Long-term effects of public health insurance on the health of children in Mexico: a retrospective study

Pablo Celhay, Sebastian Martinez, Matias Muñoz, Michelle Perez, Ricardo Perez-Cuevas

Summary

Background On Dec 1, 2006, Mexico's public health-care insurance scheme, Seguro Popular, implemented the Medical Insurance Century XXI (SMSXXI) programme, to provide insurance to children younger than 5 years without social security. SMSXXI aims to increase access to health services, decrease out-of-pocket health expenses (OOPHE), and reduce health inequities. SMSXXI covers uninsured, primarily low-income, populations who might be most at risk of the financial and health consequences of costly medical interventions.

Methods We assessed the effects of SMSXXI on health outcomes and financial protection for Mexico's children using multiple nationally representative surveys and administrative data sources spanning 2001–16. The identification of effects relied on detailed hospital-level affiliation data mapping the geographical expansion of SMSXXI's coverage across the country over time. The units of analysis included hospitals, households, and children. Primary outcomes were neonatal and infant mortality, self-reported morbidity (health status, influenza, and diarrhoea), and child's height. Secondary outcomes were OOPHE, hospital discharges, and quality of service provision. Effects controlled for fixed and time-variant confounders using double-difference and triple-difference estimation strategies. Where feasible, we also estimated effects using exogenous variation in programme eligibility rules that limited enrolment in SMSXXI to children born after Dec 1, 2006.

Findings SMSXXI was not associated with early (<1 week) neonatal mortality, but was associated with a reduction in late (<28 days) neonatal mortality by 0·139 deaths per 1000 livebirths (95% CI 0·032–0·246), or 7% (2–12) relative to the comparison base of 1·98 deaths per 1000 livebirths in 2006. SMSXI was associated with a reduction in infant mortality from conditions covered by the programme by 0·147 deaths per 1000 livebirths (0·023–0·271), or 5% (1–10) relative to the comparison base of 2·73 deaths per 1000 livebirths. The effects were largest in high baseline mortality areas. Long-term health effects, 8 years after the onset of SMSXXI, were reflected in a 0·434 cm (0·404–0·459) height increase for birth cohorts exposed to the programme and an average effect on height of 0·879 cm (0·821–0·932) for low-income populations. About 3–6 years after SMSXXI started, children reported having better health status and lower incidence of influenza and diarrhoea. The programme led to a 14% reduction (7–28) in OOPHE, primarily from hospital-related expenses. No effects were detected on hospital discharges, suggesting that SMSXXI might not have increased use.

Interpretation SMSXXI promoted access to covered interventions and encouraged better primary care. The programme also promoted increased supply and quality of care by improving human and physical resources sensitive to unmet needs. Increased resource availability and improved supply of health care, rather than increased use, contributed to reduce infant mortality and improved long-term health as proxied by self-reported morbidity and child height. Consistent with the programme's focus on uninsured and low-income populations, the effects on mortality, long-term health status, and OOPHE were concentrated in vulnerable groups.

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School of Government, Pontifical Catholic University of Chile, Santiago, Chile (P Celhay PhD, M Muñoz MA); Millennium Nucleus for the Study of the Life Course and Vulnerability, Santiago, Chile (P Celhay); Inter-American Development Bank, Washington, DC, USA (S Martinez PhD); Inter-American Development Bank, Mexico City, Mexico (M Perez MA); and Inter-American Development Bank, Kingston, Jamaica (R Perez-Cuevas MD)

Correspondence to: Dr Ricardo Perez-Cuevas, Inter-American Development Bank, Kingston, Jamaica **rperez@iadb.org**

Introduction

Improving the health of children is a global objective. Mexico's specific health policy goals since 2000 have been to bridge the existing disparities in access to health care and health status, provide high-quality health care, and offer financial protection against health-related expenditures to all age groups. Mortality of neonates, infants, and children younger than 5 years signal whether these goals are on track. Newborn and infant deaths represent 50% of all deaths that happen in children younger than 5 years of age,[1] and with access to high-quality antenatal and natal care, more than 60% of these deaths are amenable.[2]

Between 2000 and 2015, neonatal mortality in Mexico declined from 12·9 deaths per 1000 livebirths to 7·8 deaths per 1000 livebirths, infant mortality decreased from 22·5 deaths per 1000 livebirths to 12·6 per 1000 livebirths, and under-5 mortality declined from 20·0 deaths per 1000 livebirths to 14·5 per 1000 livebirths.[3–5] These gains are relevant to Sustainable Development Goals objective 3.2, namely ending avoidable deaths of newborns and children younger than 5 years by 2030. All countries

