of the program is US$ 2,128 per student. Given that the target population is 1.03 million Chilean students, the total net present value is US$ 2,200 million.

In the case of El Salvador, the average benefit for additional schooling (US$ 635), the average benefit from improved academic performance (US$ 147) and the average increase in taxes (US$ 24) amount to a total benefit per student of US$ 806. The total cost per student is US$ 244, which includes US$ 73 of government's costs, and US$ 170 of families' costs. Therefore, the net present value is US$ 563 per student. Finally, we estimate that the total net present value of the program is US$ 97 million, given that the target population is about 172,000 students.

In the case of Jamaica, the benefit from additional schooling is US$ 350, and from improved academic achievement the benefit is US$ 73. Together with the US$ 33 of increase in individual taxes, we find a total benefit of US$ 457 per student. This is close to half the individual benefit of Peru or El Salvador. This result is partly explained by the lower average wages for Jamaica's workers compared to Peruvian workers (24 percent lower). With respect to the costs of the program, the total cost per student is US$ 247. This results from the addition of the total cost for the government (US$ 120) and the total cost for families (US$ 127). This means that the net present value is US$ 210 per student, resulting in a net present value of the program of US$ 33 million.

Table 2.7. Cost-Benefit Analysis of a Digital Intervention to Reduce Dropout Rates in Selected Countries

	Peru	Chile	El Salvador	Jamaica
Benefit per student (US$)				
From additional schooling	674	1,941	635	350
From improved academic achievement	180	341	147	73
Increase in taxes	128	518	24	33
Total benefit	982	2,800	806	457
Cost per student (US$)				
Government cost	119	204	73	120
Families cost	161	468	170	127
Total cost	280	672	244	247
Results				
Net present value per student (US$)	702	2,128	563	210
Target population (million)	1.57	1.03	0.17	0.16
Total net present value (millions of US$)	1,106	2,200	97	33

Source: Authors' calculations.

2.2. Cost-Benefit Analysis of Different Policy Options to Promote Student Practice Using Technology

This subsection presents the methodology and assumptions of the cost-benefit analysis presented in Chapter 2, Section 2.4.2 of the report. Common assumptions presented in Section 1 of this technical note apply to this analysis. All the data sources used to provide estimates for the different parameters in this analysis are included in Annex 2.3 of this technical note.

2.2.1. Background

One of the critical educational challenges faced by countries in Latin America and the Caribbean (LAC) is low learning levels. Only 52 percent of third-graders in the region master basic mathematics concepts, and only 57 percent have age-appropriate reading skills according to the fourth round of the Comparative and Explanatory Regional Study (ERCE in Spanish).[19] Students that lack these basic academic skills will face important challenges in developing new skills. There is strong evidence indicating that promoting student practice using learning platforms can improve learning levels (see Section 2.4.1 of the report).

2.2.2. Program and Evaluation

[19] Available at es.unesco.org/fieldoffice/santiago/llece/ERCE2019.

The cost-benefit analysis presented in this section estimates the potential social returns of a technology program focused on student practice that seeks to increase math learning, and it is partly based on the estimates results from the experimental evaluation of the program “Conecta Ideas” implemented in Santiago, Chile in 2017 (Araya et al., 2019) as well as on the average effects of digital programs that seek to promote student practice keeping constant instructional time.[20] The prototype program evaluated in this section is one in which students attend one weekly 90-minute math session in a computer lab at primary schools, replacing traditional math instruction, where they use an online math platform with exercises aligned to the national curriculum.

As opposed to the cost-benefit analysis presented in Section 2.1, the estimation of the learning effects of the different policy options presented in this section are not obtained from a large-scale experimental evaluation. Rather, learning effects were approximated using conservative assumptions as well as information from the sources mentioned in the previous paragraph. Consequently, the results presented in this section should be interpreted with caution, and they can be refined and updated once strong empirical evidence on these key parameters is produced.

2.2.3. Overview of the Approach Followed to Estimate Benefits and Costs

We conduct a cost-benefit analysis of implementing the program “Conecta Ideas” in Peru and analyze four different policy options that differ in whether new technological infrastructure is purchased and whether teachers are supported through workshops or coaches to help them adopt and use the math learning platform. We assume that this program will be targeted to students in grades 3 to 6 in public primary schools in Peru. The benefits of implementing the program are estimated as the increase in adult earnings of each student targeted by the program.[21] This increase in adult earnings is the result of improved academic achievement. This program also generates two types of costs. First, there are implementation costs of the program (including management costs, teacher support costs, and infrastructure costs). Second, because the program will induce students to continue their studies, there are costs associated with this additional schooling. The costs

[20] Information from the implementation and evaluation of the Conecta Ideas program in Peru during 2021 was also used in this analysis.

[21] As in the cost-benefit analysis of the education program presented in Section 2.1, this program can also generate positive effects in other areas for targeted individuals as well as positive and negative externalities on non-targeted individuals. We do not incorporate into the cost-benefit analysis these effects for the reasons discussed in Section 2.1.2 above.

associated with additional schooling include tuition covered by the government and families, and opportunity costs borne by families because beneficiary students will spend more time at school. For simplicity, we perform the cost-benefit analysis for the representative targeted student who would be in grade 4 in 2022 (because targeted students are in grades 3 to 6 and the share of students in each grade is quite similar) and over the length of the intervention, which is one year.[22]

2.2.4. Estimation of Benefits and Costs for supporting teachers with coaching and purchasing new infrastructure for the base country

This section describes how we estimate the benefits and costs of the program studied for our base country (Peru) and for the policy option that involves supporting teachers with coaches and purchasing new infrastructure. We present the analysis for this policy option because it is the one that involves more detailed calculations and it is the one that maximizes the net present value for society across the four policy options. In Section 2.2.5, we report the analysis of benefits and costs for the other three policy options for the base country. For other countries for which we estimate this cost-benefit analysis (Chile, El Salvador, and Jamaica), we follow a similar procedure, though in some cases, which we explicitly mention, we take advantage of the estimates generated for Peru and introduce adjustments to extrapolate the estimates to these other countries. In Section 2.2.6, we present the modifications and additional assumptions to calculate benefits and costs for these other countries.

Target Population

The beneficiaries of the program include students in grades 3 to 6 in all public primary schools in the 2019 school census. The number of students targeted by this program is 1,819,261 and the number of schools is 29,776.

[22] In reality, the average student should be between grade 4 and 5. For simplicity, we produce the analysis assuming that the representative student is in grade 4. This decision will have a minor effect in the calculations, and it is a conservative assumption considering that assuming that the representative student is slightly younger will produce a small reduction in the present discounted benefits because future earnings are discounted for a longer period.

Average Benefit per Person

We estimate the benefits of the program as the expected increase in adult earnings for students targeted by the program.[23] We follow a procedure similar to that described in Section 2.1.3; the only difference is that the representative student is younger in this exercise and, hence, adult earnings are discounted for a longer period. Under these assumptions, we can estimate annual labor income earnings for the average student and discount them to present. Based on this calculation, we estimate that baseline discounted lifetime earnings amount to US$ 88,072.

Then, we calculate the increase in lifetime earnings due to improved academic achievement. In this policy option, we assume that the effect on math learning when teachers receive personalized support from coaches is 0.028 standard deviation.[24] This assumption considers that the program will generate an effect equal to a quarter of the average effect documented in the literature for digital programs that seek to improve academic achievement by promoting student practice keeping constant instructional time (see Section 2.4.1 in Chapter 2 of the report). We further assume that the effect on learning will be 50 percent of the math effect, resulting in an effect of 0.014 standard deviation.[25]

With this effect on learning, we estimate the expected increase in earnings due to an increase in academic achievement. Based on existing studies, we assume that a one standard deviation increase in average academic achievement generates an increase in adult earnings of 10.6 percent (see Annex 2.2). Then, we expect that earnings will rise 0.15 percent (0.014*0.106), equivalent to US$ 128 per student. Because we base our estimate of lifetime earnings on *net* labor income, we are not yet considering that increases in productivity and wages are also going to produce an increase in labor taxes that the government receives to fund social security and other programs. To incorporate this, we consider that labor deductions represent 13 percent of gross salary and hence estimate the expected increases in government revenues due to labor taxes. This is equivalent to US$ 19 (128*0.13), and, hence, the total average benefit per student will be US$ 147 (see Table 2.8).

[23] As is explained below, we also incorporate the benefits associated with increases in revenue from labor taxes that are induced by the increase in gross salaries that the program is expected to produce.

[24] There is considerable uncertainty regarding the expected effects on student learning of the program described in Peru, as measured for a national standardized examination. Hence, we make a conservative assumption to compute these effects. As more evidence is accumulated in coming years, this key parameter is expected to be refined.

[25] That is, we assume that the effect on reading will be 0.

Table 2.8. Benefit per Student of a Policy Option to Promote Student Practice Using Technology in Peru

Benefit per student from improved academic achievement (US$)	128
Increase in lifetime earnings (%)	0.15
Effect on learning (standard deviation)	0.014
Effect on math learning (standard deviation)	0.028
Increase in overall test scores (%)	50
Effect of increasing test scores by one standard deviation on earnings (%)	10.6
Lifetime earnings (US$)	88,072
Labor deductions of salary (%)	13
Increase in taxes per student (US$)	19
Benefit per student (US$)	147

Source: Authors' calculations.

Average Cost per Person

The costs generated by the program include both implementation costs and costs associated with additional schooling. We divide the implementation costs in management costs and infrastructure costs. The management costs include a fixed cost related to general management and software and a variable cost related to teacher support.

Implementation Costs

For management costs, we assume a fixed cost of US$ 800,000 related to general management and software, which will result in a fixed cost per student equivalent to US$ 0.44.[26] Next, we compute the costs associated with supporting teachers. In this policy option, in which teachers receive personalized support from coaches, we calculate the variable cost per student as follows. First, we calculate the total salary a coach will receive. For this, we assume that each coach will work for three months (one month for initial preparation and two months dedicated to coaching teachers) with a monthly salary of US$ 1,604. This results in a total cost of US$ 4,813 per coach (1,604*3). Then, we calculate the total number of students whose teachers will receive support by a coach. To do this, we consider that the average class size obtained from the 2019 school census is 18.29

[26] Our assumptions regarding the fixed costs of the program have considerable uncertainty because we have limited empirical data to make these estimates. However, it is important to note that these assumptions should have a minor effect in the estimates of the benefit-cost ratio or in the net present value of the program because fixed costs correspond to a small share of total costs.

and assume that each coach will train 56 teachers. Therefore, each coach will train the teachers of 1,024 students (18.29*56). This implies that the salary cost per student will be US$ 4.7 (4,813/1,024). In addition, we include an overhead of 30 percent for the variable cost per student equivalent to US$ 1.41 (4.7*0.30), and we incorporate the fact that teachers should not receive full support from coaches every year. Rather, we assume that the average teacher will receive support from a coach every other year.[27] Based on these assumptions, the total variable cost per student will be US$ 3.05 (6.11/2). Including the fixed and variable cost per student, the total management cost per student will amount to US$ 3.49 (see Table 2.9).

Table 2.9. Management Cost per Student of a Policy Option to Promote Student Practice Using Technology in Peru

Fixed cost per student (US$)	0.44
Variable cost per student (US$)	3.05
Salary costs per student (US$)	4.70
Salary per coach (US$)	4,813
Number of students whose teachers are coached	1,024
Overhead (%)	30
Overhead (US$)	1.41
Fraction of teachers trained each year (%)	50
Management cost per student (US$)	3.49

Source: Authors' calculations.

Regarding infrastructure costs, this policy option includes purchasing new infrastructure for those schools that do not have sufficient infrastructure to implement the program.[28] There are three main items a school would need to implement the program: electronic devices, internet

[27] This is a simplifying assumption. In reality, there is going to be heterogeneity across teachers in the amount of support that they will need to receive. It could be the case that some teachers will receive the support in the first year followed by a brief refresher in later years. Other teachers will need to have significant support every year. Additionally, there is going to be teacher turnover because every year some teachers are going to be new to the profession, some are going to be coming from private schools and others could be coming from grades not covered by this intervention. This turnover will require providing full support to a share of teachers every year.

[28] Alternatively, we could compute the full cost of all devices irrespective if they are existing or new devices. However, we prefer to consider only the costs of the new devices to incorporate the fact that there is already available infrastructure that the program could take advantage of. This approach also incorporates the fact that anecdotal evidence suggests that few of the available digital resources at schools are used in a way that is conducive to improve learning.

connection, and electricity. There are additional costs that are going to be incorporated using an overhead factor.

To calculate the number of electronic devices that are going to be purchased, we consider two factors. The first factor is the number of "sets" of devices that a school should have. We define a set as a group of devices that can be used by a complete section of students (e.g., section A in fourth grade). The second factor is the number of devices included in a set. Then, the number of devices that a school should have is equal to the number of sets that the school should have multiplied by the number of devices in a set.[29]

We define the number of sets that a school needs based on the number of sections that could share devices in a school per week. In particular, we assume that a set of devices could be shared by a maximum of 10 different sections per week.[30] This implies, for example, that one set of devices is sufficient for schools with 1 to 10 sections in grades 3 to 6, and that two sets of tablets are sufficient for schools with 11 to 20 sections in these grades. For each school in the target population (i.e., primary, public schools), we identify the number of sets a school needs using the 2019 school census.[31] Next, we estimate the number of devices that should be included in a set by considering 1.25 times the average class size. That is, we define the number of devices necessary to provide one device per student for all sections that do not have more than 25 percent of students compared to the average section.[32]

Based on these calculations, we estimate the number of devices that are needed in each school in the target population. Next, we compare this number to the total electronic devices a school has (including desktops, laptops, and tablets). The difference indicates the number of

[29] A more elaborate way of computing the number of needed devices involves considering that there could be sets of devices that include different number of devices. For example, a school could have a large set of devices that will be used for sections that have a large number of students (e.g., between 25 and 30) and a small set of devices that will be used for sections that have a small number of students (e.g., between 20 and 25). For simplicity, we abstract from this possibility, which should have a minor impact on costs.

[30] In practical terms, we consider that a set of devices could be used by two sections every day. This seems reasonable considering that schools are open 4.5 hours a day in Peru in a shift and that each learning session with devices will take about 1.5 hours. We do not consider the case that a school operates both with a morning shift and an afternoon shift, in which case a set of devices can be shared by more sections which will reduce the need of devices to purchase (a minority of schools operate with two shifts in a day).

[31] The Ministry of Education of Peru implemented a large-scale program that distributed close to one million tablets to students and teachers in primary and secondary schools in 2020-2021. We do not consider these resources that schools now have to make the case of Peru more representative of other countries in the region, such as Colombia and Ecuador, that have not implemented recent programs to distribute devices at this scale.

[32] If a section has more 25 percent of students compared to the average section, then we assume that some students are going to share a device.

devices to purchase in each school. In total, the Ministry of Education will need to purchase 145,197 devices.[33] More specifically, we assume that tablets are purchased considering that tablets have worked well for students using the Conecta Ideas software and that they are considerably less expensive compared to computers.

Regarding internet connection services, we identify schools that did not have internet access (again, according to the 2019 school census) and that are in cities and towns where internet access is available (based on principals' reports). Also, we assume the number of internet connections a school needs is equivalent to the set of devices the school needs, and the number of internet connections a school currently have is one if the school reports having internet access (zero otherwise). The difference between the needed number of internet connections and the number of internet connections that the school had in 2019 indicates the number of internet connections to purchase. In total, the Ministry of Education will need to purchase 3,259 internet connections services. For schools located in population centers without internet, we consider an offline version of the learning platform that will require that one technical staff spends two days per school per year to update the software. Then, there are 20,489 schools that will need this technical support and we assume that this involves two days of a technician.

For electricity, we identify the schools without electricity in the 2019 school census and calculate the number of solar panels and batteries needed to charge the devices. To do this, we take into account the number of devices schools need and assume one solar panel with a battery for each eight devices. This implies that the Ministry of Education will need to purchase a total of 15,471 solar panels with batteries.

Once we obtained the total number of items to purchase, we consider the price and the number of years each item will last to calculate the total amount to be spent in infrastructure per item. For example, in the case of tablets, we assume a price of US$ 35 and that the tablet will last two years. This implies the total to be spent on tablets is US$ 2,540,948 (see Table 2.10). Following this procedure for the rest of the items, the total amount spent on infrastructure will be US$

[33] Alternatively, the government could redistribute devices across schools to ensure that all schools have the necessary number of devices to implement the program. However, we consider that this option will not be politically feasible because it will be difficult to convince the staff in schools with more devices than needed to provide these devices to schools with devices shortages.

6,839,505 that increase to US$ 13,679,011 when including an overhead cost of 100 percent.[34] Therefore, with a target population of 1,819,261 students, the total infrastructure cost per student will amount to US$ 7.52. With a management cost per student of US$ 3.49 and an infrastructure cost per student of US$ 7.52, the total implementation cost for the program will be US$ 11.01 per student.

Table 2.10. Infrastructure Cost of a Policy Option to Promote Student Practice Using Technology in Peru

Item	Quantity	Price (US$)	Years	Total (US$)
Tablets	145,197	35	2	2,540,948
Internet connections	3,259	300	1	977,700
Schools covered by technical staff	20,489	107	1	2,191,475
Solar panels	15,471	180	10	278,478
Batteries	15,471	220	4	850,905

Source: Authors' calculations.

Costs Due to Additional Schooling

The cost associated with additional schooling includes tuition costs and opportunity costs. To estimate the tuition costs, we first obtained government expenditure per student in secondary and tertiary education from the INEI for 2019 and express these expenditures in current US$ (following the procedure described in Section 2.1.4). Then, we compute the cost of one additional year of education for the average student, considering how much of the increase in schooling will occur in secondary education and how much will occur in tertiary education as a result of a one standard deviation increase in math test. To do this, we run two regressions of the years of education on a constant and the standardized math test score as regressors, one for adults with secondary education and another for adults with tertiary education.[35] We then take the math coefficient of each regression (0.02 for secondary and 0.37 for tertiary) to calculate how much of the increase will occur in each level of education (considering the total is the sum of the two coefficients, 0.39).

[34] This overhead includes all other necessary costs that have to be covered to ensure that the devices work well. For example, this includes furniture, cables, modems, technical repairs, replacements due to thefts, and security measures to reduce the possibility of thefts.

[35] The regression uses data from the National Longitudinal Survey of Youth 1997 (NLSY97). From these data, we select students born in 1984. The dependent variable is years of educations at age 35. The test score variable is the Peabody Individual Achievement Test (PIAT) taken at age 12. We include student demographic, household composition, household income, age and schooling of parents, and information about student childhood as controls.

That is, we assume that 5 percent of the increase in schooling occurs in secondary (0.02/0.39) and 95 percent occurs in tertiary education (0.37/0.39). In addition, we consider how much of the cost will be covered by the government and how much by families. To do this, we assume that the tuition of all students in secondary education is funded by the government, and that the tuition of students in tertiary education is distributed between the government and families according to the percentage of tertiary students in public institutions (34 percent). This results in a discounted cost of one additional year of education of US$ 683 per student for the government and of US$ 1,192 per student for families.

Based on existing studies, we assume that a one standard deviation increase in average academic achievement generates an increase in schooling of 0.89 years of education (see Annex 2.4). Considering that the program is expected to increase average academic achievement by 0.014 standard deviation, then, the expected increase in the number of years education stands at 0.012 (0.89*0.014). To estimate the tuition costs, we take into account the estimate presented above on the cost of one additional year of education. In turn, this generates additional spending of US$ 8 per student for governments (683*0.012) and US$ 15 per student for families (1,192*0.012, see Table 2.11).

The opportunity costs borne by families are also calculated for the average student. First, we assume that when a targeted student continues studying because of the program, she will devote six hours per school day to going to school and studying that she cannot allocate to other activity (such as labor market work, household chores, or leisure). Considering that the students will attend school five days in a week, 4.3 weeks in a month and nine months in a year, we expect that the targeted student who continues going to school due to the intervention will forgo a total of 1,161 hours per year. Then, we value these hours according to the average hourly wage for full-time workers in the age groups 14-17 (for the increase in schooling in secondary education) and 18-24 (for the increase in schooling in tertiary education) using data from ENAHO 2019 expressed in current US$ (following the same procedure described in Section 2.4.1 regarding adjusting by the inflation rate and the exchange rate).

Note that to compute how much of the opportunity cost occurs in each level of education we use the same assumption described for tuition costs (5 percent in secondary and 95 percent in tertiary education). This results in a discounted opportunity cost of one additional year of education of US$ 1,523 per student. Considering the effect of increasing test scores on schooling mentioned above (0.012), the opportunity cost will amount to US$ 19 (see Table 2.11). Therefore, with a tuition cost per student of US$ 8 for the government and US$ 15 for families, and an opportunity cost per student of US$ 19, the additional schooling cost per student will be US$ 42 per student (see Table 2.11).

Table 2.11. Additional Schooling Cost per Student of a Policy Option to Promote Student Practice Using Technology in Peru

Effect of increasing test scores on schooling (years)	0.012
Effect of increasing test scores by one standard deviation on schooling (years)	0.89
Effect on overall test scores (standard deviation)	0.014
Tuition cost per student (US$)	
Government cost of one additional years of education	683
Government cost of schooling	8
Families cost of one additional year of education	1,198
Families cost of schooling	15
Opportunity cost per student (US$)	
Opportunity cost of one additional year of education	1,523
Opportunity cost of schooling	19
Additional schooling cost per student (US$)	42

Source: Authors' calculations.