Research in context

Evidence before this study

We focused on studies that analysed the effects or associations of public health insurance expansions on the health of children, including outcomes such as birthweight, neonatal mortality, infant mortality, hospital admissions, out-of-pocket health-related expenditure (OOPHE), and anthropometric measures. We also considered evidence from Conditional Cash Transfer programmes. Journals, books, and articles were identified through Google Scholar and PubMed databases searching for key words, such as "infant mortality AND public health insurance", "out of pocket expenditures AND public health insurance", and "child health AND public health insurance". The searches were done between Sept 1, 2017, and Sept 1, 2018, for articles published since database inception. Studies analysing the long-term effects of Seguro Popular on health status and financial protection are scarce, and no studies, to our knowledge, focus on the effects of Seguro Popular on children through Medical Insurance Century XXI (SMSXXI). Pfutze (2014) assessed the effect of Seguro Popular on infant mortality over the first 5 years of programme roll-out and found that the risk of a child dying in the first month of life was reduced by close to five of 1000 (0·5%) for the population at large and by seven of 1000 (0·7%) for the programme's target population. Several studies evaluate the effect of Seguro Popular on OOPHE, with mixed results. King and colleagues (2009) found that direct health-related expenses were reduced, and the use of prenatal and obstetric services had increased thanks to Seguro Popular. Knaul and colleagues (2018) found that Seguro Popular reduced the likelihood that households incurred impoverishing expenditures but had no effect on catastrophic health expenditures. Conti and Ginja (2016) found that Seguro Popular reduced infant mortality by 7% in poor municipalities of Mexico, with larger reductions associated with causes of death related to preventive care.

Added value of this study

We analysed multiple nationally representative surveys and administrative data sources to identify the effects of SMSXXI. SMSXXI provides coverage for uninsured children and promotes quality of care through financial incentives to providers. Our study compared outcomes over time for treated and untreated populations using time series data for several years before and after programme roll-out. We implemented double-difference and triple-difference estimates that controlled for underlying changes between treated and non-treated units fixed over time as well as controlling time trends in outcomes that are common across units of analysis. Our findings show SMSXXI reduced the infant mortality of conditions covered by the programme by 5% (95% CI 1–10) with larger effects on more vulnerable populations. We found a positive association of exposure to the programme during the first year of life with a gain of 0·879 cm (0·821–0·932) in height of vulnerable children. The programme also led to 10% reductions in OOPHE, primarily from hospital-related expenses. The results on health are mainly driven by improvements in the quality of health care and specialised personnel. Our study contributes to the literature on universal health care reforms. Previous studies in Mexico have focused on Seguro Popular but fail to account for systematic differences in uptake of the programme by location, providing evidence of correlation rather than programme impacts. SMSXXI offered financial resources and financial incentives to health providers on top of health insurance for children younger than 5 years old who do not have social security. Similar policies in middle-income or low-income countries usually focus on coverage but do not promote quality.

Implications of all the available evidence

There is evidence that universal health coverage improves access to health care but with considerable variation depending on the types of conditions covered. The evidence provided in this Article shows reductions in mortality and improvements in child height, a measure of cumulative health. Results for infant mortality have previously been found for other programmes in Mexico but do not consider different stages, such as mortality at 1 week, 1 month, or 1 year of life, and little evidence exists on long-term cumulative health outcomes, such as height. More is known about the effects of public health insurance on OOPHE, where these initiatives have been shown to provide financial protection to their beneficiaries. The results of this study signal that efforts to reach universal health coverage for children in Mexico are on the right track. Different countries are introducing universal health coverage schemes, but rigorous evidence on their long-term effects on health is still needed. The evidence provided in this study suggests that universal health coverage schemes that promote health insurance coverage for the population while boosting the quality of health care through provider incentives are a promising alternative.

should reduce neonatal mortality to at least 12 deaths per 1000 livebirths and under-5 mortality to at least 25 deaths per 1000 livebirths. Mexico's neonatal and infant mortality are well within reach of these goals, leaving the country to aspire to mortality levels similar to other member countries of the Organisation for Economic Co-operation and Development whose average neonatal mortality is 4·1 deaths per 1000 livebirths and infant mortality is 6·8 deaths per 1000 livebirths.[6]

Mexico's public health-care insurance scheme, Seguro Popular, provides coverage to the population without social security through two packages: the Catalogue of Universal Health Services (CAUSES), which is a list of prioritised conditions cared for at primary and secondary care levels for which Seguro Popular finances medical or surgical care, diagnostic procedures (laboratory tests and radiology), and medications, and the Fund for Protection Against Catastrophic expenditures (FPGC) that finances high-cost treatments. On Dec 1, 2006, a third programme, Medical Insurance Century XXI (SMSXXI), was added. SMSXXI provides complementary coverage for children younger than 5 years of age, in addition to interventions covered through CAUSES and FPGC.[7,8] Children who enrol in SMSXXI, along with their families, are automatically enrolled in Seguro Popular. Families receive support through a counsellor who helps the family navigate the enrolment process, provide the necessary documentation, and learn how to demand their rights.

Since its inception, SMSXXI has gradually expanded its health benefits, growing from 108 interventions (a specific medical condition for which SMSXXI finances diagnostic procedures, hospitalisation, surgery, and medication) in 2006 to over 150 interventions in 2018. The programme has also expanded its geographical reach, growing from 20% of the country's population in 2007 to 80% in 2009, and steadily thereafter. The programme's gradual expansion was driven primarily by standard of care compliance requirements for providers. As of 2016, 10% of the target population was still not covered by SMSXXI. Furthermore, the programme limited enrolment, for financial constraints, to children born on or after Dec 1, 2006, the date when the programme was announced.

SMSXXI follows a dual financing scheme; a one-time transfer of MX$210 from the Federal Government to the States for every child enrolled, in addition to the annual amount CAUSES allocates per child, and reimbursement to health providers for the interventions that SMSXXI covers on a per case basis.[9] The medical procedures covered by SMSXXI are published yearly in the programme's catalogue. This dual financing scheme offers an incentive for health providers to enrol children and provides financial resources to treat patients with conditions included in the official list of interventions. To participate in SMSXXI, the medical facility must be accredited (have the necessary human and physical resources) to treat the conditions that SMSXXI finances. The Ministry of Health commissions external evaluators to accredit facilities. To incentivise quality, the programme reimburses 50% of the value of an intervention to non-accredited hospitals and 100% to accredited hospitals. A detailed description of the SMSXXI programme is provided in the appendix (pp 3–4).

This study is the first, to our knowledge, to identify the long-term effects of public health insurance for children on child health outcomes and financial protection using the roll-out and exogenous eligibility rules of the SMSXXI programme. The expansion of SMSXXI between 2006 and 2016 resulted in more than 5 million children and their families becoming affiliated with Seguro Popular,[7] nearly 50% of the total population of children younger than 5 years in Mexico.[10] The primary objective of this study was to analyse the effects of SMSXXI on neonatal mortality and long-term health outcomes, including child morbidity and height. We also aimed to determine the effects on out-of-pocket health expenses (OOPHE) for families with children younger than 5 years and the supply-side and demand-side pathways that could lead to improved health outcomes.

Methods

Study design and data collection

In this study, we did secondary data analysis of publicly available databases and household surveys or data collected by third parties. Each outcome, data source, coverage, and responsible institution is detailed in the appendix (p 6). Our study compared outcomes over time for treated and untreated populations using time series data for several years before and after programme roll-out. We implemented double-difference and triple-difference estimates that controlled for underlying changes between treated and non-treated units fixed over time as well as controlling time trends in outcomes that are common across units of analysis.

All data were de-identified before access and use for analysis, and merging of outcome data to programme administrative records was done at the level of aggregated geographical units; thus, tracing any data to personally identifiable information was not possible. Analysis of non-identifiable secondary data is generally considered exempt from Institutional Review Board review.

Identification of programme effects

We used two approaches to identify the effects of SMSXXI: comparison of outcomes over time for treated and untreated populations, using time series data for several years before and after SMSXXI's onset, and comparison of outcomes for children born before and after Dec 1, 2006, the date SMSXXI was launched and children were first eligible to enrol. Primary outcomes were neonatal and infant mortality, self-reported morbidity (health status, influenza, and diarrhoea) and child's height (appendix pp 12–17, 21–23).

The first analytic approach uses variation in programme enrolment through the phased-in implementation of SMSXXI across Mexico, as well as variation in time of interventions being covered. These sources of variation allowed us to implement double-difference and triple-difference estimates, depending on the outcome. To reconstruct the timing of SMSXXI's geographical roll-out we used data supplied by the Comisión Nacional de Protección Social en Salud (CNPSS), including a complete registry of reimbursement requests submitted by hospitals that signed a collaboration agreement with SMSXXI between 2007 and 2016. We defined a health jurisdiction (a territorial unit used to organise the provision of health-care services) as being treated if at least one of their hospitals had signed such an agreement. Most of SMSXXI's rollout occurred between 2007 and 2009, reaching 80% of the target population (figure 1). By 2014, the programme covered 90% of the target population (figure 1). Substantial geographical variation