Total Costs per Student

Considering implementation costs (US$ 11.01) and costs associated with additional schooling for the government (US$ 8), we expect that the government will incur an average cost per student of US$ 19. Because we also include a 20 percent cost applied to the costs funded by the government due to deadweight losses associated to raising taxes, total government costs will be US$ 23. Adding to this amount the costs borne by families (families cost of schooling and opportunity cost of schooling), we arrive at a total average cost per student of US$ 56 (see Table 2.12).

Table 2.12. Cost per Student of a Policy Option to Promote Student Practice Using Technology in Peru

Government cost (US$)	23
Initial government cost	19
Deadweight loss	4
Families cost (US$)	33
Cost per student (US$)	56

Source: Authors' calculations.

2.2.5. Estimation of Benefits and Costs for the Other Three Policy Options for Peru

In this section we present the changes in the estimation of the benefits and costs for the other policy options and present the total benefit and cost per student for each of them.

For the policy option that includes purchasing new infrastructure and supporting teachers through workshops instead of coaches there are three changes with respect to the case presented in Section 2.2.4. First, we assume that the effect on math learning is a third of the effect of the policy option with coaches, which will be 0.009 standard deviation (0.028/3).[36] This results in a total average benefit per person of US$ 49 (see column 3 of Table 2.13).[37]

[36] An experimental evaluation implemented in 2021 in Lima, Peru shows that, on average, 32 percent of students whose teachers that were offered coaching use the platform in a week. In turn, on average, 15 percent of students whose teachers were offered workshops use the platform in a week. Based on these statistics we would expect that platform use would be about ½ when providing workshops compared to when coaching is provided. However, it is important to note that these estimates correspond to a period when schools were closed in Lima and hence there was substantial demand among teachers to adopt learning platforms. We hypothesize that during "normal" times (post-pandemic) the relative adoption by teachers could be lower compared to the pandemic times because the incentives to exert the effort to adopt the platform with lower levels of support could decrease. Hence, we assume that adoption (and use) of the platform when providing workshops is only 1/3 compared to when coaching is provided. And because of the strong relationship between use and learning, we expect a similar reduction in learning effects.

[37] We present the case with coaches and infrastructure in column 4 so that we follow the same structure of the tables presented in the chapter.

Table 2.13. Benefit per Student of Different Policy Options to Promote Student Practice Using Technology in Peru

	Only workshops (1)	Only coaches (2)	Infrastructure and workshops (3)	Infrastructure and coaches (4)
Benefit per student from improved academic achievement (US$)	43	128	43	128
Increase in lifetime earnings (%)	0.05	0.15	0.05	0.15
Effect on learning (standard deviation)	0.005	0.014	0.005	0.014
Effect on math learning (standard deviation)	0.009	0.028	0.009	0.028
Increase in overall test scores (%)	50	50	50	50
Effect of increasing test scores by one standard deviation on earnings (%)	10.6	10.6	10.6	10.6
Lifetime earnings (US$)	88,072	88,072	88,072	88,072
Labor deductions of salary (%)	13	13	13	13
Increase in taxes per student (US$)	6	19	6	19
Benefit per student (US$)	49	147	49	147

Source: Authors' calculations.

Second, the variable cost is calculated as follows. We assume that each teacher attends three workshops per month and that a trainer conducts 20 workshops per month with 40 teachers in each one. This results in 267 teachers trained per month by one trainer (20*40/3). Considering that there could be scheduling issues, holidays, and other factors that reduce the production of workshops compared to an ideal scenario, we apply an adjustment factor of 50 percent and, hence, assume that 133 teachers are trained per month. Based on these calculations and a class size of 18.29 students (obtained from the 2019 school census), the total number of students whose teachers are trained per month will be 2,439 (133*18.29). Assuming a salary of US$ 1,604 per trainer per month, the salary cost per student will be US$ 0.66 (1,604/2,439). In addition, we include an overhead of 30 percent equivalent to US$ 0.20 (0.66*0.30), and, as was assumed for the case of coaching, we assume that 50 percent of teachers will be trained each year. Therefore, the total variable cost per student will be US$ 0.43 (see Table 2.14).

Table 2.14. Variable Cost per Student for Supporting Teachers with Workshops in Peru

Variable cost per student (US$)	0.43
Salary costs per student (US$)	0.66
Salary per trainer per month (US$)	1,604
Number of students whose teachers are trained per month	2,439
Overhead (%)	30
Overhead (US$)	0.20
Fraction of teachers trained each year (%)	50

Source: Authors' calculations.

The third change in this policy option in comparison to the one presented in Section 2.2.4 is that the tuition costs and opportunity costs are lower as the effect on math learning is lower. This results in a total average cost per student of US$ 24 (see column 2 of Table 2.15).

For the policy option that involves supporting teachers through coaches but that does not include purchasing new infrastructure there are two changes with respect to the case presented in Section 2.2.4: the target population is reduced to 974,298 students in 5,422 schools that can implement the program with their existing infrastructure, and all infrastructure costs are equal to zero. Therefore, this results in a total average cost per person of US$ 48 (see column 2 of Table 2.15).

Lastly, for the policy option that involves supporting teachers with workshops and that does not include purchasing new infrastructure there are four changes with respect to the case presented in Section 2.2.4. First, the target population is 974,298 students in 5,422 schools as presented in the policy option described in the previous paragraph. Second, the effect on math learning is 0.009, also reducing tuition and opportunity costs, as presented in the case of infrastructure with workshops. Third, the variable cost is US$ 0.43, as in the case of infrastructure with workshops. All infrastructure costs are equal to zero. This results in a total average benefit per person of US$ 49 (as in the case of infrastructure and workshops) and in a total average cost per person of US$ 16 (see column 1 of Table 2.15).

Table 2.15. Cost per Student of Different Policy Options to Promote Student Practice Using Technology in Peru

	Only workshops (1)	Only coaches (2)	Infrastructure and workshops (3)	Infrastructure and coaches (4)
Government cost (US$)	5	15	13	23
Fixed cost per student	0.82	0.82	0.44	0.44
Variable cost per student	0.43	3.05	0.43	3.05
Infrastructure cost per student	0.00	0.00	7.52	7.52
Tuition cost for government	3	8	3	8
Deadweight loss	1	2	2	4
Families cost (US$)	11	33	11	33
Tuition cost for families	5	15	5	15
Opportunity cost for families	6	19	6	19
Cost per student (US$)	16	48	24	56

Source: Authors' calculations.

2.2.6. Estimation of Benefits and Costs for Other Countries

For other countries for which we estimate this cost-benefit analysis (Chile, El Salvador, and Jamaica), we follow a similar procedure with the following modifications.

With respect to target population, the beneficiaries of the policy option with provision of infrastructure include students in grades 3 to 6 in all public primary schools reported by Ministry of Education in 2021 for Chile (823,766 students) and El Salvador (148,411 students), and in 2015 for Jamaica (142,827).[38] For the policy options without provision of infrastructure, the target population is calculated using an estimation of the percentage of students with complete infrastructure to implement the program. This estimation is based on information from the third round of the Comparative and Explanatory Regional Study (TERCE in Spanish) and the 2019 Peru school census. For Peru, we obtained the ratio between the percentage of students with complete infrastructure to implement the program according to the 2019 Peru school census and the percentage of students who attended schools with electricity, internet, and access to computers in TERCE 2013. This ratio is equivalent to 0.86 (54/62). Then, we apply this ratio to the percentage

[38] The Ministry of Education reported 156,095 students in primary grades 3 to 6. We consider 9 percent of them to be enrolled in private institutions as reported by UNESCO.

of students obtained from TERCE 2013 for the other countries.[39] For example, for Chile 94 percent of students attended schools with electricity, internet, and access to computers according to TERCE 2013. Applying the ratio estimated for Peru, 81 percent of students have complete infrastructure to implement the program (94*0.86). This implies that the target population for the policy options without provision of infrastructure is 663,632 students (823,766*0.81, see Table 2.16).

Table 2.16. Target Population of Policy Options without Provision of Infrastructure in Selected Countries

	Peru	**Chile**	**El Salvador**	**Jamaica**
Students in schools with electricity, internet, and access to computers (TERCE 2013, %)	62	94	34	38
Students with complete infrastructure (%)	54	81	29	33
Students in grades 3 to 6, public schools	1,819,261	823,766	148,411	142,827
Target population	974,298	663,632	42,966	46,501

Source: Authors' calculations.

For all policy options, the changes in the benefits include the estimation of the baseline discounted lifetime earnings using the information from the household surveys and the labor deductions of salary of each country. With respect to the average cost per person, the management cost changes as follows. The fixed cost for Peru is adjusted by the ratio between the average monthly labor income of each country and the average monthly labor income of Peru. For the variable cost in staff, there are two modifications, the salary per month for trainer/coach is adjusted by the ratio from the average monthly labor income, and the class size is the pupil-teacher ratio for primary schools of each country. We estimate the tuition cost considering the government expenditure per student in secondary and tertiary education and the percentage of tertiary students in public institutions for each country.[40] In regard to opportunity cost, we value the hours according

[39] TERCE 2013 does not include El Salvador or Jamaica. For these countries we run a regression on the percentage of students with electricity, internet and access to computers including the logarithm of GDP per capita as regressor.
[40] Government expenditure per student in tertiary education for El Salvador and the percentage of tertiary students in public institutions for Jamaica were not available. For these cases, we assume an average of other countries.

to the average hourly wage for full-time workers in the age groups considered obtained from the household survey of each country.[41]

For the policy options with provision of infrastructure, the total number of items to purchase is calculated following a procedure similar to that in the target population calculation for the policy options without provision of infrastructure. That is, we calculate the percentage of students with complete electronic devices, the percentage with access to electricity, and the percentage with access to internet using ratios from 2019 Peru school census and TERCE 2013. From this, we obtained the total number of students who need each of the items and assumed for all countries that the number of students who share each item is equal to the one of Peru.

2.2.7. Results

Table 2.17 summarizes the main components of the cost-benefit analysis for the four policies options in Peru and presents results on key indicators such as the benefit-cost ratio and the net present value. For the policy option with infrastructure and coaches, the total benefit per student is US$ 147. This amount includes benefits from improved academic performance (US$ 128) and labor tax increases (US$ 19). The total cost per student is US$ 56, of which US$ 23 is borne by the government and US$ 33 by families. Based on these estimates, we calculate a the net present value per student subtracting the cost per student to the benefit per student. Finally, considering that the target population for this program is 1.8 million students, the total net present value of the program for this policy option is estimated at US$ 165 million (see column 4 of Table 2.17).

For the policy option with infrastructure and workshops, both benefits and costs fall due to the reduction in the effect of the program. The total benefit per student is 49 dollars, and the total cost per student is US$ 24. This option generates a benefit-cost ratio of 2.00 and a total net present value of US$ 45 million (see column 3 of Table 2.17).

For the policy option without infrastructure and including coaches, the benefit per student remains at US$ 147, and the cost reduces to US$ 48 as this option does not include infrastructure costs. This option generates a a total net present value of US$ 97 million (see column 2 of Table 2.17).

[41] For Jamaica the sample was small, and we could not compute representative hourly wage for age groups. In this case, we adjust hourly wages for age groups by the ratio between hourly wage of all population between Peru and Jamaica

For the policy option without infrastructure and including workshops, the benefit per student is reduced due to the reduction in the effect of the program and the costs reduce as a result of both the reduction in the effect of the program and zero infrastructure costs. Therefore, the benefit per student is US$ 49, and the cost per student is US$ 16. This option generates a total net present value of US$ 32 million (see column 1 of Table 2.17).

The results for the other countries are presented in Tables 2.18, 2.19, and 2.20. These results should be interpreted with caution, as they are based on assumptions made from the comparison between a recent disaggregated database (2019 Peru school census) and an older, less disaggregated database (TERCE 2013).

Table 2.17. Cost-Benefit Analysis of Different Policy Options to Promote Student Practice Using Technology in Peru

	Only workshops (1)	Only coaches (2)	Infrastructure and workshops (3)	Infrastructure and coaches (4)
Benefit per student (US$)				
From improved academic achievement	43	128	43	128
Increase in taxes	6	19	6	19
Total benefit	49	147	49	147
Cost per student (US$)				
Government cost	5	15	13	23
Families cost	11	33	11	33
Total cost	16	48	24	56
Results				
Net present value per student (US$)	33	99	25	91
Target population (millions)	0.97	0.97	1.8	1.8
Total net present value (millions of US$)	32	97	45	165

Source: Authors' calculations.

Table 2.18. Cost-Benefit Analysis of Different Policy Options to Promote Student Practice Using Technology in Chile

	Only workshops (1)	Only coaches (2)	Infrastructure and workshops (3)	Infrastructure and coaches (4)
Benefit per student (US$)				
From improved academic achievement	81	243	81	243
Increase in taxes	18	55	18	55
Total benefit	99	298	99	298
Costs (US$)				
Government cost	9	24	12	27
Families cost	23	68	23	68
Total cost	31	92	34	95
Results				
Net present value per student (US$)	68	206	65	203
Target population (millions)	0.66	0.66	0.82	0.82
Total net present value (millions of US$)	45	137	53	167

Source: Authors' calculations.

Table 2.19. Cost-Benefit Analysis of Different Policy Options to Promote Student Practice Using Technology in El Salvador

	Only workshops (1)	Only coaches (2)	Infrastructure and workshops (3)	Infrastructure and coaches (4)
Benefit per student (US$)				
From improved academic achievement	35	105	35	105
Increase in taxes	1	3	1	3
Total benefit	36	108	36	108
Cost per student (US$)				
Government cost	25	30	25	30
Families cost	9	27	9	27
Total cost	34	57	34	58
Results				
Net present value per student (US$)	2	51	2	51
Target population (millions)	0.04	0.04	0.15	0.15
Total net present value (millions of US$)	0.1	2	0.3	8

Source: Authors' calculations.

Table 2.20. Cost-Benefit Analysis of Different Policy Options to Promote Student Practice Using Technology in Jamaica

	Only workshops (1)	Only coaches (2)	Infrastructure and workshops (3)	Infrastructure and coaches (4)
Benefit per student (US$)				
From improved academic achievement	17	52	17	52
Increase in taxes	1	4	1	4
Total benefit per student	19	56	19	56
Cost per student (US$)				
Government cost	20	26	22	29
Families cost	9	27	9	27
Total cost	29	53	31	56
Results				
Net present value per student (US$)	-10	3	-12.5	0.7
Target population (millions)	0.05	0.05	0.14	0.14
Total net present value (millions of US$)	-0.46	0.15	-1.78	0.09

Source: Authors' calculations.

3. Cost-Benefit Analysis of Digital Interventions in Health

This section presents the methodology and assumptions of the two cost-benefit analyses presented in Chapter 3 of the report, entitled "Time for an Upgrade: Using Digital Interventions to Tackle Non-communicable Diseases." The present section of this technical note has two parts. The first part presents the cost-benefit analysis of three modalities of providing cognitive behavioral therapy to reduce depressive symptoms, which is presented in Section 3.4.1 of the mentioned chapter. The second part describes the cost-benefit analysis of a program that involves sending text messages to prevent the onset of diabetes, which is presented in Section 3.4.2 of the mentioned chapter.[42]

[42] For more information on technical details, please contact Pedro Bernal (pbernallara@iadb.org), the corresponding author for this section of this technical note.

3.1. Cost-Benefit Analysis of Different Modalities to Provide Cognitive Behavioral Therapy

This section presents the methodology and assumptions of the cost-benefit analysis presented in Chapter 3, Section 3.4.1 of the report. Common assumptions presented in Section 1 of this technical note apply to this analysis. All the data sources used to provide estimates for the different parameters in this analysis are included in the Annex 3.2 of this technical note.

3.1.1. Background

Depression is a common but serious mental health disorder that interferes with virtually all aspects of daily life including working, sleeping, and interacting with others. It is a major contributor to the overall global burden of disease (World Health Organization, 2021). In LAC, depression affects 3.7 percent of the population, and women are almost twice as likely to be affected as men. During 2020, with the COVID-19 pandemic, the prevalence of depression has increased from 3.7 percent to 4.6 percent in LAC (Santomauro et al., 2021). While depression can be treated cost-effectively with psychotherapy and/or medication (World Health Organization, 2021), the resources allocated by LAC countries to tackle mental health are insufficient, inefficiently used, and are inequitably distributed. In fact, prior to the pandemic 73 percent of adults in the region with depression did not receive treatment (Pan American Health Organization, 2014). Moreover, there are substantial inequities in the geographical distribution of providers. For example, most human resources for mental health are concentrated in large urban areas and in psychiatric hospitals (Pan American Health Organization, 2013a). The stigma, social exclusion, and discrimination surrounding mental disorders can also make care-seeking complex (Pan American Health Organization, 2014). Timely detection and treatment are a challenge, and median public spending on mental health across the region is a mere 2.0 percent of the health budget, with the majority (60 percent) of this allocated to psychiatric hospitals (Pan American Health Organization, 2014).

3.1.2. Program and evaluation

Cognitive behavioral therapy (CBT) is an effective method to treat a range of mental health conditions including depression (Butler et al., 2006; Shafran et al., 2009; NICE, 2009). CBT aims to provide skills to alter thought processes and modify behavior, focusing on daily difficulties and the development of skills to overcome them. CBT is a recommended treatment for persons experiencing depression and could be effective without medication (World Health Organization, 2015; Herrman et al., 2022). During therapy sessions patients learn cognitive, behavioral, and mindfulness-based strategies with assignments between sessions.

Therapy is usually delivered for 10 to 12 weekly sessions by psychologists or psychotherapists, and this number of sessions is enough to reduce depressive symptoms (Andersson et al., 2016). There are several ways to deliver this type of therapy, including in-person, group and telephone sessions or modules via websites, apps, and chatbots. All delivery modes share a similar structure in sessions/modules containing information on psychoeducation and practical exercises to be completed between sessions. This technical note presents information and analyses for three delivery modes: in-person, telephone, and internet-based CBT or iCBT (i.e., delivered via app or website).

Face-to-Face Cognitive Behavioral Therapy

The traditional and most common delivery form of CBT is face-to-face or in-person sessions. Face-to-face CBT consists of between 10 to 12 weekly sessions of at least 30 minutes each. Therapists need a minimum of six hours to perform full therapy for every patient they are treating. Cuijpers et al. (2019), in a meta-analysis comparing different delivery formats of CBT, suggest that in-person CBT is one of the best forms of therapy and produces the highest effects (see Table 3.1).

Telephone-Based Cognitive Behavioral Therapy

Telephone-based CBT is delivered for 10 to 12 weekly sessions of 30 minutes by a therapist (Castro et al., 2020). As in in-person CBT, therapists need a minimum of six hours to complete 12 sessions and complete treatment. The intervention is delivered via phone calls without in-person interaction. Telephone therapy has the potential to offer patients immediate help and anonymous treatment without the need to visit a mental health center. It could also be a particularly relevant form of therapy in areas where there is limited availability of trained therapists. Telephone CBT could have effects similar to those of in-person therapy in reducing depressive symptoms (Cuijpers et al., 2019; see Table 3.1).

Internet-based cognitive behavioral therapy guided by a therapist

Mental health care for depression has received a boost due to technological advances during the last 20 years. Therapeutic interventions, including CBT, are increasingly delivered via websites (iCBT). Internet-based interventions can be delivered with (guided) and without psychologist support (unguided). iCBT consists of therapy delivered with modules via websites. Therapists need 1.5 to two hours of guidance compared to the total of six hours in face-to-face or telephone CBT. Guided iCBT shows promising results in reducing depressive symptoms, with effects that are slightly lower than those of in-person therapy, although the difference between the two is statistically insignificant (Cuijpers et al, 2019).

Table 3.1. Effect Sizes of Different Modalities to Provide CBT

	Face-to-face	Telephone	Guided iCBT
Effect size	1.02 [0.80-1.24]	1.02 [0.63-1.42]	0.87 [0.69-1.04]

Source: Cuijpers et al. (2019).
Notes: Effect sizes in standardized mean differences relative to a waiting list as a control group of depression symptom reduction from Cuijpers et al. (2019) network meta-analysis. 95 percent confidence intervals in square brackets.

3.1.3. Overview of the Approach Followed to Estimate Benefits and Costs

We conduct three cost-benefit analyses of implementing face-to-face, telephone and guided iCBT based on the contexts of Peru, Chile, El Salvador, and Jamaica. We assume that this program will be targeted to adults with moderate to severe depression, without access to mental health services and with coverage of mobile-based internet (in the case of iCBT). The scenario we consider for all modalities of CBT is one in which each modality is compared to a counterfactual of receiving no care, which is the most common case in the region. In addition, given that the most common constraint for health ministries in the region is having trained human resources to provide therapy, we consider for all countries and modalities a scenario in which a fixed number of psychologists provide CBT. That is, we assume that 2 percent of the supply of psychologists in each country is assigned to provide CBT for depression. Table 3.2 presents the number of psychologists that we consider for each country based on this assumption.

Table 3.2. Psychologists Considered for the Cost-Benefit Analysis of CBT in Selected Countries

	Peru	Chile	El Salvador	Jamaica
Number of therapists	70	41	3	1

Source: Authors' calculations.
Notes: We assume that 2 percent of the total supply of psychologists per country provide CBT for every intervention, based on the number of psychologists per capita from Pan American Health Organization (2013b).

In terms of benefits, we consider only health benefits, which are measured as the increase in Quality-Adjusted Life Years (QALYs)[43] for each patient targeted by the CBT program. We do not consider any benefits related to savings to the health systems in terms of avoiding or preventing more severe depression, since most cases go untreated. Moreover, we do not consider other benefits such as increased productivity at work or spillover effects on other household members (such as children). In our analysis, we consider both implementation and patient costs. Implementation costs include the operating costs of the intervention, including costs related to phone calls, therapists' wages, or internet access. Patient costs include mostly opportunity costs, which include patients' time used to complete treatment and travel time to health care center (in the case of face-to-face therapy), as well as out-of-pocket costs to access treatment. Those involve transportation costs in the case of in-person therapy and internet usage in the case of guided iCBT. In addition, we estimate the cost-benefit analysis for a total of one year of implementation.