See Online for appendix

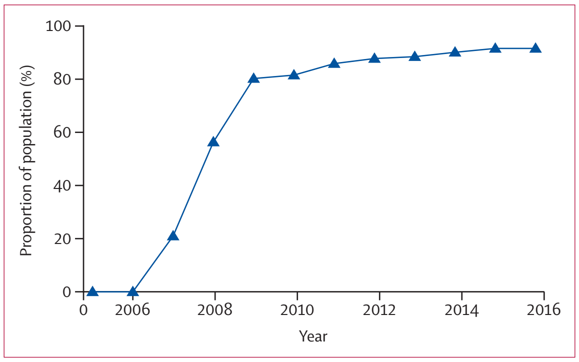

Figure 1: **Percentage of the population of children younger than 5 years living in a jurisdiction with Medical Insurance Century XXI in Mexico by year**
Based on administrative data supplied by the Comisión Nacional de Protección Social en Salud and population statistics from Instituto Nacional de Estadística, Geografía e Informática.

occurred during the first years of programme expansion throughout Mexico (appendix pp 9–11). We combined the geographical roll-out and changes in interventions over time (appendix pp 7, 8) to compare outcomes between health conditions covered and not covered by SMSXXI in a particular year, not only for treated and non-treated jurisdictions, but also within jurisdictions.

Data analysis

Our empirical method and regression specifications for estimating the effect of SMSXXI on child mortality follow a differences-in-differences-in-differences (or triple-difference) strategy, exploiting variation in the time that prioritised conditions (catalogues) and geographical areas began to be covered. Our empirical specification is given by:

$$Y^{A}_{cjt} = \tau \times (Active_{cjt}) + \varnothing_{cj} + \varnothing_{ct} + \varnothing_{jt} + \varepsilon_{cjt}$$

where c indexes catalogues, j indexes jurisdictions, and t indexes years of birth. Y^{A}_{cjt} represents mortality due to conditions covered by catalogue c in jurisdiction j per 1000 newborns in year t, for life periods A (first week, first month, and first year of life). $Active_{cjt}$ is a dummy variable that is the interaction of a dummy indicating whether jurisdiction j in year t has at least one hospital with a collaboration agreement with the CNPSS and a dummy indicating whether the conditions considered in catalogue c are part of SMSXXI's coverage for year t. The coefficient of interest is τ, which represents the intention-to-treat effect of entering SMSXXI's coverage on the mortality for conditions in catalogue c in jurisdiction j. We also include fixed effects to control for time-invariant characteristics of each catalogue-jurisdiction group (ϕ_{cj}), changes over time in each jurisdiction (ϕ_{jt}), and nationwide changes over time in each catalogue group (ϕ_{ct}). The error term ε_{cjt} represents random error correlated at the jurisdiction level. For all models of this specification we weight observations by the total deaths at the catalogue-jurisdiction (cj) level in 2006 interacted with population of individuals younger than 5 years. Because SMSXXI covers households without social security, we expected effects to be concentrated in the most vulnerable populations and separately analysed subsamples of health jurisdictions above and below the national median mortality in 2006.

We estimated the effect of SMSXXI on reported health status using a regression discontinuity approach,[11] which takes the following form:

$$y_i = \alpha + f(Z_i) + \tau * 1\,(Z_i \geq 0) + X_i + \varepsilon_i$$

where y_i is an indicator for reported health status or incidence of disease for child i. $f(\cdot)$ is a smooth function of the running variable, commonly known as the control function. Z_i represents the date of birth of child i in deviations from the threshold of Dec 1, 2006. ($Z \geq 0$) is an indicator function that takes the value of 1 when Z is greater than or equal to 0, that is, when the child was born on or after Dec 1, 2006. X_i is a vector of control variables specific to the individual, such as sex and age. ε_i represents the random error. The coefficient of interest is τ, which can be interpreted as the intention to treat a child given by the birthdate eligibility rule.

Children's height is used as an aggregate measure of long-term health.[12,13] We estimated the effects of SMSXXI on children's height about 8 years after the onset of the programme. The analysis used detailed information on date of birth and place of residence to assign different levels of programme exposure during children's first year of life, because 92% of children 6–12 years old in Mexico lived in the state they were born in during the period of study,[14] after controlling for state fixed effects, full interactions of age in months and sex, and time binary indicators.

Our specification is given by:

$$y_{ice} = \alpha + \delta AFi_{ce} + \textstyle\sum_{j=1}^{J} Age_{mi} \times Sex_i + \varnothing_e + \varnothing_c + \varepsilon_{ice}$$

where Y_{ice} is the height-for-age Z score of student i born in the month-year cohort of birth c living in state e. Afi_{ce} corresponds to the percentage of treated population under five years old living in e for cohort of birth c during the first year of a child's life. The term $\sum_{j=1}^{J} Age_{mi} \times Sex_i$ is a fully saturated interaction of an indicator for sex of student i and binary variables for each cohort of birth c. ϕ_e and ϕ_c are fixed effects for each state and cohort of birth, and ε_{ice} is the error term allowed to be correlated within states. The coefficient of interest is δ, which captures the intention-to-treat effect of changing SMSXXI coverage from 0% to 100% during a child's first year of life.

We analysed effects on OOPHE by comparing households within treated and non-treated municipalities between 2006 and 2016, before and after SMSXXI's implementation.[15–19] Our main specification was:

$$y_{mht} = \beta \times Coverage_{mt} + X_{mht} + \varnothing_m + n_t + \Sigma_{mht}$$

where m indexes municipalities, h indexes households, and t indexes years. Y_{mht} is a dummy variable indicating whether health expenditures exceed 10% of a household's total income or the ratio between the household's health expenditures and its total income. Coverage_{mt} is a dummy variable denoting whether municipality m is in a health jurisdiction where at least one hospital has already established a collaboration agreement with CNPSS for year t. ηt is a time fixed effect and ϕ_m a municipality fixed effect. Control variables are included in X_{mht}. Standard errors are clustered at the jurisdiction level and are represented by ε_{mht}. Observations are weighted by survey weights. We disaggregated OOPHE by source of expenditure: OOPHE unrelated to pregnancy and childbirth and OOPHE related to pregnancy and childbirth. We also analysed the sensitivity of the results to changes to the OOPHE threshold of 10% among other sensitivity analyses included in the appendix (pp 55–58).

To assess hospitalisation discharges, as a secondary outcome of supply response, we used a triple-difference strategy, similar to equation 1. The main specification was:

$$y^A_{cet}=\tau\times(Onset_{cet})+\emptyset_{ce}+\emptyset_{ct}+\emptyset_{et}+\varepsilon_{cet}$$

where c indexes catalogues, e indexes states, and t indexes years of birth. y^A_{cet} is the number of hospital discharges due to conditions covered by catalogue c in state e per 1000 newborns in year t, for life periods A (first week, first month, and first year of life). $Onset_{cet}$ interacts a dummy indicator of whether catalogue c in year t is part of SMSXXI's list of covered conditions and a continuous variable that represents the percentage of children younger than 5 years living in jurisdictions with access to a hospital that has already established a collaboration agreement with the CNPSS, for each state e in each year t. The coefficient of interest τ represents SMSXXI's intention-to-treat effect on the discharge rate for conditions of catalogue c in state e. We include fixed effects to control for time-invariant characteristics of each state-catalogue group (ϕ_{ce}), changes over time in each state (ϕ_{et}), and nationwide changes over time in each catalogue group (ϕ_{ct}). ε_{cet} represents the error term and can be correlated within states. Each observation is weighted by the total number of discharges for each catalogue-state level in 2006 combined with the population younger than 5 years in the state in that year.

To analyse the effect of SMSXXI on the quality of services provided by health-care units, we constructed indicators for the rate of obstetric complications in the neonatal period (ICD-10 codes O85–O92), the likelihood of suffering from infections during a hospital stay, and the likelihood of being discharged due to death. Infections during hospital stay are registered according to the corresponding Official Mexican Standard (NOM-045-SSA2-2005),[20] issued by the Mexican Health Ministry. Conditions related to infections of the urinary tract, surgical wounds, pneumonia, bacteraemia, and others are registered as intra-hospital infections so long as they occur due to an infectious agent or its toxin that was not present before admission to the hospital.[20]

We employ the following specification for discharges occurring during the first week, first month, and first year of life:

$$y^A_{det}=\beta\times Coverage_{et}+\psi_e+\omega_t+\varepsilon_{det}$$

where d indexes an individual discharge from the hospital, e indexes states, and t indexes the year when the discharged person was admitted to the hospital. The outcome variable is y_{det}, which is a dummy variable that takes the value 1 when event A occurs: either a reported infection during hospital stay or a discharge reported as a death. $Coverage_{et}$ is a continuous variable representing the percentage of population younger than 5 years living in jurisdictions with access to the programme, for each state e in each year t. We also include fixed effects at the state (ψ_e) and time (ω_t) level. Standard errors are clustered at the state level and are represented by ε_{det}.

To analyse changes in hospital resources, we constructed the following investments indicators in numbers per 1000 livebirths per year: permanent hospitalisation beds, temporary hospitalisation beds, incubators and cots, general medical doctors in contact with patients, specialists in contact with patients, and other medical and non-medical personnel. The specification is given by:

$$y_{jt}=\beta\times SMSXXI_{jt}+\gamma_j+\mu_t+\varepsilon_{jt}$$

where j indexes jurisdictions and t indexes years. Outcome y_{jt} is one of the six indicators mentioned above. $SMSXXI_{jt}$ is a dummy variable indicating whether jurisdiction j in year t had at least one hospital with a signed collaboration agreement with the CNPSS. We include fixed effects at the jurisdiction (γ_j) and time (μ_t) level. Standard errors are clustered at the jurisdiction level and are represented by ε_{jt}.