3.1.4. Estimation of Benefits and Costs

This section describes how we estimate the benefits and costs of CBT programs for the base country: Peru. For other countries for which we estimate this cost-benefit analysis (Chile, El Salvador, and Jamaica), we follow a similar procedure and use similar data sources as in the case of Peru.

Target Population

The target population of this programs include adults with moderate to severe depression, without access to mental health services and with coverage of mobile-based internet (in the case of iCBT). While the potential pool of the population that could benefit from the intervention is relatively large, the main constraint is the number of therapists: the total population that could benefit from treatment is restricted by the number of therapists. In the case of Peru, we consider 70 psychologists, which represent about 2 percent of the supply of psychologist in the country, and close to 40 percent of what Peru is adding yearly over the next three years to staff for expanding

[43] The quality-adjusted life year (QALY) is used as a summary measure of health outcome for economic evaluation. The QALYs is a standard measure of health outcome and enables comparison across different disease areas. The advantage of using an approach based on computing QALYs is that it allows combining effects of health interventions on mortality and morbidity into a simple index (Whitehead and Ali, 2010).

community mental health centers (*Centros de Salud Mental Comunitarios*).[44] This number of psychologists could treat a total of 15,680 patients during one year in the case of face-to-face CBT and telephone CBT and 47,040 in the case of guided iCBT (see Table 3.3). The main difference between modalities is due to the time the therapist needs to interact with the patient (six hours for face-to-face and telephone CBT, and two hours for guided iCBT). In addition, we assume psychologists devote 70 percent of their time per day to providing therapy and the rest to administrative or coordination activities, which means we consider a total of 1,344 working hours providing therapy during a year. This translates into 224 patients treated in a year per therapist for face-to-face and telephone, and 672 for guided iCBT. Taking adherence rates into account, a total of 84.7 percent will complete face-to-face and telephone treatments and 65.1 percent will complete the guided internet-based treatment (Van Ballegooijen et al., 2014). Hence, the total number of patients completing full treatment is 13,281 per year for telephone and face-to-face and 30,623 for guided iCBT. Note that the number of patients who complete treatment is much higher for guided iCBT as a result of two opposing effects. First, guided iCBT requires only one third of the psychologist's time compared to the other two options, and hence it is possible to treat three times more patients under this modality. Second, the share of patients who complete treatment is 65 percent for guided iCBT compared to 85 percent for the other two options. Because the first effect is much larger, it dominates the second effect and, overall, the number of patients who complete treatment is about 130 percent larger for guided iCBT compared to the other two modalities.

[44] According to the Peruvian Ministry of Health it is expected to start operating 60 *Centros de Salud Mental Comunitarios* (CSMC) every year in the next three years and the guidelines establish that three psychologists are added to staff in each CSMC. In this way, it is expected to increase the availability of psychologists by 180 for CSMC.

Table 3.3. Patients Starting and Completing Treatment for Different Modalities of CBT in Peru

	Face-to-Face	Telephone	Guided iCBT
Psychologists	70	70	70
Time requirements (hours)			
Psychologist time per patient	6	6	2
Patients time to complete treatment	6	6	8
Number of patients covered			
Patients starting treatment	15,680	15,680	47,040
Adherence	84.7%	84.7%	65.1%
Patients completing treatment	13,281	13,281	30,623

Source: Authors' calculations.
Notes: Estimates of patients starting and completing treatment in one year based on each of the 70 psychologists working full-time for each modality and devoting 70 percent of their time to treating patients. We use Van Ballegooijen et al. (2014) for the adherence figures.

Average Benefit per Person

The benefits of the interventions are estimated as the increase in Quality-Adjusted Life Years (QALYs) for each patient targeted by the CBT program. To that end, we reviewed the literature documenting the effects of CBT treatments for depression measured in QALYs and establish that CBT interventions produce an increase of 0.064 QALYs per month (Wu et al., 2020). We assume that the duration of the effect of completing treatment lasts three months, meaning a total effect of 0.192 gained QALYs for every patient (0.064*3). This is a conservative estimate for the duration of the effect, which according to the literature could range between three to six months (Bennet et al., 2020; Nair et al., 2018). As a reference, Ross et al. (2019) estimate the QALYs gained from in-person CBT relative to no treatment as 0.715 over one year, which will translate to around 0.18 QALYS in three months, which is comparable to the figure we use.

The QALYs gained of 0.192 is for the case of traditional face-to-face CBT treatment. We consider the relative effect sizes, from Cuijpers et al. (2019), to determine the QALYs gained under each modality. For instance, since telephone CBT has the same effect size than face-to-face, we consider 100 percent of the QALYs obtained from traditional face-to-face treatment in the telephone modality (0.192 QALYs). In contrast, guided iCBT has an effect size that represents 85.3 percent of that from face-to-face CBT, and therefore we consider 0.164 as the QALYs gained from this modality (0.853*0.192).

To define the monetary gain of an additional QALY, we assume that its value is measured by the GDP per capita of each country.[45] The GDP per capita of Peru estimated by the International Monetary Fund (IMF) is US$ 6,781.12. We estimate a monetary benefit per patient of US$ 1,301.97 for face-to-face and telephone CBT (6,781.12*0.192) and US$ 1,110.51 for guided iCBT (6,781.12*0.164). Then, the total benefit per user is US$ 1,301.97 for face-to-face and telephone CBT and US$ 1,110.51 for guided iCBT (see Table 3.4).

Table 3.4. Benefit per Patient Completing Treatment of Different Modalities to Provide CBT in Peru

	Face-to-Face	Telephone	Guided iCBT
Gained QALYs with treatment	0.192	0.192	0.164
Effect of CBT (QALYs per month)	0.064	0.064	0.064
Duration of effect assumed (months)	3	3	3
% Effect received	100%	100%	85.3%
Value of QALY (US$)	6,781.12	6,781.12	6,781.12
Benefit per patient (US$)	1,301.97	1,301.97	1,110.51

Source: Authors' calculations.
Notes: The percentage of effect received is based on the relative effect sizes from Cuijpers et al. (2019). The gained QALYs are per month after treatment finalization. The QALYs per month gain are based on Wu et al. (2020). We assume that the value of QALY is equal to GDP per capita for the country. All monetary figures are in US$.

Average Cost per Person

Common costs for the three CBT modalities. We consider two similar implementation costs across CBT modalities: personnel costs and personnel training costs. Additionally, we consider for all modalities the opportunity costs for patients due to completion of the treatment. The personnel cost is the hourly payment to therapists that treat patients. There is limited information about the wages of psychologists in the region, and to ensure comparability across the analyses for all countries we use a common source for these data. Our data for wages are based on Serje et al.

[45] There is substantial discussion in the literature on the best approach to value a QALY, particularly in the context of low-and-middle income countries (Marseille et al., 2015; Woods et al. 2016). The WHO recommends as a threshold for cost-effectiveness analysis using between one and three GPDs per capita, and NICE (from the United Kingdom) usually considers this threshold to be between around US$ 30,000 - £ 25,000 (Donaldson et al., 2011). Some agencies in Latin American countries recommend using one GPD per capita (CSG, 2017) to value QALYs in cost-benefit analysis, and we hence use this approach.

(2018), which estimates earnings of different types of health workers as a multiple of GDP per capita for countries according to their income-level. Since there is no specific data on psychologists, we use physicians' earnings as a proxy, which in the case of Peru is 2.7 times of GDP per capita. Using this assumption, yearly therapist wages are US$ 18,309.01 (6,781.12*2.7) and the hourly wage is US$ 13.62. To estimate the personnel cost per patient treated we consider the amount of time required for treatment plus an additional 30 percent of time to account for administrative or coordination activities. Hence for CBT modalities that last six hours for full treatment (face-to-face and telephone), we obtain a total therapist wage of US$ 106.26 per patient (13.62*6*1.3), and for guided iCBT, with two hours, a total wage of US$ 35.42 (13.62*2*1.3) per patient.

Training costs are applied to telephone and guided iCBT treatments. We assume that therapists receive some training prior to the start of program (e.g., how to provide telephone-based therapy or how to best guide a patient using iCBT) and that it lasts for one day of work. The total cost of training then consists of the time of the therapist to complete training (8 hours or US$ 109) plus the training cost (e.g., materials and instructors), which we assume at US$ 15 per therapist. Total cost of training is therefore US$ 124 per psychologist (109+15) for a total of US$ 8,678.8 for 70 psychologists. We obtain a training cost per patient of US$ 0.65 (8,678.8/13,281) for telephone CBT and US$ 0.28 (8,678.8/30,623) for guided iCBT.

The main patient cost that is common across modalities is patient's time to complete treatment, which is the opportunity cost of completing the therapy. Based on the treatment duration considered in this analysis, a patient will need a total of six hours to complete face-to-face and telephone CBT and eight hours (six of treatment and two of guidance) for guided iCBT. For the average hourly wage per country, we use the estimation of the International Labour Organization. That is, the average hourly wage for Peru is US$ 2.6 and gives a total of US$ 15.6 for face-to-face and telephone (2.6*6) and US$ 20.8 for guided iCBT (2.6*8). The estimate approximates the patients' average lost wages for completing the treatment.

For the estimation of the final per patient implementation cost we include an overhead cost component and a deadweight loss component. We assume an additional 15 percent to implementation cost as an overhead to account for administration costs that could include therapists' supervisors, managers, administrative staff, offices, materials, and other costs related to administration of the intervention.[46] We also assume an additional 20 percent of implementation costs (including administration costs) of deadweight loss since we consider that the intervention will be publicly funded and hence, there are distortions introduced into the economy by the collection of taxes to fund these services, as described in Section 1. As an illustration, if the per patient implementation cost is US$ 100, with the additional 15 percent of overhead, we now have an implementation cost of US$ 115 (100*1.15), and, with the additional 20 percent of deadweight loss, we obtain a final per patient implementation cost of US$ 138 (115*1.2).

Face-to-Face cognitive behavioral therapy. In addition to the common costs, we include two specific patient costs for face-to-face therapy. The first cost is the transportation cost that a patient incurs to get to the health center, and the second cost is the patient cost measured as the time the patient needs to get to health center. To estimate the time and distance that patients need to travel to get to a health center, we use data from Weiss et al. (2020). They estimate the distance between a patient's home and a health center in car time for proportions of population in four intervals: less than 10 minutes, 10 to 30 minutes, 30 to 60 minutes, and more than 60 minutes. With the average time, for every interval, we can obtain the distance that patients need to travel with an average car speed of 30 kilometer per hour. We assume that an average car can travel 12 kilometers for each liter of gasoline, and we obtain the gasoline needed to get to the health center. To estimate the total gasoline cost to travel, we retrieve data of the gasoline price per liter in Peru from Global Petrol Prices, which is US$ 1.499. We use the gasoline costs estimated on Table 3.5 to travel to the nearest health center as a proxy for transportation prices.

Table 3.5. Travel Time and Transportation Cost to a Health Center

Distance from home	% Of population	Average travel time (hours)	Distance traveled (km)	Gasoline liters needed	Gasoline cost (US$)
< 10 minutes	46.10%	0.08	2.50	0.208	0.31
10-30 minutes	16.80%	0.33	10.00	0.833	1.25
30-60 minutes	12.00%	0.75	22.50	1.875	2.81
> 60 minutes	25.10%	1.50	45.00	3.750	5.62

Source: Authors' calculations based on Weiss et al. (2020).

[46] Based on Dhaliwal et al. (2013).

With the information presented in Table 3.5 we are able to measure the average transportation cost and travel time to a health center. The average travel time to a health center is 0.56 hours, calculated as a weighted average between the percentage of population and average travel time. Then, every patient needs to go to the health center and return to their home 1.12 hours, which is the average travel time for each session. The estimation of the average travel cost follows the same idea: we calculated the weighted average between the percentage of population and gasoline cost for the distance traveled. The result is US$ 2.1 to get to the health center, given a total of US$ 4.2 for each session. Total cost of transportation per patient for all sessions is US$ 50.45 (4.2*12) and total cost of travel time, measured with the average hourly wage, is US$ 35 (1.12*12*2.6).

The total cost for the implementer is the sum of personnel cost, administrative cost and deadweight loss, with a total of US$ 146.64 (106.26 + 15.94 + 24.44). The total patient costs per patient is the sum of wage loss of time to complete treatment, wage loss of travel time and travel cost to health center, with a total of US$ 101.03 (15.59 + 34.99 + 50.45). With the cost for the implementer and patient costs, we obtain a total cost of the intervention per patient of US$ 247.67 (see Table 3.6).

Table 3.6. Cost per Patient of Face-to-Face CBT in Peru

Cost for the implementer per patient (US$)	146.64
Implementation costs including administrative costs	122.20
Personnel cost	106.26
Administrative cost (15%)	15.94
Deadweight loss (20%)	24.44
Patient cost per patient (US$)	101.03
Wage loss due to patient's time to complete treatment	15.59
Wage loss due to patient's travel time	34.99
Travel cost	50.45
Total cost per patient (US$)	247.67

Source: Authors' calculations based on a scenario of 70 psychologists providing treatment.
Notes: Cost for the implementer per patient includes 15 percent of overhead and 20 percent of estimated deadweight loss. Fifteen percent of overhead is calculated from the total implementation cost per patient, and 20 percent of deadweight loss is calculated from the total implementation cost per patient plus overhead.

Telephone-based cognitive behavioral therapy. In addition to common costs, we consider one additional implementation cost for telephone CBT: the costs necessary to complete phone calls. We consider that these costs are assumed by the implementer, since free calls can be provided via an 800 number. We assume that each session will take 30 minutes via phone calls. With a total of 12 sessions, we assume that the program will take six hours of calls between therapists and patients. This is the same duration we consider for face-to-face CBT.

To estimate phone calls cost, we assume that a group of patients will receive the calls with an 800 number and other group will receive the calls via internet. On one hand, based on the costs of a Latin American company, we obtain that a 30-minute cost of an 800 phone calls is US$ 1.982. On the other hand, we obtain an average cost of gigabyte (GB) from the four main mobile phone companies in Peru so we can estimate the cost of internet calls. Considering that two megabytes (MB) are needed for a minute of internet audio call, we need 0.06 GB for a 30-minute session.[47] The average cost per mobile GB is US$ 1.1, meaning that the cost of 30-minute call via internet is US$ 0.06. We define which patients are receiving internet calls based on the mobile-based internet coverage of each country. For the Peruvian case, we obtain that 50.5 percent of population has access to mobile internet. The total cost of phone calls per patient is the weighted average between the cost associated with the use of an 800 number and the cost of using internet calls for those with mobile internet coverage. The cost per patient of phone calls for 12 sessions of 30-minute each is US$ 12.18 (0.06*12*0.505 + 1.98*12*0.495).

We estimate a total cost for the implementer per patient of US$ 164.35, as the sum of personnel cost, personnel training cost and phone calls cost with overhead (15 percent) and deadweight loss (20 percent) and a total patient cost per patient of US$ 15.59, from the time that a patient needs to complete treatment. The total cost of intervention per patient is US$ 179.94 (see Table 3.7).

[47] Based on www.techradar.com/deals/how-much-data-do-i-need.

Table 3.7. Cost per Patient of Telephone CBT in Peru

Cost for the implementer per patient (US$)	164.35
Implementation costs including administrative costs	136.95
Personnel cost	106.26
Personnel training cost	0.65
Phone calls cost	12.18
Administrative cost (15%)	17.86
Deadweight loss cost (20%)	27.39
Patient cost per patient (US$)	15.59
Patient time to complete treatment	15.59
Total cost per patient (US$)	179.94

Source: Authors' calculations based on a scenario of 70 psychologists providing treatment.
Notes: Cost for the implementer per patient includes 15 percent of overhead and 20 percent of estimated deadweight loss. Fifteen percent of overhead is calculated from the total implementation cost per patient and 20 percent of deadweight loss is calculated from the total implementation cost per patient plus overhead.

Internet-based cognitive behavioral therapy guided by a therapist. In addition to common costs, we include one implementation cost and two patient costs for guided iCBT: an implementation cost of software and internet usage for calls with therapists, and patient time cost to complete treatment and usage of internet. Unlike telephone CBT, we consider that in guided iCBT the calls are made only by internet and not by landline, because internet calls are less expensive than landline calls and the intervention is already via internet. We assume the same call costs as the telephone case (US$ 0.06 for a 30-minute audio call). In guided iCBT, we consider that the guided part consists of a total of two hours of calls (Etzelmueller et al., 2020; Josephine et al., 2017) with a total call cost of US$ 0.26 (0.066*4) per patient.

For the license of the software, we use the cost of "*Beating the Blues*," a program included in several meta-analysis and literature reviews. The licensing is based on an annual subscription per psychologist, in which the psychologist can refer unlimited patients to complete the iCBT program. The program has a weekly cost of US$ 13.19 per therapist with a yearly cost of US$ 633.12. This type of pricing is relevant for the cost-benefit analysis since it reflects more clearly the marginal cost of adding an additional patient to iCBT once it has been developed. Though currently *Beating the Blues* is not available in Spanish, we consider a similar pricing could be obtained for an iCBT even if it is fully developed for the LAC context, as long as it has the right scale of patients to treat. We include the total number of therapist (70) of the program and the total number of patients starting the treatment (47,040) to calculate the software per patient cost. Finally, the cost per patient is US$ 0.94 (633.12*70/47,040).

The internet cost is estimated in the same way as in the case of telephone intervention. We assume that patients need a total of one GB of internet use for all the intervention. We estimate that one half will be used for videos and the other half will be used for other multimedia and documents.[48] Cost per GB is US$ 1.09, with a total of US$ 1.09 for all the intervention. Total cost for the implementer per patient is US$ 50.93, as the sum of personnel cost, personnel training cost, software cost, phone calls cost, overhead cost and deadweight loss cost. Total patient cost per patient is US$ 22.15, from the time that patients need to complete the treatment and internet costs. Note that, unlike face-to-face and telephone, patient costs are higher due to treatment lasts eight hours (six of treatment and two of guidance) instead of six hours (see Table 3.8).

Table 3.8. Cost per Patient of Guided iCBT in Peru

Cost for the implementer per patient (US$)	50.93
Implementation costs including administrative costs	42.44
Personnel cost	35.42
Personnel training cost	0.28
Software cost	0.94
Phone calls cost	0.26
Administrative cost	5.54
Deadweight loss cost	8.49
Patient cost per patient (US$)	22.15
Patients time to complete treatment	20.79
Internet cost	1.09
Total cost per patient (US$)	73.08

Source: Prepared by the authors based on a scenario of 70 psychologists providing treatment.
Notes: Cost for the implementer per patient includes 15 percent of overhead and 20 percent of estimated deadweight loss. Fifteen percent of overhead is calculated from the total implementation cost per patient, and 20 percent of deadweight loss is calculated from the total implementation cost per patient plus overhead.

[48] Beating the Blues has a duration of 24 modules each lasting around 15 minutes. Assuming each module has a five-minute video, this could use approximately 480 MB of data (a total of two hours of video at resolution similar to that of the default on Youtube). We consider then than a GB will be more than enough as an estimate of the internet usage if the content of Beating the Blues uses plenty of multimedia. See www.techradar.com/deals/how-much-data-do-i-need for the estimates of data requirements of video considered.

Benefits and Costs of Patients Who Do Not Complete Treatment

So far, we have included the benefits and costs for patients who complete the full treatment. However, a portion of patients do not complete the treatment (documented to be higher for iCBT compared to the other two modalities). To include the benefits and costs of patients who do not complete the treatment, we assume that they have proportional benefits and costs based on the number of sessions completed. For example, in the case of in-person and telephone CBT, which includes a total of 12 sessions, we assume that, among those who drop out, 9.1 percent (1 out of 11 sessions completed) do so after the first session, 9.1 percent leave after the second session, and so on. We also assume that patients who drop out after the first session receive 8.3 percent (1/12) of the benefit, but also incur 8.3 percent of the costs. For the patients who drop out after the second session, we assume that they experience 16.7 percent of the benefits and costs (2/12), and so on.

In the case of guided iCBT the scenario is similar. The main difference is that literature reviews of Beating the Blues suggest that half of patients who drop out do so after the first two sessions. Hence, we consider that 25 percent of patients who drop out, leave after the first session, and 25 percent leave after the second session. We thereafter assume a linear cumulative drop out rate. The benefits received and the costs incurred in this treatment behave in the same way as the previous ones. See Table 3.9 for the summary of total benefits and costs of the intervention for patients who do not complete treatments.

Table 3.9. Benefits and Costs of Patients Who Do Not Complete Treatment of Different Modalities to Provide CBT in Peru

	Face-to-Face	Telephone	Guided iCBT
Total benefits (millions of US$)	1.6	1.6	7.4
Total costs (millions of US$)	0.3	0.2	0.5

Source: Authors' calculations based on a scenario of 70 psychologists providing treatment and adherence figures from Van Ballegooijen et al. (2014).

Notes: Estimates based on the assumption that patients receive proportional benefits and costs depending on the number of sessions completed. We assume patients linearly leave the program in both face-to-face and telephone CBT. For the case of guided iCBT, based on the literature, we consider that 50 percent of patients dropout after the second session and linearly afterwards.

3.1.5. Results

Table 3.10 summarizes all the benefits and costs for the cost-benefit analysis for the three different modalities of iCBT for Peru. We include all the costs, that is, implementation, patient, administrative and deadweight loss costs. We also include the benefits and costs for all the patients who do not finish the treatment.