Role of the funding source

SM and RP-C were employees of the funder at the time of the study's conception and implementation, and PC, MM, and MP were paid consultants. All had a role in study design, data collection, data analysis, data interpretation, or writing of the report. All authors had full access to all the data and final responsibility to submit for publication.

Results

The study population includes at least 11·39 million children born and living in Mexico between 2002 and 2016 and their households. Before the onset of SMSXXI, the total number of births in Mexico in 2006 was about 2·5 million, with fertility of 2·46 births per woman. Mortality during this period was 0·833 per 1000 livebirths

	n	Base group	Impact coefficient (95%CI)	p value
Mortality (per 1000 livebirths) in full sample of jurisdictions				
First week of life	16 940	0·833	−0·024 (−0·079 to 0·030)	0·383
First month of life	16 940	1·982	−0·139 (−0·246 to −0·032)	0·011
First year of life	16 940	2·738	−0·147 (−0·271 to −0·023)	0·021
Mortality (per 1000 livebirths) in high mortality jurisdictions				
First week of life	8470	0·969	−0·031 (−0·107 to 0·045)	0·425
First month of life	8470	2·325	−0·182 (−0·330 to −0·035)	0·016
First year of life	8470	3·262	−0·213 (−0·384 to 0·043)	0·015
Mortality (per 1000 livebirths) in low mortality jurisdictions				
First week of life	8470	0·688	−0·012 (−0·076 to 0·052)	0·704
First month of life	8470	1·618	−0·055 (−0·178 to 0·068)	0·376
First year of life	8470	2·189	−0·016 (−0·129 to 0·097)	0·777
Reported health status				
Health very good	1400	0·118	0·072 (0·038 to 0·106)	<0·0001
Episode of influenza	1400	0·372	−0·146 (−0·254 to −0·038)	0·0080
Episode of diarrhoea	1296	0·061	−0·048 (−0·096 to −0·001)	0·051
Height-for-age Z score				
Full sample of schools	9 699 756	8·312	0·087 (0·081 to 0·092)	<0·0001
High social vulnerability schools*	2 344 461	8·097	0·181 (0·169 to 0·192)	<0·0001
Low social vulnerability schools*	7 355 295	8·233	0·059 (0·053 to 0·064)	<0·0001

The sample was divided into high and low initial mortality on the basis of the median mortality during the first year of life in 2006. The base group column reports the average mortality for each period of life in 2006 (pretreatment year), health status is the average of children born before Dec 1, 2006, and height-for-age is the average for children born in 2006. We included fixed effects at the jurisdiction-year, year-catalogue, and catalogue-jurisdiction level. In models of mortality, we used weights at the catalogue-jurisdiction level. Each observation is weighted by the population younger than 5 years in each state interacted with the number of deaths during the first year of life for each jurisdiction and each catalogue in pretreatment years. Standard errors are clustered at the health jurisdiction level. Reported health status presents the results for the effects of being eligible for SMSXXI by the date of birth rule estimated using a Regression Discontinuity design (appendix pp 52–53). Height-for-age Z score presents results for the effects of SMSXXI on standardised height, taking the Growth Reference Pattern Study[26] as the standardisation. In all models, we include fixed effects for the year of birth, state of residence and the full set of interactions between the age in months and sex. Standard errors are clustered at the school level. SMSXXI=Medical Insurance Century XXI. *As defined by the Ministry of Education of Mexico using a social vulnerability index.

Table 1: **Effect of SMSXXI on neonatal and infant mortality, morbidity, and height for age Z scores**

during the first week of life, 1·982 per 1000 livebirths during the first month, and 2·738 per 1000 livebirths during the first year (calculations based on data published by the National Statistics Office[21–23]). The population covered by the programme, to which the results below are valid, are on average younger, have children, are less educated, are poorer, and are less likely to live in metropolitan areas of the country than population not covered by the programme.[24] Conditions covered by SMSXXI represented 22% of preprogramme causes of infant mortality. The remaining 78% of causes of infant mortality not covered by SMSXXI was divided as follows: 24·9% respiratory and cardiovascular disorders specific to the perinatal period, 23·4% congenital malformations and chromosomal abnormalities, 10·9% infections specific to the perinatal period, and the remaining 19·1% to other causes (calculations based on mortality records published by the National Statistics Office and the Mexican Health Ministry[25]).

SMSXXI had no effects on early neonatal mortality (first week of life; table 1). The programme reduced late neonatal mortality (first month of life) by 0·139 deaths per 1000 livebirths (95% CI 0·032–0·246), a 7% (2–12) decrease in mortality due to conditions covered by SMSXXI relative to the comparison base of 1·982 deaths per 1000 livebirths in 2006. Likewise, infant mortality decreased by 0·147 deaths per 1000 livebirths (0·023–0·271), a reduction of 5% (1–10; table 1). The largest mortality reductions were achieved in jurisdictions with higher levels of baseline mortality (table 1). SMSXXI lowered late neonatal mortality by 0·182 deaths per 1000 livebirths (0·034–0·33) and infant mortality by 0·213 deaths per 1000 livebirths (0·043–0·384) in jurisdictions with above-median mortality, but had no effect on mortality in jurisdictions with below-median baseline mortality. Similar results by terciles of baseline mortality are presented in the appendix (p 49).

The third round of the Mexican Family Life Survey spanned 2009 to 2012. The resulting subsample of children born before and after Dec 1, 2006, was 21–67 months old at the time of measurement. Eligible children were 7·2 percentage points (95% CI 3·8–10·6) more likely to have very good health status as reported by their mothers, a 61% (32–90) increase compared with non-eligible children. They were also 14·6 percentage points (3·8–25·4) less likely to have had an influenza episode in the past 4 weeks, a 39% (10–68) decrease with respect to non-eligible children, and 4·8 percentage points (0·1–9·6) less likely to have had a diarrhoea episode, or a 78% (2–156) decrease. However, SMSXXI had no detected effects on episodes of fever (appendix p 53).

About 8 years after the programme started, a 10 percentage point increase in the roll-out of the programme during a child's first year of life increased height-for-age Z score by 0·087 SDs (95% CI 0·081–0·092; table 1). To understand the absolute magnitude of this effect, we computed the SD of the group of children born in 2007, but not exposed to the programme (8·312), and the average enrolment (60%) during the first year in our sample. The effect is an increase of 0·052 SDs (0·047–0·056) in their height-for-age score, which corresponds to a 0·434 cm (0·404–0·459) effect in absolute height.

Children in socially vulnerable schools gained 0·181 SDs (0·169–0·192) in height-for-age for each 10 percentage point increase in the roll-out of the programme in the first year of life (table 1), corresponding to a 0·879 cm (0·821–0·932) increase for children in Mexican states with an average enrolment. Children in less vulnerable schools experienced an increase of 0·059 SDs (0·053–0·064; table 1). This three-fold difference is consistent with the results found for mortality, which showed that children who lived in more vulnerable areas, those with higher mortality and lower socioeconomic status, benefited the most from the roll-out of SMSXXI.

SMSXXI was associated with a reduction in the probability of OOPHE by 1·1 percentage points (0·5–1·6) for households without social security, a 15·6% (7·1–22·7) decrease relative to the pre-intervention period (table 2). SMSXXI did not change OOPHE for ineligible

	Probability of expenditures >10% of income, n=239 721			Percentage of income, n=239 718		
	Base group	Impact coefficient (95% CI)	p value	Base group	Impact coefficient (95% CI)	p value
All health expenditures						
Households without social security	0·070	–0·011 (–0·016 to –0·005)	<0·001	3·1%	–0·003 (–0·005 to –0·002)	<0·001
Households with social security	··	0·0003 (–0·007 to 0·007)	0·938	··	–0·001 (–0·0038 to 0·0009)	0·239
General (non-pregnancy and childbirth) expenses						
Households without social security	0·048	–0·007 (–0·011 to –0·002)	0·003	2·2%	–0·002 (–0·0032 to –0·0001)	0·031
Households with social security	··	0·003 (–0·002 to 0·009)	0·252	··	–0·0005 (–0·002 to 0·001)	0·581
Pregnancy and childbirth expenses						
Households without social security	0·012	–0·003 (–0·0053 to –0·0006)	0·013	0·5%	–0·002 (–0·0024 to –0·0007)	<0·001
Households with social security	··	–0·003 (–0·0064 to 0·0006)	0·110	··	–0·0006 (–0·0016 to 0·0003)	0·213

Variable SMSXXI marks the time when the programme becomes available at the household's health jurisdiction. We also report the average of the outcome variable for households with no access to social security during the pretreatment years, referred to as the base group. In the Probability of expenditures >10% of income column, the outcome variable is a dummy indicator which takes the value 1 when the household spends more than 10% of its total income on health expenditures, 0 if less than 10%. In the second column, the outcome is the ratio of health expenditures to total income. All estimates use the sampling weights provided by the Encuesta Nacional de Ingresos y Gastos de los Hogares. For all outcomes, we report the average from 2002–06 for households without access to social security as the base group. All estimates used fixed effects at the municipality level and year level. Standard errors are clustered at the municipality level. SMSXXI=Medical Insurance Century XXI.