Table 3.10. Cost-Benefit Analysis of Different Modalities to Provide CBT in Peru

	Face-to-Face	Telephone	Guided iCBT
Time requirements (hours)			
Psychologist time per patient	6	6	2
Patients time to complete treatment	6	6	8
Number of patients covered			
Patients starting treatment	15,680	15,680	47,040
Adherence	84.7%	84.7%	65.1%
Patients completing treatment	13,281	13,281	30,623
Benefit per patient who finished treatment (US$)			
Total benefit per patient	1,301.97	1,301.97	1,110.51
Cost per patient who finished treatment (US$)			
Implementation cost	106.26	119.09	36.9
Administrative cost	15.94	17.86	5.54
Deadweight cost	24.44	27.39	8.49
Patients cost	101.03	15.59	22.15
Total costs per patient	247.67	179.94	73.08
Patients who finished treatment (millions of US$)			
Total benefits	17.3	17.3	34.0
Total costs	3.3	2.4	2.2
Patients who did not finish treatment (millions of US$)			
Total benefits	1.6	1.6	7.4
Total costs	0.3	0.2	0.5
All patients (millions of US$)			
Total benefits	18.9	18.9	41.4
Total costs	3.6	2.6	2.7
Benefit-cost ratio	**5.3**	**7.2**	**15.3**
Net present value (millions of US$)	**15.3**	**16.3**	**38.7**

Source: Authors' calculations based on a scenario of two percent of the supply of psychologists providing treatment for each modality.
Notes: Estimates also consider adherence figures from Van Ballegooijen et al. (2014). All monetary figures are in US$. Details of the calculations can be found in the preceding tables.

Table 3.11 summarizes the main results of the cost-benefit analysis performed for Peru, Chile, El Salvador, and Jamaica. We include the benefits and costs for patients who complete the treatment and for those who do not complete the treatment. As stated before, all estimates for all countries are based on calculations and data sources similar to those discussed for Peru in the previous section. In the table we can see the total benefits and costs of implementing face-to-face CBT, telephone CBT, and guided iCBT. We can also see the benefit-cost ratios and the total net present value of the three interventions. For example, total benefit of implementing guided iCBT is US$ 41.41 million and total cost is US$ 2.7 million in Peru. With these estimates, we calculate a benefit-cost ratio of 15.27 and a net present value (benefit minus cost) of US$ 38.7 million.

Table 3.11. Cost-Benefit Analysis of Different Modalities to Provide CBT in Selected Countries

	Face-to-Face	Telephone	Guided iCBT
Peru			
Total benefit (millions of US$)	18.9	18.9	41.4
Total cost (millions of US$)	3.6	2.6	2.7
Benefit-cost ratio	5.3	7.2	15.3
Net present value (millions of US$)	15.3	16.3	38.7
Chile			
Total benefit (millions of US$)	28.8	28.8	63.3
Total cost (millions of US$)	3.6	2.7	3.2
Benefit-cost ratio	8.0	10.8	20.0
Net present value (millions of US$)	25.2	26.1	60.2
El Salvador			
Total benefit (millions of US$)	0.5	0.5	1.2
Total cost (millions of US$)	0.1	0.1	0.1
Benefit-cost ratio	3.8	3.9	9.1
Net present value (millions of US$)	0.4	0.4	1.0
Jamaica			
Total benefit (millions of US$)	0.2	0.2	0.5
Total cost (millions of US$)	0.0	0.0	0.0
Benefit-cost ratio	5.5	7.7	16.4
Net present value (millions of US$)	0.2	0.2	0.5

Source: Prepared by the authors based on a scenario of two percent of the supply of psychologists providing treatment for each modality.
Notes: Estimates also consider adherence figures from Van Ballegooijen et al. (2014). Total benefits and total costs include benefits and costs of patients who complete treatment and patients who do not complete treatment. All monetary figures are in US$. Details of the calculations can be found in the preceding tables.

3.2. Cost-Benefit Analysis of an SMS Intervention for Prediabetic Patients

This subsection presents the methodology and assumptions of the cost-benefit analysis presented in Chapter 3, Section 3.4.2 of the report. Common assumptions presented in Section 1 of this technical note apply to this analysis. All the data sources used to provide estimates for the different parameters in this analysis are included in Annex 3.3 of this technical note.

3.2.1. Background

One of the critical health challenges in Latin America and the Caribbean is the growing prevalence rates of noncommunicable diseases and the burden it imposes on population health and on health systems. In fact, it is estimated that the number of people with Type 2 Diabetes has tripled in the region since 1980 (World Health Organization, 2016b).[49] Moreover, the Pan American Health Organization (PAHO) estimates that 30 to 40 percent of people with diabetes in the Americas are undiagnosed, and between 50 to 75 percent of cases of diabetes in the region are not being treated (PAHO, 2022). Along with this growing prevalence, its economic burden is expected to rise substantially in the coming decades, in terms of both direct healthcare costs and indirect costs measured in terms of foregone earnings due to years of productive life lost as a result of premature mortality and disability (World Health Organization, 2016b; Bloom et al., 2011).

3.2.2. Program and Evaluation

The cost-benefit analysis presented here estimates the potential social returns of a digital health application that seeks to reduce the onset of diabetes among persons identified as prediabetic, who are at the highest risk of developing this condition. There is evidence that structured lifestyle interventions that help patients at risk of developing diabetes to reduce weight and increase physical activity by providing education, coaching, and support can be highly effective in reducing the onset of diabetes and that the effects are persistent for over 10 years (Ali et al., 2017; Diabetes Prevention Program Research Group, 2002, 2009). However, these interventions tend to be costly and hard to scale, as they are intensive in human resources. For this reason, substantial research has been done to develop digital adaptations so they can be less intensive in human resources, less

[49] Diabetes is a chronic condition that affects how the body regulates blood glucose. There are two types of diabetes, Type 1, which is genetic, whereas Type 2 is related to risk factors in lifestyle. Type 2 is the most common form of this disease.

costly, more scalable, and hence more feasible in the context of lower- and middle-income countries.

In this setting, we conduct the cost-benefit analysis on a digital intervention that consists of promoting healthy eating and physical activity among prediabetic patients by sending SMS for about two years. The intervention has been tested in multiple contexts, namely in China, India, and the United Kingdom. Results of randomized controlled trials in these settings show that the effects of this type of intervention range from 5 to 30 percent reduction in the onset of diabetes after two years (Ramachandran et al., 2013; Wong et al., 2013; Nanditha et al., 2020). Moreover, evidence from India shows that the effects could persist even three years after the end of the intervention (Nanditha et al., 2018). Due to its low-cost and scalability, this intervention has received substantial attention and the World Health Organization has included it in a set of recommended of mobile-based interventions to tackle diabetes (World Health Organization, 2016a). Moreover, this digital intervention could have a large reach in LAC, since it only requires text messages and cellphone coverage is larger than internet coverage in the region.

3.2.3. Overview of the Approach Followed to Estimate Benefits and Costs

We estimate the social returns of implementing this intervention as an add-on service to patients who have been identified as prediabetic by the public health system in the four selected countries in the region (Peru, Chile, El Salvador, Jamaica). Hence, this analysis is based on the current capacity of the health system to identify prediabetic patients, who are then assigned to receive around 18 SMS tailored every month for two years, which is the average dose and duration of the intervention.[50] The status quo in most countries is that at the primary care level there is no support for high-risk patients to achieve lifestyle changes like reducing weight and increasing physical activity (López-Jaramillo et al., 2017).

In our scenario for the cost-benefit analysis, the target population includes those age 20 to 79 who use public health services, are detected as prediabetic, and have access to a mobile phone. Given the wide range in effects of the intervention in the literature, we use a weighted average of the effects, i.e., a 10.8 percent reduction in the onset of diabetes after two years of intervention.[51]

[50] See Ramachandran et al. (2013) for some examples of messages and the theoretical framework behind their development.
[51] We use a weighted average by sample size of the effects of reduction in diabetes onset from Ramachandran et al. (2013); Wong et al. (2013) and Nanditha et al. (2020).

In addition, to account for uncertainty in the take-up of the intervention, we consider four different levels of take-up: 5, 25, 50, and 75 percent of the targeted population. This is relevant since there are no empirical data on the take-up of this type of intervention as part of primary care in a public health system.

We consider the benefits and costs over the length of the intervention, which is two years. The benefits considered include the health gains measured in Quality-Adjusted Life Years (QALYs)[52] of each patient and a reduction in healthcare costs stemming from the prevention of diabetes onset. In terms of costs, we consider implementation costs (content development, SMS sending and management, introduction to the program provided by nurses, training for nurses, and administrative costs) and patient costs (mainly the opportunity cost of patient time to enroll in the program).[53]

3.2.4. Estimation of Benefits and Costs for the Base Country

This section describes how we estimate the benefits and costs of the program studied for our base country: Peru. We present the analysis for the scenario with mid-level take-up of 50 percent. For other countries for which we estimate this cost-benefit analysis (Chile, El Salvador, and Jamaica), we follow a similar procedure and use data sources similar to those in the case of Peru, except for the modifications presented in section 3.2.5.

[52] QALYs are a standardized measure of disease burden which combines both survival and health-related quality of life into a single index (Turner et al., 2013).

[53] Our focus is on the main costs and benefits of the intervention that have been documented, but the program could also generate other cost or benefits for targeted individuals as well as externalities on non-targeted individuals. For example, for targeted individuals, the program can generate improvements in mental health as a result of a change in the amount of physical activity. Additional positive effects can be found on patients who were able to delay the onset of diabetes because they will not have to attend more medical appointments and hence gain time that would otherwise be dedicated to the appointment itself and in transportation. Regarding positive spillovers, if patients targeted by the program change their behaviors regarding eating habits and physical activity, this can also induce improvements in the behaviors of other members of the household who can also be at risk of developing diabetes, especially if the targeted patients are role models within the household or do grocery shopping or cooking for the household. Finally, the program could generate some costs not contemplated here, such as consuming more vegetables (which could be more expensive that the status quo diet), payments to obtain a gym membership or opportunity costs related to additional time preparing healthy meals or exercising.

Target Population

The targeted beneficiaries of the program include adults aged between 20 and 79 years old with diagnosed prediabetes (impaired fasting glucose) who are covered by the public healthcare system, and who have access to a mobile phone.[54] Table 3.12 provides the estimate of the target population for different take-up scenarios. To obtain an estimate of the target population we combine information from multiple sources. We start with the population aged 20 to 79 years old obtained from the World Bank. This is around 22 million for Peru (33.6 million*0.6611). For the prevalence of prediabetes, we use impaired fasting glucose, since we have data on prevalence using this definition across all countries studied from the International Diabetes Federation (IDF). According to the IDF Diabetes Atlas (2021) the prevalence of impaired fasting glucose among adults aged 20 to 79 years old ranges from 10.6 to 14.6 percent in the countries studied and is 13.15 percent in the case of Peru. We found no common source of data to obtain the share of prediabetes patients who are detected (i.e., diagnosed, or aware they have the condition). Hence, to calculate this figure,, we use the latest estimates of prediabetes awareness (15.3 percent) published by the Centers for Disease Control and Prevention (CDC) National Diabetes Statistics Report (2020), and we assume that countries from the region manage to detect about half of the cases detected in the United States (7.5 percent).[55] The percentage of the population that is covered by the public health system represents 78 percent in Peru (World Bank and WHO, 2022). Finally, we use the unique mobile subscribers as percentage of the population for mobile coverage, provided by the Global System for Mobile Communications (GSMA), which is a global organization that represents mobile operators and organization across the mobile ecosystem. According to these data, the share of unique mobile subscribers in Peru is 67 percent (Sharma and Lucini, 2016). Once these sources are taken into account, the pool of target population for the program will be around 115,000 people for the case of Peru (33.6 million*0.6611*0.1315*0.075*0.7834*0.67). From this number, we establish different scenarios of take-up (5, 25, 50 and 75 percent). Table 3.12 presents this calculation across countries studied.

[54] There are several definitions of prediabetes, for the purposes of this analysis we use impaired fasting glucose, which is defined as glucose levels of 100 to 125 mg per dL (5.6 to 6.9 mmol per L) in fasting patients (Rao et al., 2004). We use this definition, as there are estimates of its prevalence across multiple countries in the region from the International Diabetes Federation.

[55] We consulted several health policy experts, and they considered this assumption feasible.

Table 3.12. Target Population and Take-Up Scenario of an SMS Intervention for Prediabetic Patients in Selected Countries

	Peru	Chile	El Salvador	Jamaica
Target population				
Total population	33,684,000	19,250,000	6,550,000	2,985,000
Population aged 20-79 (%)	66.11%	71.75%	63.24%	67.34%
Prevalence of prediabetes, age 20-79 (%)	13.15%	14.65%	12.10%	10.60%
Prediabetic patients the health system detects (%)	7.50%	7.50%	7.50%	7.50%
Population in the public health system (%)	78.34%	79.84%	75.51%	70.11%
Population with a mobile phone (%)	67%	93%	81%	72%
Total target population	**115,255**	**112,667**	**22,983**	**8,067**
Take-up scenario				
5%	5,763	5,633	1,149	403
25%	28,814	28,167	5,746	2,017
50%	57,627	56,333	11,492	4,033
75%	86,441	84,500	17,237	6,050

Source: Authors' calculations.

Notes: This table shows the target population and the population that takes-up the intervention. The target population refers to persons aged 20 to 79 detected as prediabetic by the public health system who have a mobile phone. Take-up scenarios are obtained with a respective percentage from the total target population. To calculate the target population, we take the total population and multiply it by the percentage of the population between 20 and 79 years old, the prevalence of prediabetes, the percentage of the population with prediabetes that the health system manages to detect, the percentage of the population that has access to the public health system, and the percentage of the population that has a mobile phone. The full list of data sources for this calculation is in Annex 3.3. The total population and the percentage of population aged 20 to 79 come from World Bank (2022b). The prevalence of prediabetes comes from the IDF (2021), and we consider impaired fasting glucose as the prediabetes definition. The percentage of the population covered by the public health system comes from World Bank and WHO (2022). The share of prediabetic patients detected by the health system is assumed to be half of what is presented in CDC (2020). Finally, the percentage of the population with a mobile phone is counted as the share of unique mobile subscribers, which refers to a single individual who has subscribed to a mobile service (Sharma and Lucini, 2016).

Average Benefit per Person

We estimate the benefits of the program as the expected health gains and health care costs savings from the reduction in the onset of diabetes for adults targeted by the program. To estimate the effect size, in terms of reduction in the onset of diabetes due to the intervention, we use the sample-weighted average from the trials conducted in India (Ramachandran et al., 2013), China (Wong et al., 2016), and India and the United Kingdom (Nanditha et al., 2020). This weighted average is equivalent to a 10.8 percent reduction in the onset of diabetes after two years of intervention.

Health gains are calculated using the estimated 0.071 QALYs from Wong et al. (2016), which is obtained by projecting the effects of the delay in diabetes onset caused by the intervention over a 50-year period relative to usual care. We use GPD per capita of 2023 as the monetary value of a QALY,[56] since benefits of this intervention are realized two years after the start of the intervention. In this way, for every patient in which diabetes was averted during the intervention, we estimate a health gain of US$ 507.6 (7,149.52*0.071).

Once a patient develops diabetes, it requires substantial health care services, which can be costly. As a result, we also estimate health care savings emerging from patients who did not progress towards diabetes. According to IDF (2021) the average annual health care related costs of a diabetic patient, which includes the costs of treating diabetes, diabetes-related complications, and comorbidities, amounts to US$ 1,430.7 in the case of Peru.[57] The health gains and savings in health care costs are related only to those patients who delayed the onset of diabetes, hence to obtain the average benefit per patient we multiply these gains (507.6+1,430.7) by the total number of patients who did not develop the disease (6,243) and divide it by the total number of enrollees (57,627). The average benefit per patient is thus around US$ 209.9 in the case of Peru (1938.3*0.1083), which brought to present value at a 3 percent rate equals to US$ 203.8 since we accrue all benefits until the second year of the intervention. Table 3.13 shows all relevant values for this calculation for the four take-up scenarios. Note that, since the number of patients that do not develop diabetes is 10.83 percent of patients, the average benefits per patient are constant across all take-up scenarios, while the estimate of total benefits will vary.

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[56] There is substantial discussion in the literature of the best approach to value a QALY particularly in the context of low-and-middle income countries (Marseille et al., 2015; Woods et al. 2016). The WHO recommends as a threshold for cost-effectiveness analysis using between one and three GPDs per capita, and NICE (from the United Kingdom), usually considers this threshold to be between around US$ 30,000 -£ 25,000 (Donaldson et al., 2011). Some agencies in Latin American countries recommend using one GPD per capita (CSG, 2017) to value QALYs in cost-benefit analysis, and we hence use this approach.

[57] We adjust the figure published by IDF (2021) by inflation since all benefits are accrued in the second year of the intervention.

Table 3.13. Benefit per Patient of an SMS Intervention for Prediabetic Patients in Peru

	Take-up scenario			
	5%	25%	50%	75%
Number of patients	5,763	28,814	57,627	86,441
Reduction in onset of diabetes (%)	10.83	10.83	10.83	10.83
Number of patients that did not develop diabetes	624	3,121	6,243	9,364
QALYs gained per patient not developing diabetes	0.071	0.071	0.071	0.071
Value of a QALY (US$)[1/]	7,149.52	7,149.52	7,149.52	7,149.52
Health gains per patient not developing diabetes (US$)	507,6	507,6	507,6	507,6
Health care savings per patient not developing diabetes (US$)	1,430.69	1,430.69	1,430.69	1,430.69
Present value of benefits per patient (US$)	203.86	203.86	203.86	203.86

Source: Authors' calculations.

Notes: The reduction in the onset of diabetes is the weighted average of the reduction in the onset for the interventions in China, India and the United Kingdom (Wong et al., 2016; Ramachandran et al., 2013; Nanditha et al., 2020). The estimated QALYs gained per patient come from Wong et al. (2016). The healthcare savings are the average health care expenditures of a patient with diabetes, which includes the costs of health care resources used for treating diabetes, diabetes-related complications, and comorbidities (IDF, 2021). The value of health gains and health care savings are in US$ of the second year of the intervention, but the benefit per patient is in present value US$.

[1/] We value a QALY as the GDP per capita of the country, in this case it varies from the one use from the CBT modalities of care, since we use the forecast for 2023 as the benefits are accrued two years after the start of the intervention.

Average Cost per Person

The costs generated by the program include implementation costs, patient costs, and deadweight loss. The implementation costs include content adaptation, SMS management, and costs of the introductory session provided by trained nurses to patients. Table 3.14 shows the break-out of implementation cost per patient. To estimate the content adaptation costs, we consider that the World Health Organization (WHO) has already published the content of the SMS used in the Indian intervention (Ramachandran et al., 2013; World Health Organization, 2016a), thus we only need a team that translates and adapts the content published by WHO to the context of each country. We assume this will be a fixed cost of US$ 30,000, and hence the cost per patient will vary depending on the level of take-up.[58] In the case of Peru, it will vary from US$ 5.21 in the 5 percent take-up scenario to as little as US$ 0.35 for the highest take-up scenario (75 percent).

[58] We assume US$ 30,000 as a fixed cost for adaptation and translation in all countries except for Jamaica, in which the only cost will be to adapt, since the content is already in English. Hence for Jamaica we consider an adaptation cost of US$ 15,000.

The SMS management costs accounts for the price of sending a SMS, the number of SMS sent to the patient per month and the cost of having a platform that manages the SMSs. The intervention involves sending each patient 18 SMS per month during the first year, and 12 SMS per month during the second year, which is the median number of messages sent in Ramachandran et al. (2013). Thus, each patient will receive 360 messages over the course of the intervention. The number of messages received is high since changes in lifestyle (weight reduction and increased physical activity) require frequent contact and different types of messages (e.g., educational, calls to action, motivational, and maintenance behaviors). We consider the individual cost of each message to be US$ 0.01 across all countries.[59] In addition, the platform that manages the SMSs costs $25 plus $0.01 per additional message contact after 1,000 contacts, which comes from TextIt.[60] As a result, we estimate the SMS management cost per patient around US$ 3.84 in all take-up scenarios (see Table 3.14).

The intervention considers a short (10-minute) introduction to the program provided by nurses once a patient is identified as having impaired fasting glucose. This introduction is key since it will provide the basics of the importance of weight reduction and physical activity to prevent diabetes and will be useful to explain to patients how the program works. Considering an hourly wage of US$ 6.04 for nurses obtained from the wage estimates of health workers globally from Serje et al. (2018), the 10-minute introduction will cost US$ 1.03 in Peru.[61] To make this introduction and teach nurses how to enroll patients in the program we consider a two-hour training to all nurses in primary care facilities in the country (8,148 health facilities for the case of Peru; Gobierno del Perú, 2022). We consider that the training will be included as a component of trainings scheduled for nurses, and hence the main costs of this training include US$ 20,000 for developing the training and materials and two hours of each nurse's salary to attend the training to capture the opportunity cost of their time. Overall training costs in Peru will be of US$ 118,427, which include US$ 98,427 in nurse wages (6.04*2*8,148) and US$ 20,000 for developing the materials. Since this is a fixed cost, the cost per patient will vary, from US$ 20.56 in the low take-

[59] This is the cost charged by Commcare, an open-source platform to build Android-based mobile health applications, and it is similar to the price of other providers.

[60] For more information about the platform see www.textit.com

[61] Serje et al. (2018) classify health workers into three cadres: physicians, nurses and midwives, and other health workers. Depending on the World Bank income group, they provide an average earnings index which is understood as a multiple of GDP per capita.

up scenario to US$ 1.37 in the high take-up scenario and comprise between 58 to 18 percent of total implementation costs.

We consider administrative costs from the implementation of the program as an additional 15 percent from implementation costs. In this way, total implementation costs per patient (including the administrative costs) range from US$ 35.29 in the low take-scenario to US$ 7.57 in the high take-up scenario (see Table 3.14). As explained before, the wide range in costs in the different scenarios stems from the fixed costs, which include content creation, but consist mostly of nurse training.

Table 3.14. Implementation Cost per Patient of an SMS Intervention for Prediabetic Patients in Peru

	Take-up scenario			
	5%	**25%**	**50%**	**75%**
Cost per patient (US$)				
Content translation and adaptation	5.21	1.04	0.52	0.35
SMS management cost	3.84	3.84	3.84	3.84
Nurse orientation to patients	1.03	1.03	1.03	1.03
Nurse training	20.56	4.11	2.06	1.37
Administrative cost	4.60	1.50	1.12	0.99
Total implementation cost	35.29	11.53	8.56	7.57

Source: Authors' calculations.
Notes: We assume a content translation and adaptation cost of US$ 30,000. The SMS management cost includes two sources, CommCare and TextIt. The former is a SMS solutions provider which provides the prices for each SMS and the latter is the platform that manages the SMSs. The 10-minute introductory session considers the hourly wage per nurse which comes from Serje et al. (2018). To calculate the number of nurses needed to provide the personalized training, we consider a trained nurse for each of the 8,148 primary health centers in the country (Gobierno del Perú, 2022). The administrative cost is an overhead cost of 15 percent to the sum of implementation costs.

Patient costs include the opportunity costs borne by the patients from their participation in the program. This includes the cost of their time in the 10-minute introductory session and the time devoted to reading the messages.[62] Considering a length of 144 characters for each SMS and an average word length of 5.1 characters (Bochkarev et al., 2015), each SMS will have 28.2 words. According to Brysbaert (2019), average reading speed in English is 238 words per minutes, so that each SMS will take 0.12 minutes to read (28.2/238). During the first year, each patient will devote 10 minutes to the introductory session plus around 26 minutes to reading messages (0.12*18*12)

[62] We do not consider the time of activities that could change behavior of patients such as grocery shopping, meal preparation or exercise, since there might be substantial heterogeneity and we have no reference value for this time.

for a total of 0.6 hours. In the second, year each patient will devote and additional 17 minutes reading messages (0.12*12*12) or 0.28 hours. Then, we value these hours according to the average hourly earnings of employees by country (US$ 2.60 for Peru, using data from ILOSTAT). This results in an opportunity cost of US$ 2.29 per patient at present value. Since we are assuming the government is the implementer, we also consider a deadweight loss to account for distortions created when using public funding equivalent to 20 percent of implementation costs as presented in Section 1. Table 3.15 provides a summary of all costs per patient.

Table 3.15. Cost per Patient of an SMS Intervention for Prediabetic Patients in Peru

	Take-up scenario			
	5%	**25%**	**50%**	**75%**
Cost per patient (US$)				
Implementation costs	35.29	11.53	8.56	7.57
Deadweight loss	7.06	2.31	1.71	1.51
Patient costs	2.29	2.29	2.29	2.29
Total costs per patient	44.64	16.12	12.56	11.37

Source: Authors' calculations.
Notes: We assume that all implementation costs are covered by the government. The deadweight loss of tax-related distortions is assumed to be a 20 percent additional cost for all governmental expenses. The patients' cost is the opportunity cost which accounts for the time each patient spends during the intervention, and we value these hours according to the average hourly earnings of employees from ILOSTAT.

Cost-Benefit Analysis for Peru

Table 3.16 summarizes the results of the cost-benefit analysis for the intervention in Peru by take-up scenario. Overall, we estimate a net present value of between US$ 0.9 and US$ 16 million and a benefit-cost ratio ranging from 4.6 to 17.9 for the country depending on the level of take-up. Results show that this intervention can provide value to society, but the value increases with the scale of patients as it has some fixed costs.

Table 3.16. Cost-Benefit Analysis of an SMS Intervention for Prediabetic Patients in Peru

	Take-up scenario			
	5%	**25%**	**50%**	**75%**
Number of patients	5,763	28,814	57,627	86,441
Benefits per patient (US$)	203.86	203.86	203.86	203.86
Costs per patient (US$)	44.64	16.12	12.56	11.37
Implementation costs	35.29	11.53	8.56	7.57
SMS	3.84	3.84	3.84	3.84
Content creation	5.21	1.04	0.52	0.35
Nurse orientation to patients	1.03	1.03	1.03	1.03
Nurse training	20.56	4.11	2.06	1.37
Administrative costs	4.60	1.50	1.12	0.99
Deadweight loss	7.06	2.31	1.71	1.51
Patient costs	2.29	2.29	2.29	2.29
Benefit-cost ratio	**4.6**	**12.6**	**16.2**	**17.9**
Net present value (millions of US$)	**0.9**	**5.4**	**11.0**	**16.6**

Source: Authors' calculations.
Notes: All parameters and assumptions for the estimates can be found in the previous tables and sections. All monetary values are expressed in US$. Benefit-cost ratios are estimated based on the net present value of benefits and costs over two years and a three percent discount rate

3.2.5. Estimation of Benefits and Costs for Other Countries

For other countries for which we estimate this cost-benefit analysis (Chile, El Salvador, and Jamaica), we follow a similar procedure with the same data sources, except for the number of primary health centers, which we obtained from government sources in each country (see Annex 3.3). Also, we consider a lower content cost for Jamaica (US$ 15,000 instead of US$ 30,000) since the messages are already in English and they will only need adaptation, whereas in the rest of the countries they will require adaptation and translation.

3.2.6. Results

Table 3.17 summarizes the main components of the cost-benefit analysis for all countries in a 50 percent take-up scenario and Table 3.18 presents results on key indicators such as the benefit-cost ratio and the net present value for the four take up scenarios in all countries. Results are similar across countries, but as expected, the net present value is higher for countries with more population such as Chile and Peru. In addition, benefit-cost ratios are closer to one for small countries like Jamaica and El Salvador (see Table 3.18) in the lowest take-up scenario given the fixed costs included in the analysis (nurse training and content translation and adaptation). However, in higher take-up scenarios the benefit cost-ratio range from around 4 to as high as 19.6.

Table 3.17. Cost-Benefit Analysis of an SMS Intervention for Prediabetic Patients in Selected Countries Assuming 50 Percent Take-Up

	Peru	Chile	El Salvador	Jamaica
Benefits (US$)	203.86	308.50	153.60	148.76
Health gain	53.39	138.94	34.55	44.29
Health care savings	150.47	169.56	119.05	104.47
Implementation cost (US$)	8.56	8.95	12.27	16.98
SMS	3.84	3.87	3.87	3.98
Content creation	0.52	0.53	2.61	3.72
Nurse Orientation	1.03	1.95	1.41	1.04
Nurse training	2.06	1.43	2.78	6.03
Administrative costs	1.12	1.17	1.60	2.21
Deadweight loss (US$)	1.71	1.79	2.45	3.40
Patient costs (US$)	2.29	5.91	1.82	1.47
Benefit-cost ratio	**16.2**	**18.5**	**9.3**	**6.8**

Source: Authors' calculations.
Notes: The benefits are disaggregated by gains in health from the intervention and gains from diabetes-related health care savings by delaying the onset of diabetes. Costs are disaggregated into three categories: implementation costs, deadweight loss costs, and patient costs. All monetary values are expressed in US$. Benefit-cost ratios are estimated based on the net present value of benefits and costs over two years and a 3 percent discount rate.

Table 3.18. Cost-Benefit Analysis of an SMS Intervention for Prediabetic Patients in Selected Countries

	Peru	Chile	El Salvador	Jamaica
5% Take-up scenario				
Number of patients	5,763	5,633	1,149	403
Benefit per patient (US$)	203.86	308.50	153.60	148.76
Cost per patient (US$)	44.64	41.11	83.85	144.02
Benefit-cost ratio	4.6	7.5	1.8	1.0
Net present value (millions of US$)	0.9	1.5	0.1	0.0
25% Take-up scenario				
Number of patients	28,814	28,167	5,746	2,017
Benefit per patient (US$)	203.86	308.50	153.60	148.76
Cost per patient (US$)	16.12	19.37	24.02	35.42
Benefit-cost ratio	12.6	15.9	6.4	4.2
Net present value (millions of US$)	5.4	8.1	0.7	0.2
50% Take-up scenario				
Number of patients	57,627	56,333	11,492	4,033
Benefit per patient (US$)	203.86	308.50	153.60	148.76
Cost per patient (US$)	12.56	16.65	16.54	21.84
Benefit-cost ratio	16.2	18.5	9.3	6.8
Net present value (millions of US$)	11.0	16.4	1.6	0.5
75% Take-up scenario				
Number of patients	86,441	84,500	17,237	6,050
Benefit per patient (US$)	203.86	308.50	153.60	148.76
Cost per patient (US$)	11.37	15.74	14.05	17.32
Benefit-cost ratio	17.9	19.6	10.9	8.6
Net present value (millions of US$)	16.6	24.7	2.4	0.8

Source: Authors' calculations.
Notes: This table summarizes the benefits and costs per patient for all take-up scenarios (5, 25, 50, and 75 percent). The benefits include gains in health from the intervention and gains from diabetes-related health care savings by delaying the onset of diabetes. The costs per patient include the implementation costs, deadweight loss costs, and patient costs. Benefit-cost ratios are estimated based on the net present value of benefits and costs over two years and a three percent discount rate.

4. Cost-Benefit Analysis of Digital Interventions in Government Transactional Services

This section presents the methodology and assumptions of the two cost-benefit analyses presented in Chapter 4 of the report, entitled "Digitalization Is Just the Beginning: Maximizing the Potential of Online Transactional Services." The present section of this technical note has two parts. The first part presents the cost-benefit analysis of two programs aiming to promote the renewal of identity cards (text message reminders and a combination of text message reminders with an online platform). These two programs are covered in Section 4.2.1 of Chapter 4 in the report. The second part of the present section describes the cost-benefit analysis of a program that uses biometric authentication systems to improve the delivery of public services, which is presented in Section 4.2.2 of Chapter 4 in the report. Each of the studies we used to obtain the parameters for our analysis was carried out in countries other than those we analyzed. However, the interventions we analyze are sufficiently generalizable and applicable to other contexts as well, allowing us to obtain key parameters used in the cost-benefit analyses.[63]

4.1. Cost-Benefit Analysis of Scenarios to Promote Identification Card Renewal

This subsection presents the methodology and assumptions of the cost-benefit analysis presented in Chapter 4, Section 4.2.1 of the report. Common assumptions presented in Chapter 1 of this technical note apply to this analysis. All the data sources used to provide estimates for the different parameters in this analysis are included in Annex 4.1 of this technical note.

4.1.1. Background

The digital transformation of governments is improving how services are provided to citizens. This transformation provides digital tools that allow citizens to feel closer to the government, reduce transaction, time and transportation costs, and access more services. These digital tools are varied and respond to different objectives within the transaction cycle. For example, these tools may take the form of electronic notifications via text messages or emails to inform citizens about a new service or deadlines for accessing a service. Another example is transactional portals, which allow citizens to complete one or multiple steps of a transaction autonomously online.

[63] For more information on technical details, please contact Julieth Santamaria (juliethsa@iadb.org), the corresponding author for this chapter of this technical note.

We present a cost-benefit analysis for two technological solutions designed to encourage the renewal of identification (ID) cards studied by Reyes et al. (2021). The intervention takes place in Panama, where only 25.2 percent of people renew their identification cards on time. To overcome the challenge of having a low rate of timely ID renewals, the authors and the government partnered to implement two potential solutions involving technology use. In the first treatment arm, citizens from a randomly selected group received text messages encouraging them to renew their ID along with the expiration date of their ID. In the second arm, another group of citizens received similar text messages plus a link to an online platform on which they could start the renewal process online.

4.1.2. Program and Evaluation

In partnership with the Agencia Nacional de Innovación Gubernamental (AIG), the institution in charge of modernizing public services in Panama, Reyes et al. (2021) conducted a randomized controlled trial (RCT) in Panama with two strategies to encourage on-time renewals: sending reminders through text message, and a combination of sending text messages and implementing an online platform to carry out the transaction. The experiment was rolled out using a sample of 3,459 citizens whose identity cards were set to expire between January 20 and March 20. This sample was subdivided into three groups: 1,173 who participated in the first treatment arm, 1,177 who were part of the second treatment arm, and 1,109 citizens who served as the control group. From January to August 2020, the two treatment groups received four text messages. The first treatment arm received SMS containing phrases encouraging the renewal of ID cards along with the expiration date. The second treatment arm received similar text messages and a personalized link to the online platform. From now on, we refer to the first treatment arm as *SMS* and to the second treatment arm as *SMS + Online Platform.*

Taking advantage of this RCT, the authors provide estimates of the effect on timely renewals of ID cards of sending SMS and providing access to an online platform to carry out transactions. They find that text message increased the likelihood of renewing the ID by 12.30 percentage points, and the combination of text messages plus giving access to an online platform to renew the ID increases this likelihood by 8.70 percentage points. We use these estimates in the cost-benefit analysis to approximate the effects that similar interventions would have had in the countries we analyze: Chile, El Salvador, Jamaica and Peru. In addition to these indicators, we also use information from the country context to adjust the estimates (see Annex 4.1 for a complete list of sources).

4.1.3. Overview of the Approach Followed to Estimate Benefits and Costs

To conduct the cost-benefit analysis, we consider the benefits and costs for the citizens and the implementer over one year of implementation. As mentioned, we are analyzing two interventions: one in which citizens received reminders to renew their identification card through SMS, and another in which they received those reminders in addition to a link to complete the process online. In the case of the online platform made available to citizens, we consider two scenarios: one in which the online platform has technical errors or might be more challenging to use (as the case of intervention evaluated by Reyes et al., 2021), and one hypothetical scenario in which the online platform is flawless and easy to use.

Two benefits to citizens are associated with the interventions summarized in Reyes et al. (2021). First, receiving text messages resulted in more citizens renewing their ID cards, and having a valid ID allows citizens to carry out numerous transactions. For example, a person who needs to complete a banking transaction such as opening a bank account or applying for a loan needs an unexpired ID (Gestión, 2021). Thus, we estimate a monetary value of having a valid identification document to carry out transactions. We tried different routes to create an estimate, and present results for an approximation based on a set of assumptions. Acknowledging the challenge of an estimation on a service as complex as the renewal of ID cards, we also present robustness checks that assume different monetary benefits of having an up-to-date ID card (see Annex 4.2). The second benefit for citizens is perceived by those who, before the intervention, were planning to renew their identification in person, but thanks to the intervention were able to complete it online. Having the possibility of carrying out the process online could generate reductions in transportation costs and transaction time. Depending on the intervention we analyze (only SMS or with online platform), benefits may vary according to the course of action taken by individuals susceptible to the changes induced by the interventions. For example, because of the text messages, some people who in absence of the intervention would not have renewed their identification did so. Thus, they received benefits associated with accessing transactions that required unexpired IDs, and those who were given access to the online platform, receive benefits from not having to make the transaction in person.

Turning to the benefits for the implementer, governments benefit from citizens updating their ID cards because they can have more reliable data on their citizens, which can help the government implement better-targeted social programs and reduce fraud (Michael, 1995; Matthews, 2002; Goldman, 2004; Knight, 2003; Al-Khouri, 2008; Al-Khouri, 2014). Additionally, in countries where voting is mandatory, the government benefits from its citizens renewing their ID because a larger share of the population can vote (Vercellotti et al., 2006). All these benefits are also difficult to quantify. For simplification purposes, we assume that the per capita benefits the government receives are similar to the per capita benefits a citizen perceives.

Concerning the costs of this intervention for citizens, we identify that the increase in the percentage of citizens who renewed their ID generated spillover effects on those who would not have renewed it in the absence of the intervention. These costs, in the case of those who carried out the renewal in person, are associated with the time and transportation required to complete the transaction. That is, because receiving the SMS generated that some individuals renew their identity cards, it is important to consider the additional costs experienced by people and the government due to these behavioral responses.

For those who renewed their ID online (only citizens in the SMS + online platform), the costs are associated with the time devoted to completing the transaction online, which depends on different capabilities. On the one hand, it depends on the digital skills of citizens: more able citizens would know how to attach files on websites and how to take selfies with ease; however, this dimension is difficult to quantify and therefore we do not take it into account the heterogeneity across users for this exercise. On the other hand, the time spent on completing the transaction online also depends on the quality of the online platform and the simplicity of completing the process online when the transaction is digitized. To incorporate this issue into the analysis, we assume the two scenarios described above: one in which citizens would experience technical difficulties and complex steps to complete (the real scenario that was evaluated in the mentioned study), and another in which the online platform is simple and easy for citizens to use (a hypothetical scenario in which it is assumed that all users who start the process online end up by renewing their identification card).

Turning to the costs for the implementer, we consider two types of costs in the analyses. First are the costs of sending four text messages to each citizen in the two treatment arms, and the cost of implementing an online platform to complete the transaction online, which only applies to the second treatment arm. Additionally, there are costs associated with the increase in the number of people who renew their identifcation cards (which generates costs for the government). Details on the computation of each of these costs are presented later in this section.

4.1.4. Estimation of Benefits and Costs for the Base Country

This section describes how we estimate the benefits and costs of the program studied for the base country, Peru. For other countries for which we estimate this cost-benefit analysis (Chile, El Salvador, and Jamaica), we follow a similar procedure using the estimates from the study by Reyes et al. (2021) and adjust other parameters to the specific country of analysis. In Section 4.1.5, we present the benefits and costs for the four countries analyzed (Chile, El Salvador, Jamaica, and Peru).

Target population

The beneficiaries of the program are citizens who must renew their identification document. That is, the population of a country that is 18 or older, who already have an identification card with an expiration date. In the case of Peru, there are 21,274,776 people 18 or older, and 98.24 percent of them have a National Identification Card (ID4D, 2017) that needs to be renewed every eight years (RENIEC, 2019).[64] The number of citizens targeted by this program is 2,612,597 (21,274,776*0.9824/8).

Average Benefit per Person

As mentioned in section 4.1.3, we consider benefits for citizens and the government. To compute the benefits to citizens of receiving reminders, one would ideally like to have a valuation for all the services a citizen could access thanks to having an unexpired ID. Alternatively, one would like to know the cost to a citizen of losing access or not being able to have access to services offered by the public and private sector when these services require an up-to-date identification card. However, this value is difficult to estimate because different types of citizens require an unexpired

[64] Note that the ID acquisition process and renewal times vary from country to country, especially for minors. For example, in Peru, minors and adults have different types of ID cards that have different renewal criteria. In Chile, minors and adult have the same type of ID card with similar renewal times. Given these varied conditions on the type of ID that minors have as well as the complexity that would involve including minors in the analysis, we only consider impacts on the adult population of each country. Another reason for this decision is that the results presented by Reyes et al. (2021) only involved adults.

ID for various transactions. For example, wealthier citizens might need it to travel within the LAC region or to apply for loans, whereas poorer citizens may need it to access newly available social programs. An accurate computation of this value would require knowing which transactions, managed by the public and the private sector, require non-expired ID cards, the volume of those transactions to serve as weights, and the average citizen's valuation or willingness to pay for being able to access or complete each of these transactions. This computation is not feasible, however, because each component of this calculation is challenging to estimate.[65] Instead, we assume that this benefit's per capita valuation is approximately US$ 20, though we recognize there is large uncertainty about this valuation. For this reason, we also present results for per capita valuations ranging from US$ 10 to 50 (see Annex 4.2).

The next step in the computation is to identify the share of the population who will benefit from the interventions. We identify five groups of beneficiaries. The first group is those who in absence of the intervention would not have renewed their ID card, but because of the intervention did so in person. This group represents 12.3 percent in SMS intervention and 6.44 percent in SMS + online platform intervention (additional percentage of citizens renewing their ID reported by Reyes et al., 2021). The second group is those who in absence of the intervention would not have renewed their ID card, but because of the intervention did so online (2.26 percent). The third group is those who would have used the in-person renewal process, but because of the intervention carried out the online process (3.74 percent). The fourth group is those who, regardless of the intervention, always renew their identification in person. This group is estimated to decrease by 3.74 percent given that some of them selected to carry out the transaction online. The last group corresponds to those who failed to complete the transaction online, which represent 77.82 percent of those who started the online renewal process in the real scenario and 20 percent in the hypothetical scenario. Notice that groups ii) to v) of beneficiaries only involve the SMS + online platform intervention.

[65] Although we currently use a monetary value based on a set of assumptions, we tried to obtain an estimate from citizen surveys. The objective of the survey was to understand how valuable is having an up-to-date identification is from the citizen's point of view. For this purpose, we built several questionnaires with open-ended and closed-ended questions that sought to collect information about this valuation. These questions were based on good practices endorsed by the literature for willingness-to pay-questionnaires (Cummings et al., 1986; Whittington et al., 1990; Carías et al., 2011; Berlinski et al., 2016), and discussions with experts. The exercise was reviewed, internally validated for application to a sample of Peruvian citizens, and adjusted according to the results obtained. Despite adjustments, however, the questions were challenging for most of the citizens surveyed to understand and answer. We concluded that the exercise's results were not more reliable than the assumption adopted in the cost-benefit analysis calculation.

Table 4.1 summarizes the computations of the benefits for each group of beneficiaries. In the case of sending reminders (column 1), the per capita benefit for citizens amounts to US$ 2.46 (20*0.123). Concerning the beneficiaries of the second arm of intervention (column 2 and 3), the benefit from the groups of individuals who previously did not renew is US$ 1.29 per capita for those who now choose to renew in person (20*0.0644) and US$ 0.45 for those who now choose the online platform (20*0.0226). In the case of the group who renews online and previously did so in person, the benefit is US$ 9.87 per capita when the platform does not work well (column 2), which is composed of time savings (US$ 8.61) and transportation cost savings (US$ 1.27) for no longer making the transaction in person. When the platform works properly (column 3), the benefit is US$ 11.26, explained mainly by a more significant benefit in time savings (US$ 10.00). Thus, the total benefit for those who now renews their ID in the online platform is US$ 0.37 in the case of platform failures (9.87*0.0374) and US$ 0.42 when the platform works well (11.26*0.0374). Finally, the total benefit for each group of individuals is added to calculate the benefit to the citizen. That is, the per capita benefit for citizens is US$ 2.11 in the case of platform failures and US$ 2.16 when the platform works well.

Table 4.1. Benefit for Citizens for Scenarios to Promote ID Card Renewal in Peru

	SMS (1)	**SMS + online platform (real)** (2)	**SMS + online platform (hypothetical)** (3)
Panel A. Citizens who would not have renewed their ID card, and after intervention renews in-person			
Benefit from renewing the ID (US$)	2.46	1.29	1.29
Estimated benefit of renewing the ID (US$)	20.00	20.00	20.00
Citizens in this category (%)	12.30	6.44	6.44
Panel B. Citizens who would not have renewed their ID card, and after intervention renews online			
Benefit from renewing the ID (US$)	-	0.45	0.45
Estimated benefit of renewing the ID (US$)	-	20.00	20.00
Citizens in this category (%)	-	2.26	2.26
Panel C. Citizens who would have renewed their ID card in-person, and after intervention renews online			
Benefit from using the online renewal process	-	0.37	0.42
(US$)	-	9.87	11.26
Transaction savings (US$)	-	8.61	10.00
Time savings	-	1.27	1.27
Transport savings	-	3.74	3.74
Citizens in this category (%)			
Benefit per capita for citizens (US$)	**2.46**	**2.11**	**2.16**

Source: Authors' calculations.
Notes: This table summarizes the per capita benefits we identified for the interventions presented in Reyes et al. (2021). The first column displays the computations for the first arm of intervention that sent text messages. Columns 2 and 3 display the computations for the second arm of intervention under two scenarios: one in which the online platform has technical difficulties and one in which the online platform works flawlessly. There are three groups of beneficiaries we identified. Panel A and B summarize the benefits from renewing the ID for those who, in the absence of the interventions, would have not renewed their ID card. Panel C presents the results for those who, in the absence of the second arm of intervention, would have renewed their ID but because they were given access to a renewal process online, they carried it out in that manner. Citizens who would have renewed their ID in person before and after the intervention (3.74 percent), and those who attempted to complete the transaction on the online platform but were unsuccessful (77.8 percent of those who started the transaction in the real scenario and 20 percent in the hypothetical scenario) do not receive benefits from the intervention. For each panel, computed benefits are presented first, and then its components are itemized below. The total benefits received by all beneficiaries of the interventions are displayed in the last row.

The second set of benefits from this intervention come from the government and are summarized in Table 4.2. We approximate government benefits using citizen benefits. This is because there are government benefits from renewing the identification document that could not be monetized. Some of these benefits are the mitigation of fraud and identity theft for carrying out transactions and savings in transaction time due to a reduction in identity verification time, among others. Assuming a government benefit from ID renewals of US$ 20 per capita and multiplying by the additional percentage of people who renewed their ID because of the reminder (12.30 percent), the benefits to the implementer for the SMS intervention amount to US$ 2.46 per capita (see column 1 in Table 4.2).

For the SMS + online platform intervention (column 2 and 3 in Table 4.2), the government experiences benefits for those who previously did not renew their ID and now choose to renew in person that amount to US$ 1.29 per capita (20*0.0644) and from those who now choose the online platform a benefit of US$ 0.45 per capita (20*0.0226). Note that these values are also approximated from the citizen benefits. In addition, the government experiences benefit for those who, before the intervention, carried out the transaction in person and now do so online. These benefits represent the savings for each transaction that is no longer made in person (US$ 2.92), which are calculated as the difference between i) half of the government costs per face-to-face transaction (6.48*0.50), assuming that 50 percent of these costs are variable and should therefore be accounted for in the present analysis; and ii) the government costs of offering a transaction on a platform (US$ 0.32) from Roseth et al. (2018).[66] That is, the total benefits to the government for those individuals who, before the intervention, transacted face-to-face and now use the platform are US$ 0.11 per capita (2.92*0.0374).

[66] The costs of offering a transaction in-person and online come from Roseth et al. (2018), who reported those costs for Mexico in 2014. To transform these costs to the Peruvian context in year 2022, we used the PPP exchange rate from the World Development Indicators, and the inflation rate from the International Monetary Fund.

Table 4.2. Benefit for the Implementer for Scenarios to Promote ID Card Renewal in Peru

	SMS (1)	**SMS + online platform (real)** (2)	**SMS + online platform (hypothetical)** (3)
Panel A. Citizens who would not have renewed their ID card, and after intervention renews in-person			
Benefit from ID renewals (US$)	2.46	1.29	1.29
Estimated benefit of renewing the ID (US$)	20.00	20.00	20.00
Citizens in this category (%)	12.30	6.44	6.44
Panel B. Citizens who would not have renewed their ID card, and after intervention renews online			
Benefit from ID renewals (US$)	-	0.45	0.45
Estimated benefit of renewing the ID (US$)	-	20.00	20.00
Citizens in this category (%)	-	2.26	2.26
Panel C. Citizens who would have renewed their ID card in-person, and after intervention renews online			
Benefit from online renewal processes (US$)	-	0.11	0.11
Government transaction savings (US$)	-	2.92	2.92
In-person transaction variable cost (50% in-person transaction cost) (US$)	-	3.24	3.24
In-person transaction cost (US$)	-	6.48	6.48
Government cost per transaction on a platform (US$)	-	0.32	0.32
Citizens in this category (%)	-	3.74	3.74
Benefit per capita for the implementer (US$)	**2.46**	**1.85**	**1.85**

Source: Authors' calculations.
Note: Citizens who would have renewed their ID in person before and after the intervention (3.74%), and those who attempted to complete the transaction on the online platform but were unsuccessful (77.8% of those who started the transaction in the real scenario and 20% in the hypothetical scenario) do not receive benefits from the intervention.

Finally, we calculate total average benefits per person as the sum of the benefits per capita for citizens and the benefits per capita of the implementer, so that the benefits per user amount to US$ 4.92 for the SMS intervention (see Table 4.3). In the case of the second intervention arm and its two scenarios, the benefit per person is lower than in the benefit per person in the first intervention arm. It should be noted that, in the scenario in which the platform works appropriately and makes life easier for those who wish to carry out the transaction, the benefits are slightly higher than for the scenario in which the platform has some shortcomings that complicate the completion of the transaction (US$ 4.01 vs. US$ 3.96).

Table 4.3. Total Average Benefit per Person for Scenarios to Promote ID Card Renewal in Peru

	SMS (1)	**SMS + online platform (real)** (2)	**SMS + online platform (hypothetical)** (3)
Benefit per capita for citizens (US$)	2.46	2.11	2.16
Benefit per capita for the implementer (US$)	2.46	1.85	1.85
Total average benefit per person (US$)	**4.92**	**3.96**	**4.01**

Source: Authors' calculations.
Notes: This table summarizes the benefits to society that can be attributed to the interventions implemented by Reyes et al. (2021) and that have already been presented in detail in Tables 4.1 and 4.2 of this technical note.

Average Cost per Person

The costs generated by the program include both the costs to the citizen and the costs associated with the implementer, both reported per capita. The costs for citizens are associated with two facts. First, sending SMS caused citizens who were not carrying out the transaction to begin doing so. That is the case of those who selected the in-person or online channel after receiving the SMS, but who would have not renewed their ID in absence of the intervention (Panels A and B, respectively). Second having access to an online platform made some citizens try it unsuccessfully.

In the first case, citizen costs represent i) the cost of time and ii) transportation costs incurred by citizens who choose to renew their ID in person because of the reminder. First, to estimate the time costs, we consider the hours it takes a person making a transaction in person (4.5 hours) from Roseth et al. (2018) and the monetary value that an hour has for the citizen in the country of analysis (US$ 2.5). In total, a citizen incurs in US$11.24 (4.5*2.5) per transaction. The value of time for each citizen was approximated using the average monthly wage of the main activity in local currency 2019 for each country with available data in the Socio-Economic Database for Latin America and the Caribbean (SEDLAC) of World Bank. In Peru, this number is 1,311.77 PEN. We then forwarded this value to US$ April 2022. Next, we assumed that an average person works 8 hours a day, 6 days a week for 4.3 weeks a month. This allows us to calculate the average hourly wage for the main activity by taking the SEDLAC average monthly wage in US$ for 2022 and dividing it by 206.4 hours of work per month (4.3*6*8).

Second, transportation costs are calculated by multiplying the number of trips a person must make to a government office and the price of taking a bus in Peru (US$ 0.63). In all cases, the number of trips was based on the number of trips that citizens had to make in the experiment of Reyes et al. (2021)—i.e., two round trips: one to submit the application and one to pick up the ID card up. Adding the transportation (US$ 2.54) and time costs (US$ 11.24), the cost of performing the ID renewal in person is US$ 13.78. When multiplied by the additional percentage of people who renew their ID because of the message (12.3 percent), the per capita cost for the citizen is US$ 1.69 (see column 1 in Table 4.4). Notice that there are no other costs associated with the SMS intervention since the only option for citizens in this scenario was to renew their ID in person.

Turning to the costs faced by citizens in the intervention that combined SMS and an online platform, we also considered the costs to citizens who, with the intervention, made the transaction either in-person (6.44 percent) or online (2.26 percent), but who would have not carried it out in absence of the intervention. The calculations of these costs follow the same logic as explained above. In addition, we also considered costs for those who tried to carry out the transaction online but failed to do so. For this group, we considered two scenarios that we call the "real" scenario and the "hypothetical" scenario, which vary according to the platform's ease of use. The real scenario corresponds to what happened during the implementation of the program, that is, people had difficulty completing the transaction online. The hypothetical scenario will be one in which the platform is widely tested and leads to a user-friendly platform. Each scenario is presented in columns 2 and 3 of Table 4.4. We assume that the percentage of citizens who tried to carry out the transaction on the platform and could not complete it was 77.82 percent (from Roseth et al., 2018) or 20.00 (assumed) percent in the real and hypothetical scenario, respectively.

The transaction cost in each scenario is computed by multiplying the cost of time and transportation of completing the transaction by the percentage of individuals who experience that cost. For example, those who previously did not complete the transaction and with the intervention make it in person must go twice to a government office to make the transaction, which represents four trips that translate into US$ 2.54 in the context of Peru (4*0.63). In addition, they must spend 4.5 hours to perform a transaction face-to-face (Roseth et al., 2018), which transforms into a time cost of US$ 11.24 (4.5*2.5). Then, the cost of doing the transaction face-to-face is US$ 13.78 (11.24 + 2.54), which once multiplied by the percentage of individuals who, because of the intervention, decide to switch from not carrying out the transaction to doing so in person (6.44

percent) results in a transaction cost for those who previously did not carry out the transaction and, with the intervention, do so face-to-face at a cost of US$ 0.89 per capita.

Similarly, people who did not make the transaction and with the intervention make it in the online platform go once to a government office to pick up their document. That is, they make two trips (one outbound and one return), so the cost of transportation for the case of Peru per person is US$ 1.27 (2*0.63). At the same time, it takes 1.06 hours to perform the transaction on the platform when it does not work well and 0.5 hours when it does (Reyes et al., 2021). Thus, the time costs in such situations are US$ 2.64 (1.06*2.5) and US$ 1.25 (0.5*2.5), respectively. Therefore, the costs of transacting on the platform per citizen are US$ 3.91 (1.27 + 2.64) for the real scenario and US$ 2.52 (1.27 + 1.25) for the hypothetical scenario. When they are multiplied by the percentage of people who switch from not making the transaction to making it on the platform once the treatment occurs (2.26 percent), these values result in transaction costs of US$ 0.09 and US$ 0.06 per capita for that type of individual, according to the platform's user-friendliness.

Consequently, the cost to the citizen under the scenario in which the platform works properly is US$ 0.94 (0.89+0.06+0.00). In contrast, in the scenario in which 77.82 percent of people cannot complete the transaction on the platform due to problems associated with the platform, the citizen's costs increase to US$ 2.06 (0.89+0.09+1.08). Table 4.4 presents these costs disaggregated for a better understanding.

Table 4.4. Cost for Citizens for Scenarios to Promote ID Card Renewal in Peru

	SMS (1)	**SMS + online platform (real)** (2)	**SMS + online platform (hypothetical)** (3)
Panel A. Citizens who would not have renewed their ID card, and after intervention renews in-person			
Transaction cost (US$)	1.69	0.89	0.89
In-person transaction cost (US$)	13.78	13.78	13.78
Transport cost	2.54	2.54	2.54
Time cost	11.24	11.24	11.24
Citizens in this category (%)	12.30	6.44	6.44
Panel B. Citizens who would not have renewed their ID card, and after intervention renews online			
Transaction cost (US$)	-	0.09	0.06
Platform transaction cost (US$)	-	3.91	2.52
Transport cost	-	1.27	1.27
Time cost	-	2.64	1.25
Citizens in this category (%)	-	2.26	2.26
Panel E. Citizens who attempted to complete the transaction on the online platform but were unsuccessful			
Cost from failed transaction attempts on platform	-	1.08	-
(US$)	-	1.39	-
Time cost of trying the transaction on the platform			
(US$)	-	77.82	20.00
Citizens in this category (%)			
Cost per capita for citizens (US$)	**1.69**	**2.06**	**0.94**

Source: Prepared by the authors.
Note: Citizens who would have renewed their ID in person before and after the intervention (3.74 percent), and those who would have renewed their ID card in-person, and after intervention renew online (-3.74 percent) do not incur costs.

Turning to the cost associated to the implementer, we included costs of sending text messages, government costs of providing the service in person for the additional percentage of people who renewed the ID because of the reminder, overhead costs, and deadweight costs due to tax-related distortions. For the calculation of the costs of sending text messages, we take the average number of messages per person (4 SMS) that was sent in the experiment of Reyes et al. (2021) and multiply it by the cost of sending a text message (US$ 0.01). Regarding the additional cost of providing the service in person, we use the government cost of performing an in-person transaction in Mexico (US$ 9.10) from Roseth et al. (2018), adjusted to the Peruvian context by purchasing power parity (World Bank, 2022) and subsequently translated to 2022 US$ (US$ 6.48). Once the monetary cost of the in-person transaction is obtained, we assume that 50 percent of this cost is variable and should be considered within government costs; therefore, we weight the government cost per transaction (US$ 6.48) by 50 percent, resulting in US$ 3.24. This value is multiplied by the additional percentage of people who decide to renew their ID card due to the reminder message (12.30 percent) to obtain the cost of face-to-face transactions for people affected by the intervention (US$ 0.69).

The overhead costs are calculated as 15 percent of the government transaction costs, i.e., US$ 0.40 (3.24*0.123), and of sending text messages (US$ 0.04). Tax-related distortions are calculated as 20 percent of government transaction costs for that additional percentage of people renewing their IDs after the intervention (US$ 0.40), text messages cost (US$ 0.04) and overhead costs (US$ 0.07). Finally, the costs of sending text messages (US$ 0.04), the social cost of tax distortions (US$ 0.10), the overhead cost (US$ 0.07) and the in-person transaction cost to the government (US$ 0.40) are added to obtain the per capita cost of the implementer (see Table 4.5).

In the scenarios of SMS + online platform, the implementer's cost is the cost of providing the service to those citizens who previously did not carry out the transaction and decide to do so after the intervention, either through the face-to-face channel or the platform. For those who previously did not renew their ID and now perform the transaction in person (6.44 percent), the same costs described in the section on the SMS scenario apply. That is, 50 percent variable costs per transaction that is US$ 3.24 (6.48*0.50). The transaction cost is then obtained by multiplying that US$ 3.24 by the percentage of the population who previously did not renew their ID and now perform the transaction in person (6.44 percent).

As for people who before the intervention did not make the transaction and now make it on the platform (2.26 percent), a cost is incurred for carrying out the transaction on the platform. This cost is calculated as the government cost for a transaction on the platform (US$ 0.32) from Roseth et al. (2018), multiplied by the percentage of people who would not have renewed their ID card and after intervention renew online (2.26 percent).

As is the case in the only SMSs branch, messages are sent that carry a cost of US$ 0.04 (4*0.01). There is an overhead cost of 15 percent on the last three costs described that is US$ 0.04

(0.15*(0.21+0.01+0.04)). Tax-related distortions are included as 20 percent of the government transaction costs for citizens who previously did not renew and now do so in person (US$ 0.21), for citizens who previously did not renew and now do so on the platform (US$ 0.01), per capita message cost (US$ 0.04) and overhead costs (US$ 0.04). Then, both government transaction costs (US$ 0.21 and US$ 0.01), the cost of sending messages (US$ 0.04) and the overhead cost (US$ 0.04) are added together with the tax distortion costs (US$ 0.06) to obtain the per capita cost of the implementer (see Table 4.5).

Table 4.5. Cost for the Implementer for Scenarios to Promote ID Card Renewal in Peru

	SMS (1)	**SMS + online platform (real)** (2)	**SMS + online platform (hypothetical)** (3)
Panel A. Citizens who would not have renewed their ID card, and after intervention renew in-person			
Transaction cost (US$)	0.40	0.21	0.21
In-person transaction variable cost (50% in-person transaction cost) (US$)	3.24	3.24	3.24
In-person transaction cost (US$)	6.48	6.48	6.48
Citizens in this category (%)	12.30	6.44	6.44
Panel B. Citizens who would not have renewed their ID card, and after intervention renew online			
Transaction cost (US$)	-	0.01	0.01
Platform transaction cost (US$)	-	0.32	0.32
Citizens in this category (%)	-	2.26	2.26
Cost of sending messages (US$)	0.04	0.04	0.04
Overhead cost (US$)	0.07	0.04	0.04
Deadweight loss (US$)	0.10	0.06	0.06
Cost per capita for the implementer (US$)	**0.61**	**0.35**	**0.35**

Source: Authors' calculations.
Note: The government do not to incur costs for citizens who would have renewed their ID in person before and after the intervention (3.74%), for who would have renewed their ID card in-person, and after intervention renews online (-3.74%) and for those who attempted to complete the transaction on the online platform but were unsuccessful (77.8% of those who started the transaction in the real scenario and 20% in the hypothetical scenario).

The costs presented above imply that the citizens will incur an average cost per capita of US$ 1.69 and the government will incur an average cost per capita of US$0.61. Therefore, the total average cost per person will be US$ 2.30. In the scenario in which the platform makes it difficult to conduct the transaction, the citizen (US$ 2.06) and implementer (US$ 0.35) costs result in a total average cost per person of US$ 2.41. In the scenario in which the platform works as expected, the citizen's costs (US$ 0.94) and the per capita cost for the government (US$ 0.35) result in a total average cost per person of US$ 1.30 (see Table 4.6).

Table 4.6. Total Cost per Person for Scenarios to Promote ID Card Renewal in Peru

	SMSs (1)	**SMS + online platform (real)** (2)	**SMS + online platform (hypothetical)** (3)
Cost per capita for citizens (US$)	1.69	2.06	0.94
Cost per capita for the implementer (US$)	0.61	0.35	0.35
Total cost per person (US$)	**2.30**	**2.41**	**1.30**

Source: Authors' calculations.

4.1.5. Estimation of Benefits and Costs for Other Countries

For other countries for which we estimate this cost-benefit analysis (Chile, El Salvador, and Jamaica), we follow a similar procedure using other data sources to adapt the parameters to each context. Among the parameters that change from country to country, we obtained the ID validity duration, country population over 18 years, bus trip fares, and citizen time to complete a transaction face-to-face (see detailed sources of information in Annex 4.1). When the data were not available for one country, we used the average in LAC. That is the case of the time of completing an in-person transaction in Jamaica, in which we assumed the average of LAC countries reported in Roseth et al. (2018).

4.1.6. Results

Table 4.7 reports the main components of the cost-benefit analysis for all countries and presents the results of key indicators such as the benefit-cost ratio and the net present value. For example, in Peru, the results for the SMS intervention show a total benefit per person of US$ 4.92. This comes from the estimated benefits of renewing the ID received by citizens and the government (US$ 2.46). The total cost per capita is US$ 2.30, of which US$ 1.69 is borne by each citizen renewing his or her ID and US$ 0.61 by the government. From these estimates, we calculated a benefit-cost ratio of 2.14. We also calculated the net present value per person (US$ 2.62) from the difference between the benefit per person and cost per person. Finally, considering that the target population of this program is 2.61 million people, the total net present value for this intervention in Peru is estimated at US$ 6.84 million.

Similarly, in Chile, Jamaica and El Salvador the benefit per person amounts to US$ 4.92 with the same composition of benefits for the citizen (US$ 2.46) and the implementer (US$ 2.46). However, costs vary from country to country. In Chile, they reach a value of US$ 2.19 per person, of which most is borne by the citizen (US$ 1.49 vs. US$ 0.70). Dividing the total benefits per person by the total costs per person gives a benefit-cost ratio of 2.25 for each US$ invested. The net present value per person is US$ 2.73, which when multiplied by a target population of 1.26 million people results in a total net present value of the program for Chile of US$ 3.46 million.

Moreover, for El Salvador, the costs are US$ 1.29 per person. Costs are distributed in 63.50 percent for the citizen and 36.50 percent for the implementer. The benefit-cost ratio for this country results in 3.82, while the net present value per person is US$ 3.63 and the target population amounts to 0.16 million people. These results together allow us to calculate a total net present value of the program of US$ 0.58 million in El Salvador. In Jamaica, the total per capita costs are US$ 2.45, which are distributed as follows: US$ 1.78 per citizen and US$ 0.67 for the government per person renewing their ID. The benefit-cost ratio results in 2.01 for each US$ invested, and the net present value per person is US$ 2.47. The target population in Jamaica is 0.03 million people, which contributes to a total net present value of the program in Jamaica of US$ 0.07 million (see Table 4.7).

Table 4.7. Cost-Benefit Analysis of Scenarios to Promote ID Card Renewal in Selected Countries

	SMS (1)				SMS + online platform (real) (2)				SMS + online platform (hypothetical) (3)			
	Peru	Chile	El Salvador	Jamaica	Peru	Chile	El Salvador	Jamaica	Peru	Chile	El Salvador	Jamaica
Benefit per capita (US$)												
For citizens	2.5	2.5	2.5	2.5	2.1	1.9	1.9	2.1	2.2	2.0	1.9	2.2
For implementer	2.5	2.5	2.5	2.5	1.8	1.9	1.8	1.9	1.8	1.9	1.8	1.9
Total benefit	4.9	4.9	4.9	4.9	4.0	3.8	3.7	4.0	4.0	3.9	3.8	4.0
Cost per capita (US$)												
For citizens	1.7	1.5	0.8	1.8	2.1	3.1	1.3	2.2	0.9	0.9	0.5	1.0
For implementer	0.6	0.7	0.5	0.7	0.4	0.4	0.3	0.4	0.4	0.4	0.3	0.4
Total cost	2.3	2.2	1.3	2.4	2.4	3.5	1.6	2.6	1.3	1.3	0.7	1.4
Results												
Benefit-cost ratio	2.1	2.3	3.8	2.0	1.6	1.1	2.3	1.5	3.1	3.0	5.1	2.9
Net present value per capita	2.6	2.7	3.6	2.5	1.5	0.3	2.1	1.4	2.7	2.6	3.0	2.6
Target population (million)	2.6	1.3	0.2	0.0	2.6	1.3	0.2	0.0	2.6	1.3	0.2	0.0
Net present value (millions of US$)	6.8	3.5	0.6	0.1	4.0	0.3	0.3	0.0	7.1	3.3	0.5	0.1

Source: Authors' calculations.

4.2. Cost-Benefit Analysis of a Biometric Identification Intervention for Service Delivery

This subsection presents the methodology and assumptions of the cost-benefit analysis presented in Chapter 4, Section 4.2.2 of the report. Common assumptions presented in Section 1 of this technical note apply to this analysis. All the data sources used to provide estimates for the different parameters in this analysis are included in Annex 4.3 of this technical note.

4.2.1. Background

All transactions with the government require some form of authentication to identify who is carrying out the transaction. The authentication process varies from country to country and depends on the availability of unique identification documents, the level of sophistication of the ID, and the quality of the registries. These three dimensions are already a challenge in the region. First, some countries do not have a unique identification document. In those case, citizens must show whichever document they have at hand such as birth certificates, tax identification certificates, or passports, among others. Second, some countries have identification cards without associated biometric information that could serve to speed up any transaction. Third, some countries' identification documents do not have an expiration date, which means that the registration office does not have updated information on the address or picture of the citizen after he turns 18. All these issues not only make the authentication process more difficult, but also increase the likelihood of identity theft and fraud.

Biometric and digital identification are thus emerging as solutions to the problem of efficiency and security in government transactions. These solutions are incipient, and there is little empirical evidence about how these identification systems can affect citizens' experience when transacting with the private and public sectors. Within the existing evidence, two papers by Muralidharan et al. (2016, 2021) are worth highlighting. The authors study the effects of implementing biometric authentication to improve the delivery of public services in India. We extrapolate their findings to our context of analysis to calculate the benefits and costs of the implementation of these types of systems.

4.2.2. Program and Evaluation

Muralidharan et al. (2016) and Muralidharan et al. (2021) analyze the effects of implementing biometric systems for the provision of aid. In the first case, they study the provision of smartcards to deliver two of the largest social programs in the state of Andhra Pradesh: one for those able to work (NREGS) – that offered each rural household up to 100 days of paid employment per year – and for those who could not work (known as SSP) – that distributed unconditional monthly payments. Smartcards often included a digital photograph and a chip with biographic, biometric (fingerprints), and bank account information. Although the program was initially launched in 2006, the integration of systems and coordination with local banks took a long time. In 2010, seeing little progress, the government decided to relaunch the program using lessons learned from districts that had successfully achieved to integrate necessary systems. The authors study the randomized deployment of this program from 2010-2012 and find that NREGS beneficiaries collected their payments faster (22 fewer minutes or a 20 percent reduction), leakage decreased between 2.8 percentage points (SSP) and 12.7 percentage points and coverage of the programs remained unaffected. They also report that between 90 to 93 percent of beneficiaries preferred the new system.

The second study focuses on the case of biometric identification for the delivery of the largest social program in the state of Jharkhand, India, and find opposite effects to their 2016 study. In this case, smartcards replaced "ration cards" that allowed beneficiaries to purchase a fixed monthly quantity of grain and other commodities at a subsidized price in government-run stores. Contrary to the 2016 paper, they find that there were no fiscal savings. They also do not find changes in coverage of the program but do find a small drop in corruption explained by the increase in accountability to which grain distributors were subjected. Moreover, the authors find that the program generated a 17 percent increase in citizens' transaction costs since the number of times citizens had to go to the government stores doubled. Failures of the biometric authentication system and the lack of manual alternatives for authentication were the main factors explaining this increase in costs.

The authors acknowledged these problems in the implementation of the biometric authentication system that occurred in the second study. They mentioned that the difference in effects can be attributed mainly to the length of project planning and implementation between the two studies. While in the first case the project planning took more than four years and was done in coordination with different institutions, in the second case the experiment was planned and implemented in less than six months, giving little time to foresee system and project failures. For example, in the Jharkhand study, the possibility of paper-based authentication as a backup option in case of failure of the biometric identification was not considered. Because of these implementation problems, we focus our analysis on the first study since the objective is to understand the benefits and costs of biometric authentication assuming that the system in place works as expected.

4.2.3. Overview of the Approach Followed to Estimate Benefits and Costs

To conduct the cost-benefit analysis, we consider the benefits and costs over one year of implementation. Society, in these interventions, has three stakeholders that need to be considered: the beneficiaries, the intermediaries and the government. Intermediaries had the role of i) distributing the government transfers, and ii) reporting to the government the budget needs to deliver the subsidy to the target population. The authors argue that the role of these actors created space for corruption. On the one hand, intermediaries requested more funds from the government than they actually needed for redistribution (for example, by indicating that there were more beneficiaries than the actual number of beneficiaries), and on the other hand, they distributed fewer rations to beneficiaries. Results indicate that, as a consequence of the biometric authentication, the leakage of funds decreased, mainly explained by an increase in the amount disbursed to beneficiaries. This means that intermediaries lost revenue from the implementation of biometric identification. However, corruption does not benefit society, so we excluded from the analysis any losses that intermediaries may have experienced.

We consider two benefits of citizens' access to a biometric authentication system: i) increases in social program transfer payments due to reductions in corruption and ii) a reduction in waiting times in line to claim subsidies. It should be noted that this simplified characterization of benefits is associated with the fact that we only have information about how the implementation of the biometric system affected the execution of the programs studied in Muralidharan et al. (2016). However, biometric authentication has the potential to bring about other potential benefits that are not considered in this cost-benefit analysis. For example, it guarantees that subsidies are delivered to the person for whom they were intended, it provides a more secure process of authentication, and it reduces transportation costs by allowing beneficiaries to access different subsidy delivery points, among other advantages. On the government side, we identify that an authentication system improves the effectiveness of subsidy distribution due to the elimination of ghost beneficiaries and improves the efficiency of such distribution due to a decrease in corruption. Both benefits are difficult to quantify, but for the development of this cost-benefit analysis we assume that it is equal to the citizen benefit generated by the decrease in waiting times.

On the other hand, we identified that the only cost to citizens is associated with the time spent registering in the biometric authentication system. In the context of Muralidharan et al. (2016), enumerators were stationed at high-traffic points to identify and register those who were beneficiaries of the subsidy, therefore, there were no costs associated with transportation to the government office to conduct this registration. With respect to the implementer's costs, we consider the costs of setting up POS (point-of-sale) stations at distribution locations, the expense of training the intermediaries in charge of distributing the subsidy, the administrative costs of coordinating the program, and a deadweight cost associated with the tax collection necessary to implement this program.

4.2.4. Estimation of Benefits and Costs for the Base Country

This section describes how we estimate the benefits and costs of the program studied for the base country: Peru. For other countries for which we estimate this cost-benefit analysis (Chile, El Salvador, and Jamaica), we follow a procedure similar to that for the base country and adjust parameters to the specific country of analysis. In Section 4.2.5, we present the benefits and costs for the four countries analyzed (Chile, El Salvador, Jamaica, and Peru).

Target Population

In general, biometric identification presents a wide range of benefits for all citizens. This type of authentication benefits citizens without identification, in countries that do not have a unique identification method, who are unbanked or live in areas that are difficult to access, and reduces transportation costs to government offices and transaction times. Biometric identification additionally provides benefits to those who already have a unique ID by speeding up the authentication process with public and private institutions and ensuring the security of citizen information.

However, our objective for this analysis is to study the benefits of biometric identification in the context of government aid distribution. In case of India studied by Muralidharan et al. (2016), the objective was to implement biometric identification to improve accountability and speed up authentication for the delivery of the largest transfer program. Thus, similarly, our target population in this study is the population receiving subsidies in Peru and the other countries of analysis. For this reason, for the Peruvian case we focus on analyzing the cost-benefit of implementing biometric identification for the delivery of the *Juntos* program in Peru. In particular, we focus on the rural population of the *Juntos* program because they would benefit the most from biometric identification.[67]

Average Benefit per Person

As mentioned above, both citizen and government benefits were considered in calculating the benefits of the program. With respect to the benefits to the citizen, we considered two components. First, Muralidharan et al. (2016) find that due to biometric identification, the corruption of

[67] Beneficiaries in urban areas could receive their subsidies using debit cards and the existing network of banks, business that accept debit cards, and ATMs.

intermediaries decreased, in turn generating a greater transfer of subsidies to citizens. The authors estimate that the annual leakage reduction due to smart cards is about 5 percent. In other words, beneficiaries received an increased in subsidies of about 5 percent of their transfer after biometric cards were put in place. To translate this benefit for the Peruvian context, we used data from the *Juntos Perú* program, the largest conditional cash transfer (CCT) program that provides aid to poor households in Perú. By 2022, the annual per capita budget execution of *Juntos Perú* was US$ 134.07. The latter was computed by dividing the reported 2021 total budget for *Juntos Perú* (US$ 1,088.16million), reported by the Ministry of Development and Social Inclusion of Peru, by the number of beneficiaries of this program in the same year, which are approximately 2.49 million people according to data from the Ministry of Development and Social Inclusion of Peru and Esri (0.69 million households*3.6 persons per household) in 2021. We used the per capita budget execution in Peru along with the effect size reported in Muralidharan et al. (2016) to compute the expected increase in transfer payments due to corruption reduction in biometric authentication used to deliver the program. Thus, annual increases in CCT payments are expected to be US $ 6.70 per beneficiary (US $134.07 * 0.05).

The second component of citizens' savings is time savings due to the reduction of time required to complete the transaction. In the context of the Muralidharan et al. (2016) study, beneficiaries had to keep attending intermediaries" distribution points to claim their subsidy. Thus, there was no savings in transportation costs. However, upon arrival at the distribution point, there was a reduction in waiting time in line. The authors estimate a reduction in transaction time of about 10.00 percent over the status quo or the scenario in which there was no smartcard biometric authentication. To assess this reduction in the Peruvian context, we first used the number of times that beneficiaries of the program could claim the subsidy annually. *Juntos Perú* beneficiaries receive a bimonthly payment (Women's World Banking, 2019), and therefore they should have to attend the distribution office 6 times a year. Thus, the time saved in carrying out the transaction is 2.7 hours and is computed as 10 percent of the time it takes the average beneficiary to complete an in-person transaction without the smartcard (4.5 hours, according to Roseth et al., 2018) multiplied by the times a *Juntos Perú* beneficiary must claim payment per year (6 times). Then, we monetize the time saved per year by multiplying the latter factor by the average hourly wage of a poor person in Peru (US$ 1.99). We used the average hourly wage of a poor person because that is the target population of the *Juntos* program.

That wage is approximated by averaging the minimum hourly wage in 2022 (El Comercio, 2022) and the average hourly wage in 2022. Together, the hours that a citizen saves in carrying out the CCT claim (2.70 hours) multiplied by the average hourly wage of a poor person in Peru (US$ 1.99) results in a benefit in transaction time of about US$ 5.38 per beneficiary.

Altogether, adding the increases in payment received due to the reduction of corruption (US$ 6.70) and the savings in transaction time experienced by the citizen (US$ 5.38) results in a per capita benefit to the citizen of US$ 12.09, as reported in Table 4.8.

Table 4.8. Benefit for Citizens of a Biometric Identification Intervention for Service Delivery in Peru

Increase on CCT payment due to corruption reduction per capita (US$)	6.70
CCT annual leakage reduction due to smart cards (%)	5
Annual budget execution per capita (Juntos Peru)) (US$)	134.07
Transaction time savings per capita (US$)	5.38
Time to carry out an in-person transaction (hours)	4.5
% Time reduction (in minutes) to collect payments (%)	10
Average wage per hour, for the poor (US$)	1.99
Times collecting Juntos payment per year (times)	6.00
Benefit per capita for citizens (US$)	12.09

Source: Authors' calculations.

With respect to the benefits to the implementer, we identified many, but they are challenging to quantify. For example, biiometric authentication eliminates ghost beneficiaries from the group subject to subsidy distribution. It also reduces leakage during the distribution of the subsidy, given that biometric authentication increases accountability of the intermediaries, and improves targeting since the subsidy is delivered to the person intended. Officials who authenticate beneficiaries increase their productivity because they can make more subsidy distributions in less time because the authentication process becomes faster. When viewed as a whole, there are several benefits to the implementer. However, due to the difficulty of monetizing all these benefits and the lack of evidence about the effect size on some of the effects, we focus on the monetization of the reduction in time when authenticating the beneficiary. For this reason, we assume that the implementer's time savings can be approximated by using the citizens' time savings during a transaction (US$ 5.38), as shown in Table 4.9.

Table 4.9. Benefit for the Implementer of a Biometric Identification Intervention for Service Delivery in Peru

Transaction time saved on authentication and identity verification per capita (US$)	5.38
Transaction time savings per capita (US$)	5.38
Benefit per capita for the implementer (US$)	5.38

Source: Authors' calculations.

Finally, the societal total benefit per person is computed as the sum of the benefit per citizen (US$ 12.09) and the benefit to the implementer per capita (US$ 5.38), as shown in Table 4.10.

Table 4.10. Total Benefit per Person of a Biometric Identification Intervention for Service Delivery in Peru

Benefit per capita for citizens (US$)	12.09
Benefit per capita for the implementer (US$)	5.38
Total benefit per person (US$)	17.47

Source: Authors' calculations.

Average Cost per Person

In this case, we also take into account the costs involved for both the citizen and the implementer of putting in place a biometric authentication system. According to the intervention design studied by Muralidharan et al. (2016), all costs to citizens are associated with enrollment in the biometric system. In this study, enrollment was done by deploying government officials at high-agglomeration locations. Thus, citizens did not have to travel to the government office but did have to allocate some of their time to complete the registration. We assume the time to complete a registration is similar to the time of completing a transaction in person (4.5 hours) reported by Roseth et al., 2018. We monetize this value using the average wage for the poor computed as stated above. In addition, we assumed that registration or the biometric identification is valid for 5 years. Thus, the monetary cost of registering in the smart card system is expected to be US$1.79 (4.5*1.99/5) per citizen. This computation is shown in Table 4.11.

Table 4.11. Cost for Citizens of a Biometric Identification Intervention for Service Delivery in Peru

Time spent registering for the smart card system per capita (US$)	1.79
Citizen time to make the transaction face-to-face (hours)	4.50
Average poor wage per hour (US$)	1.99
Years receiving smartcard benefits (years)	5.00
Cost per capita for the citizens (US$)	1.79

Source: Authors' calculations.

Turning to the costs for the implementer, we considered five costs (see Table 4.12): i) the training of intermediaries, ii) the installation of POS stations, iii) the cost of smartcards, iv) overhead costs of implementing the program, and v) tax distortion costs generated because of the additional tax collection needed to implement the biometric authentication program. First, it should be noted that before the intervention, intermediaries were authenticating beneficiaries manually and recording subsidy payments on paper. Therefore, by implementing POS stations in each distribution center, it would be necessary to train intermediaries in the use of the new system. We assumed that such training would require approximately 8 hours per trainee, who would earn the average national wage in Peru (US $ 2.50). In other words, the cost of training each intermediary would be US$ 20 (2.50*8). To compute the per capita cost, we additionally considered that if this program were implemented in Peru, there will be approximately 55.33 Juntos program beneficiaries attending each POS station. We computed this figure using the number of beneficiaries in rural areas of the Juntos Program (548,123.4), and the number of POS stations that would need to be implemented in Peru if this program were rolled out (9,907.2).[68] In addition, we assume there is a turnover of trained employees every two years. We also assume an overhead cost of the training of about 100 percent, which accounts for the coordination and administration of the training. Thus, the cost of training per each beneficiary would be US$0.36 (US$ 20*(1+100%)/(55.33*2)).

Second, to compute the expenditure on POS stations we took into consideration costs of implementation and maintenance of the new system. Implementation costs per beneficiary include the costs of acquiring POS stations for intermediaries (US $ 193.81 per POS station) assuming

[68] The number of POS stations needed to implement the program in Peru was computed assuming that i) one intermediary can authenticate and deliver the subsidy to 4 beneficiaries in 1 hour, ii) each intermediary is open 8 hours per day, 6 days a week, 52 weeks a year. Thus, the number of POS stations needed is 9,907.2 (4*8*6*52).

each station would be working for about 5 years and would provide service to 55.33 beneficiaries. Thus, the costs of implementation are US $ 0.70 (193.81/(55.33*5)). On the other hand, we assume maintenance costs are 3 percent of the cost of implementation (US$ 0.02 or 0.70*0.03). Together the cost of implementation and maintenance of POS stations per beneficiary amount to US$0.72.

Third, by implementing the biometric system, the government would need to acquire smartcards. Each smartcard costs about US$0.92. Next, we considered overhead costs of 15 percent due to the administration and logistics of acquiring the POS stations and smartcards ((US$0.72+US$0.92)*0.15). Finally, we assumed that deadweight loss of collecting taxes to implement this program would be 20 percent of the total cost for the implementer (US$2.24*0.2).

Table 4.12. Cost for the Implementer of a Biometric Identification Intervention for Service Delivery in Peru

Time spent training an intermediary (US$)	0.36
Time of biometric verification training (hours)	8.00
Average wage per hour (US$)	2.50
People claiming payment by smartcard who are served by intermediary per year (people)	55.33
Years in which the intermediary is employed in the store (years)	2.00
Overhead cost (%)	
POS station cost per capita (US$)	0.72
Implementation cost (US$)	0.70
Maintenance cost (US$)	0.02
Smartcard cost per capita (US$)	0.92
Overhead cost (US$)	0.25
Deadweight loss (US$)	0.45
Cost per capita for the implementer (US$)	2.69

Source: Authors' calculations.

All in all, the average cost of implementing a biometric system for the delivery of subsidies is composed of i) the cost for citizens ($1.79), and the costs for the implementer ($2.69), for a total cost of US$4.49 per capita for society, as shown in Table 4.13.

Table 4.13. Total Cost per Person of a Biometric Identification Intervention for Service Delivery in Peru

Cost per capita for citizens (US$)	1.79
Cost per capita for the implementer (US$)	2.69
Total cost per person (US$)	4.49

Source: Authors' calculations.

4.2.5. Estimation of Benefits and Costs for Other Countries

Cash transfer programs in the region widely varied in terms of the targeted population, the amount and method of transfer, and the type of conditionality. To simplify the comparison across countries, we envisioned a scenario in which the program Juntos Peru was present in the other countries of analysis. The first challenge of making such assumption is to compute the mass of beneficiaries. To compute this number, we first calculated the total number of beneficiaries in Peru as a percentage of the population, assuming that there is only one beneficiary per household. In total, there are 692,075 households who benefit from the program and approximately 3.6 persons per household. Thus, the total number of direct and indirect beneficiaries of the Juntos program in Peru represent 7.56 percent of the population. We assume that there would be a similar portion of beneficiaries in the other countries of analysis: 1,444,489 in Chile (19,116,209*0.0756), 490,120 (6,486,201*0.0756) in El Salvador, and 223,756 (2,961,161*0.0756) in Jamaica (based on data from World Bank, 2020).

In the case of wages, we used the midpoint between the minimum wage and the average wage in each country to compute the salary of the poor (ILOSTAT, 2014; SEDLAC, 2022). We used the same price of POS stations in Peru as in other countries since technological products should have international prices. To compute the amount disbursed per beneficiary, we first calculated the ratio between the annual per capita execution of the Juntos program (US $134.07) to the GDP per capita in Peru (US $ 6,479.32). This is an estimate of the transfer as percentage of the average annual individual income (2.07 percent). Using this ratio and the GDP per capita of the other countries of analysis, we computed the estimated transfer if the Juntos program were implemented in Chile (US $356.61), El Salvador (US$ 93.91) and Jamaica ($97.70). Finally, we took the available pricing of POS stations and smartcards in each country available in Global Microless for year 2022.

4.2.6. *Results*

The intervention proves to be cost-effective for all four intervention countries, especially Peru. The difference in cost-effectiveness across countries is mainly related to differences in the benefits to citizens, as shown in Table 4.14. Starting with Peru, we see that the benefit-cost ratio is 3.89 per US$1 invested. Given that the expected target population for this intervention would be 550.000 citizens, the expected net present value of this intervention is 7.11 million US$. This result is highly influenced by significant benefits for citizens due to the decrease in corruption and the reduction in transaction costs. It is also influenced by the relatively low implementation costs.

Turning to the results in other countries, we find that their cost-effectiveness highly depends on the benefits for citizens and the costs for the implementer. Benefits for citizens are 5 percent of the cash transfer allocation. In turn, we assumed this allocation depends on the GDP per capita of the country of analysis. For this reason, we have a higher allocation in Chile, followed by Peru, Jamaica and El Salvador. On the other hand, the costs per capita per beneficiary are dependent on the number of beneficiaries of the program and the percentage of the population living in rural areas. Given that the implementation of the program is composed of fixed and variable costs, the smaller the number of beneficiaries, the larger the fixed costs per capita. Also, higher levels of rurality increass the costs of implementation of the program. The latter is a factor affecting mostly the cases of El Salvador and Jamaica, with respective rural populations of 27 and 44 percent.

Overall, the implementation delivers a positive net present value regardless of the country of implementation. Jamaica has the lowest benefit-cost ratio with a return of 1.41 per US$ invested, followed by El Salvador with a return of 1.50. As expected, the total net present value of implementing biometric authentication will depend on the number of beneficiaries in a country, and therefore, on the country's population. For this reason, the total net present value ranges from US$ 0.46 million in Jamaica to 7.11 million in Peru.

Table 4.14. Cost-Benefit Analysis of a Biometric Identification Intervention for Service Delivery in Selected Countries

	Peru	Chile	El Salvador	Jamaica
Benefit per capita (US$)				
Benefit for citizens	12.09	21.32	7.76	10.41
Benefit for the implementer	5.38	3.49	3.06	5.53
Total benefit	17.47	24.80	10.82	15.94
Cost per capita (US$)				
Costs for citizens	1.79	1.16	1.02	1.84
Costs for the implementer	2.69	7.40	6.19	9.46
Total cost	4.49	8.56	7.21	11.31
Results				
Benefit-cost ratio	3.89	2.90	1.50	1.41
Net present value per capita (US$)	12.98	16.24	3.61	4.63
Target population (million)	0.55	0.17	0.13	0.10
Total net present value (millions of US$)	7.11	2.81	0.48	0.46

Source: Authors' calculations.

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Annex 2.1. Data Sources for Cost-Benefit Analysis of a Digital Intervention to Reduce Dropout Rates

Data	Source
Target population and target schools	Peru: 2019 school census Chile: Ministry of Education 2021 El Salvador: Ministry of Education 2021 Jamaica: Ministry of Education, Youth and Information 2015/16 2018 PISA
Annual net labor income	Peru: ENAHO 2019 Chile: Encuesta de Caracterización Socioeconómica Nacional (CASEN) 2017 El Salvador: Encuesta de Hogares de Propósitos Múltiples (EHMP) 2019 Jamaica: Labour Force Survey (LFS) 2016
Average annual growth of real labor income	Peru: ENAHO 2006-2019 Chile: CASEN 2006-2017 El Salvador: EHMP 2006-2019 Jamaica: LFS 2006-2016
Return to an additional year of education	Montenegro, C. E., & Patrinos, H. A. (2014).
Labor deductions % of gross salary	Employer social security tax rates, KPMG
Government expenditure secondary education and government expenditure tertiary education	Peru: INEI 2019 Chile: Ministry of Education 2015 El Salvador: Ministry of Education 2019 Jamaica: World Bank 2015
Percentage of tertiary students in public institutions	Peru: INEI 2018 Chile: Ministry of Education 2021 El Salvador: Ministry of Education 2017
Hourly wage 14-17 years-old and hourly wage 18-24 years-old	Peru: ENAHO 2019 Chile: CASEN 2017 El Salvador: EHMP 2019
Hourly wage 18-65 years-old	Peru: ENAHO 2019 Chile: CASEN 2017 El Salvador: EHMP 2019 Jamaica: LFS 2016

Annex 2.2. Studies that Document the Relationship Between One Standard Deviation Increase in Academic Achievement and Earnings

Country	Grade / Age (test)	Variable	Grade / Age (results)	%	Reference
USA	KG	Annual earnings	age 25-27	9.6	Chetty et al. (2011)
USA	KG	Annual earnings	age 25-27	18.0	Chetty et al. (2011)
UK	grade 8	Annual earnings	7 years after high school	14.4	Rose (2006)
USA	age 12	Annual earnings	age 35	13.7	Own calculations from NLSY97
USA	grade 3-8	Annual earnings	age 28	1.3	Chetty et al. (2014)
USA	grade 3-8	Annual earnings	age 28	12.0	Chetty et al. (2014)
UK	age 7	Hourly wages	age 33	8.0	Krueger (2003)
UK	age 7	Hourly wages	age 33	7.6	Krueger (2003)
Average				**10.6**	

Annex 2.3. Data Sources for Cost-Benefit Analysis of Different Policy Options to Promote Student Practice Using Technology

Data	Source
Target population	Peru: 2019 school census Chile: Ministry of Education 2021 El Salvador: Ministry of Education 2021 Jamaica: Ministry of Education, Youth and Information 2015/16 2013 TERCE
Annual net labor income	Peru: ENAHO 2019 Chile: CASEN 2017 El Salvador: EHMP 2019 Jamaica: LFS 2016
Average annual growth of real labor income	Peru: ENAHO 2006-2019 Chile: CASEN 2006-2017 El Salvador: EHMP 2006-2019 Jamaica: LFS 2006-2016
Return to an additional year of education	Montenegro, C. E., & Patrinos, H. A. (2014).
Labor deductions % of gross salary	Employer social security tax rates, KPMG
Class size	Peru: 2019 school census World Bank 2018
Number of items to purchase	Peru: 2019 school census TERCE 2013
Average monthly labor income	Peru: ENAHO 2019 Chile: CASEN 2017 El Salvador: EHMP 2019 Jamaica: LFS 2016
Government expenditure secondary education Government expenditure tertiary education	Peru: INEI 2019 Chile: Ministry of Education 2015 El Salvador: Ministry of Education 2019 Jamaica: World Bank 2015
Percentage of tertiary students in public institutions	Peru: INEI 2018 Chile: Ministry of Education 2021 El Salvador: Ministry of Education 2017
Hourly wage 14-17 years-old Hourly wage 18-24 years-old	Peru: ENAHO 2019 Chile: CASEN 2017 El Salvador: EHMP 2019
Hourly wage 18-65 years-old	Peru: ENAHO 2019 Chile: CASEN 2017 El Salvador: EHMP 2019 Jamaica: LFS 2016

Annex 2.4. Studies that Document the Relationship Between One Standard Deviation Increase in Academic Achievement and Schooling

Country	Grade / Age (test)	Variable	Grade / Age (results)	Completed years	Reference
Peru	age 12	Schooling	age 22	1.12	Das et al. (2020)
USA	age 12	Schooling	age 35	0.66	Authors' calculations from NLSY97
Average				**0.89**	

Annex 3.1. Disease Burden for Cardiovascular Diseases, Depression and Diabetes in Latin America and the Caribbean

Table A.3.1 presents the disease burden for cardiovascular diseases, diabetes and depression in Latin America and the Caribbean. Of these three conditions, cardiovascular disease is the most prevalent, affecting in 1 in 5 people in LAC, and it is slightly more common in men, while diabetes affects 1 in 12 people in LAC, and it is slightly more common in women. Depression is the least prevalent of the three, affecting 3.7 percent of the population, with women almost twice as likely to be affected as men. Due to the pandemic, it is estimated that globally the prevalence of clinical depression has increased by 28 percent, representing an increase from 3.7 percent to 4.6 percent in LAC, and it is expected that the crisis will create mental health problems among previously healthy people and worsen conditions for those with pre-existing ones (Santomauro et al., 2021). At its worst, depression can lead to suicide. Although the rate of suicide in LAC (7 per 100,000 people) is lower than other parts of the world, it has been increasing slowly over the last three decades (Savedoff et al., 2020).

Table A.3.1 Deaths, DALYS, and Prevalence of Cardiovascular Disease, Depression and Diabetes in the 26 IDB Borrowing Member Countries

	Cardiovascular Disease			**Depression**			**Diabetes**		
	Total	Female	Male	Total	Female	Male	Total	Female	Male
Deaths per 100,000	164.3	156.8	172.1	-	-	-	34.0	35.8	32.1
DALYS per 100,000	3,465.3	3,019.4	3,925.9	622.0	807.8	430.1	1,375.7	1,382.9	1,281.5
Prevalence	20.3%	18.0%	22.8%	3.7%	4.6%	2.7%	8.8%	9.4%	8.2%

Sources: The data for cardiovascular disease are from the burden of cardiovascular diseases in the region of the Americas, 2000-2019 (PAHO, 2021), and worldwide trends in blood pressure from 1975 to 2015: a pooled analysis of 1,479 population-based measurement studies with 19.1 million participants (NCD Risk Factor Collaboration, 2017, published in *The Lancet*). The data for depression are from the burden of mental disorders in the region of the Americas, 2000-2019 (PAHO, 2021), and Global Burden of Disease Study 2019 (GBD, 2019). Results by Global Burden of Disease Collaborative Network, 2020 (ghdx.healthdata.org/gbd-results-tool). The data for diabetes are from the burden of diabetes mellitus in the region of the Americas, 2000-2019 (PAHO, 2021), and worldwide trends in diabetes since 1980: a pooled analysis of 751 population-based studies with 4.4 million participants (NCD Risk Factor Collaboration, 2016, published in *The Lancet*).

The burden of disease varies highly among the discussed in this chapter, both due to prevalence and the health system's ability to timely detect and effectively treat these diseases. To illustrate this variation, we include examples of one country from each of the IDB sub-regions highlighted in this publication: Chile, El Salvador, Jamaica and Peru. As seen in Table A.3.2, diabetes and cardiovascular disease cause significantly more deaths and DALYS in Jamaica than in Chile, El Salvador, or Peru, although the prevalence of these illnesses is comparable to Chile. Meanwhile, Chile reports a slightly higher prevalence of DALYs due to depression than the other countries.

Table A.3.2. Deaths, DALYS, and Prevalence of Diabetes, Cardiovascular Disease and Depression in Chile, El Salvador, Jamaica and Peru

	Cardiovascular Disease				Depression				Diabetes			
	Chile	El Salvador	Jamaica	Peru	Chile	El Salvador	Jamaica	Peru	Chile	El Salvador	Jamaica	Peru
Deaths per 100,000	150	127	182	78	-	-	-	-	17	22	70	14
DALYS per 100,000	2,801	2,431	3,562	1,718	747	615	567	370	907	1,123	2,241	63
Prevalence (%)	22.7	16.8	21.9	12.6	4.3	3.6	3.4	2.4	11.4	7.3	11.9	6.9

Sources: The data for cardiovascular disease are from the burden of cardiovascular diseases in the region of the Americas, 2000-2019 (PAHO, 2021), and worldwide trends in blood pressure from 1975 to 2015: a pooled analysis of 1479 population-based measurement studies with 19.1 million participants (NCD Risk Factor Collaboration, 2017, published in *The Lancet*). The data for depression are from the burden of mental disorders in the region of the Americas, 2000-2019 (PAHO, 2021), and Global Burden of Disease Study 2019 (GBD. 2019). Results by Global Burden of Disease Collaborative Network, 2020 (ghdx.healthdata.org/gbd-results-tool). The data for diabetes are from the burden of diabetes mellitus in the region of the Americas, 2000-2019 (PAHO, 2021), and worldwide trends in diabetes since 1980: a pooled analysis of 751 population-based studies with 4.4 million participants (NCD Risk Factor Collaboration, 2016, published in *The Lancet*).

Annex 3.2. Data Sources for Cost-Benefit Analysis of Providing Cognitive Behavioral Therapy

Data	**Source**
Population	World Bank (2022)
Population between 15 and 59 years old	World Bank (2022)
Adults with depression between 18-59 years old	World Health Organization (2017)
Levels of depression	Barboza et al (2020)
Population with depression without access to mental health services	Pan American Health Organization (2013a)
% of individuals using internet	World Bank (2022)
Adherence rate	Van Ballegooijen et al (2014)
Psychologists per 100,000 population	Pan American Health Organization (2013b)
Health worker earnings	Serje et al (2018)
% of deadweight loss	Harberger et al. (1997)
Average hourly wage	International Labour Organization (2022)
Exchange rate	Country Central Banks (n.d.)
Travel distance and time to health center from home	Weiss et al (2020)
Gasoline prices	Global Petrol Prices (2022)
CBT effects on monthly QALYs	Wu et al (2020)
% of effect received	Cuijpers et al (2019)
GDP per capita and forecast	International Monetary Fund (2022)
MB per minute of audio call	Tech Radar (2020)
Internet cost	Country principal mobile internet companies (n.d.)
Phone calls cost	Country principal mobile phone companies (n.d.)
iCBT treatment information	Beating the Blues (n.d.)

Annex 3.3. Data Sources for Cost-Benefit Analysis of an SMS Intervention to Prevent Onset of Diabetes

Data	Source
Population	World Bank Group (2022)
Prediabetes prevalence (impaired fasting glucose)	International Diabetes Federation (2021)
Population in public health system (%)	World Bank & WHO (2022)
Prediabetic patients the health system detects (%)	Assumption of half the rate in the USA based on CDC (2020)
Population with a mobile phone (%)	Sharma & Lucini (2016)
Hourly wage of nurse in public sector	Serje et al. (2018)
Cost per SMS	CommCare HQ (2022)
SMS Platform per month	TextIt (2022)
Average workers wage per hour	International Labour Organization (n.d.)
GDP per capita and forecast	International Monetary Fund (2022)
Health care cost of diabetic patients	International Diabetes Federation (2021)
Number of public primary care centers	Peru: Gobierno del Peru (2022) Chile: Ministerio de Salud de Chile (2022) El Salvador: Ministerio de Salud de El Salvador (2022) Jamaica: PAHO (2001)

__Annex 4.1. Data Sources for Cost-Benefit Analysis of Scenarios to Promote ID Card Renewal__

Data	Source
ID validity duration	Peru: RENIEC 2019 Chile: Registro civil e identificación de Chile (2022) El Salvador: Asamblea legislativa república de El Salvador (2022) Jamaica: CIA’s World Factbook 2022
Average wage per hour 2019	Peru: SEDLAC 2022 Chile: SEDLAC 2022 El Salvador: SEDLAC 2022 Jamaica: ILOSTAT 2014
Population	World Bank: World Development Indicators 2020
Population over 18 years	Peru: INEI 2020 Chile: INE 2017 El Salvador: Ministerio de salud El Salvador (2020) Jamaica: Stadistical Institute of Jamaica (2022)
Unregistered population	Banco Mundial: ID4D 2017
% Unregistered population	Unregistered population / Population over 18 years
Bus trip cost	Peru: La República 2019 Chile: La República 2019 El Salvador: Presidencia El Salvador (2020) Jamaica: Precios Mundi 2022
Number of trips to complete the transaction face to face Number of trips to complete the transaction on platform Citizen time to make the transaction on platform Citizen ideal time to make the transaction on platform	Reyes, A., Roseth, B., & Vera-Cossio, D. A. (2021). Technology, Identification, and Access to Social Programs: Experimental Evidence from Panama (No. 11535). Inter-American Development Bank.
Cost per SMS	CommCare HQ (2022)
Government cost for face-to-face transactions Government cost for platform transactions Citizen time to make the transaction face to face	Roseth, B., Reyes, A., Farias, P., Porrúa, M., Villalba, H., Acevedo, S., ... & Fillotrani, P. (2018). El fin del trámite eterno: Ciudadanos, burocracia y gobierno digital. Inter-American Development Bank.

Percent change: Inflation, average consumer prices (USD)	Monetary International Fund: World Economic Outlook 2021
Exchange rate: Average nominal exchange rate (Local currency per 1 USD)	World Bank: World Development Indicators 2022
PPP adjustment: Price level ratio of PPP conversion factor (GDP) to market exchange rate	World Bank: World Development Indicators 2022

Annex 4.2. Robustness Check Assuming Different Monetary Citizens' Benefit from ID Renewal

Figure A.4.2. Robustness Results for Benefit-Cost Ratio of Program Promoting ID Card Renewal

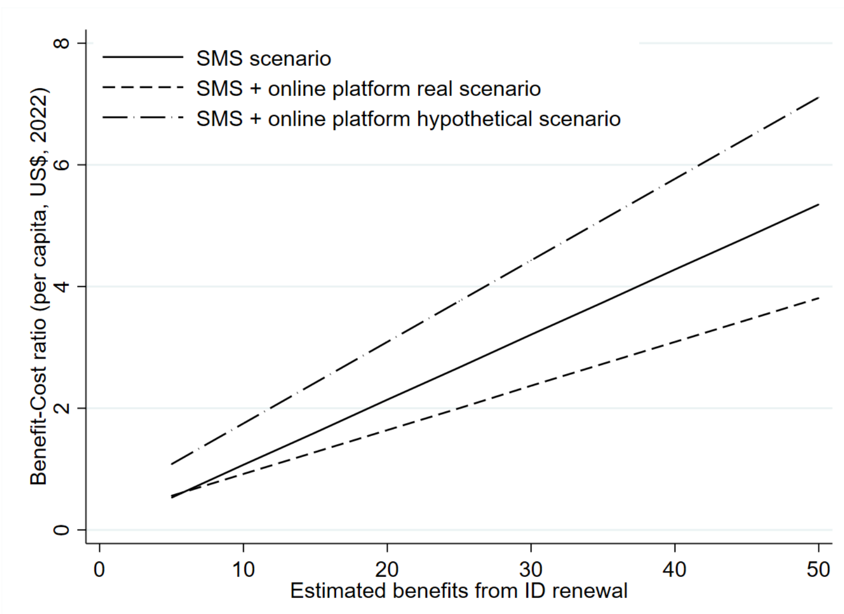

Table A.4.2. Robustness Results for Net Present Value of Program Promoting ID Card Renewal

Estimated citizens' benefit from ID renewal (US$)	**SMS (1)**	**SMS + online platform (real)** (2)	**SMS + online platform (hypothetical)** (3)
10	0.42	-0.50	2.54
30	13.27	8.59	11.63
50	26.13	17.68	20.72

Annex 4.3. Data Sources of a Biometric Identification Intervention for Service Delivery

Data	Source
Average wage per hour 2019	Peru: SEDLAC 2022 Chile: SEDLAC 2022 El Salvador: SEDLAC 2022 Jamaica: ILOSTAT 2014
Minimun wage per hour	Peru: El Comercio 2022 Chile: MIDIS 2022 El Salvador: El Salvador mi país 2022 Jamaica: Jamaica Information Service 2022
Population Population living in poverty of the country's population (%) % Rural population	World Bank: World Development Indicators 2020
Rural people of country population	% Rural population * Population
Population over 18 years	Peru: INEI 2020 Chile: INE 2017 El Salvador: Ministerio de salud El Salvador (2020) Jamaica: Stadistical Institute of Jamaica (2022)
% Population over 18 years	Population over 18 years / Population
People per household	ESRI 2021
Households in the CCT program (Juntos Peru) Annual budget execution (Juntos Peru)	MIDIS 2021
% Holding of accounts	Peru: INEI 2021 Chile: Comisión para el Mercado Financiero 2020 El Salvador: Elsalvador.com 2018 Jamaica: World Development Indicators 2014
People in CCT program (based on % of people in Juntos Peru)	Peru: (Households in CCT program (Juntos Peru) * People per household) Chile: % juntos beneficiaries of Peru total population * Country population El Salvador: % juntos beneficiaries of Peru total population * Country population Jamaica: % juntos beneficiaries of Peru total population * Country population
Citizen time to make the transaction face to face	Roseth, B., Reyes, A., Farias, P., Porrúa, M., Villalba, H., Acevedo, S., ... & Fillotrani, P. (2018). El fin del trámite eterno: Ciudadanos,

	burocracia y gobierno digital. Inter-American Development Bank.
Costs of the smart card system for CCT CCT annual leakage reduction due to smart cards Time savings collecting payment NREGS (%)	Muralidharan, Karthik, Paul Niehaus, and Sandip Sukhtankar. 201“. "Building State Capacity: Evidence from Biometric Smartcards in Ind”a." The American Economic Review.
Cost of acquiring a POS station Plastic card (TK4100 Blank Proximity ID Card price)	Microless 2022a, Microless 2022b
Years receiving smartcard benefits	Assumption
Times collecting Juntos payment in a year	Women's World Banking 2019
Average transaction time savings for NREGS program (22 min or -20%) and SSP (0 min or 0%)	(Citizen time to make the transaction face to face * Saving time collecting payment NREGS)+(Citizen time to make the transaction face to face * Saving time collecting payment SSP)/2
Costs of the smart card system for CCT pc	Costs of the smart card system for CCT pc / People in CCT program (Juntos Peru)
People that can be attended in a POS store every year	People attended by the intermediary per hour * Working hours per day * POS Stores open 6 days per week * Weeks per month * 2 months of Juntos payment
Number of smartcards POS stores required	Juntos rural beneficiaries / People that can be attended in a POS store monthly
People claiming payment by smartcard who are served by intermediary per year	Juntos rural beneficiaries / People that can be attended in a POS store every year
Juntos rural beneficiaries or CCT rural beneficiaries	People in CCT program (Juntos Peru) * % Poor rural people
Minimum wage per hour	El Comercio 2022