Table 2: **Effect of SMSXXI on out-of-pocket health expenditures**

households (with social security; table 2), suggesting that the previous results for eligible individuals are unlikely to be spurious. As a sensitivity analysis we analysed the probability that OOPHE exceeds 25% of households' income. A reduction on OOPHE of 0·7 percentage points (0·1–1·3) from a mean of 1·5% in pretreatment occurred (appendix p 58). Disaggregating OOPHE by source indicated a 0·7 percentage point (95% CI 0·2–1·1) decline in the probability of a catastrophic OOPHE unrelated to pregnancy and childbirth (appendix p 56), which corresponds to a relative decline of 14·6% (4·1–22·9). The probability of a catastrophic OOPHE related to pregnancy and childbirth care fell by 0·3 percentage points (0·1–0·5; table 2), or 25% (8·3–41·7) in relative terms.

To understand mechanisms leading to improved health and reduced OOPHE, we analysed hospital admission data and investments in hospitals. No changes in hospitalisations occurred, except for quality of care proxies (table 3), where SMSXXI was associated with a decline of 0·591 puerperal complications (ICD codes O85–O92) per 1000 livebirths (95% CI –1·108 to –0·075), a 39% (5 to 73) decrease relative to preprogramme averages. There were no effects on hospital admissions due to external causes (ICD codes T or S), which we used as a falsification test. SMSXXI had no effect on the probability of suffering an infection during hospital stay or death at discharge (table 3), quality proxies related to hospital admissions for children younger than 5 years.

SMSXXI promoted higher investments in resources and medical staff (figure 2). Health jurisdictions affiliated with SMSXXI increased permanent hospital beds by 1·2 per 1000 livebirths (95% CI 0·22–2·19) and temporary hospital beds by 2·3 per 1000 livebirths (1·38–3·22; figure 2), corresponding to 8% (1–14) and 13% (8–19) increases from pre-SMSXXI levels. The programme also increased incubators and cots by 0·71 per 1000 livebirths (0·4–1·03), medical specialists by 1·72 per 1000 livebirths (0·57–2·87), and staff members by 6·3 per 1000 livebirths (0·46–12·07; figure 2). These estimates correspond to relative increases of 14% (8–21), 8% (3–13), and

	n	Base group	Impact coefficient (95% CI)	p value
Discharges per 1000 livebirths				
First week of life	1600	17·233	0·159 (–1·780 to 2·099)	0·868
First month of life	1600	18·888	0·301 (–1·859 to 2·461)	0·778
First year of life	1600	21·098	0·384 (–1·727 to 2·494)	0·713
Obstetric complications and placebos				
Puerperal complications per 1000 livebirths	448	1·525	–0·591 (–1·108 to –0·075)	0·026
External (T-code) conditions per 1000 people	448	0·419	–0·025 (–0·094 to 0·043)	0·455
External (S-code) conditions per 1000 people	448	1·224	–0·048 (–0·223 to 0·127)	0·581
Probability of infection during hospital stay				
First week of life	395 852	0·015	0·004 (–0·004 to 0·011)	0·344
First month of life	442 178	0·016	0·004 (–0·003 to 0·011)	0·301
First year of life	498 013	0·013	0·004 (–0·003 to 0·012)	0·207
Probability of deceased at discharge				
First week of life	438 740	0·078	0·003 (–0·006 to 0·012)	0·482
First month of life	489 533	0·077	0·004 (–0·004 to 0·013)	0·292
First year of life	551 374	0·062	0·004 (–0·003 to 0·012)	0·245

ICD codes T and S are presented as placebos, because external conditions should not be affected by SMSXXI coverage. We also report the national average for each outcome in 2006 referred to as the base group. For discharges per 1000 live births, we include fixed effects at the catalogue-time, catalogue-state, and state-time level. For the others, we include fixed effects at the state and year level. For discharges per 1000 livebirths, we use weights at the catalogue-state level, where the weight is equal to the population of children younger than 5 years in each state interacted with the number of discharges during the first year of life in each state and for each catalogue for pretreatment years. For obstetric complications and placebos, we use weights at the state level, where the weight is equal to the population of fertile women according to the 2010 Census. Standard errors are clustered at the state level in all estimates presented. SMSXXI=Medical Insurance Century XXI.

Table 3: **Effect of SMSXXI on hospital admissions and quality of care outcomes**

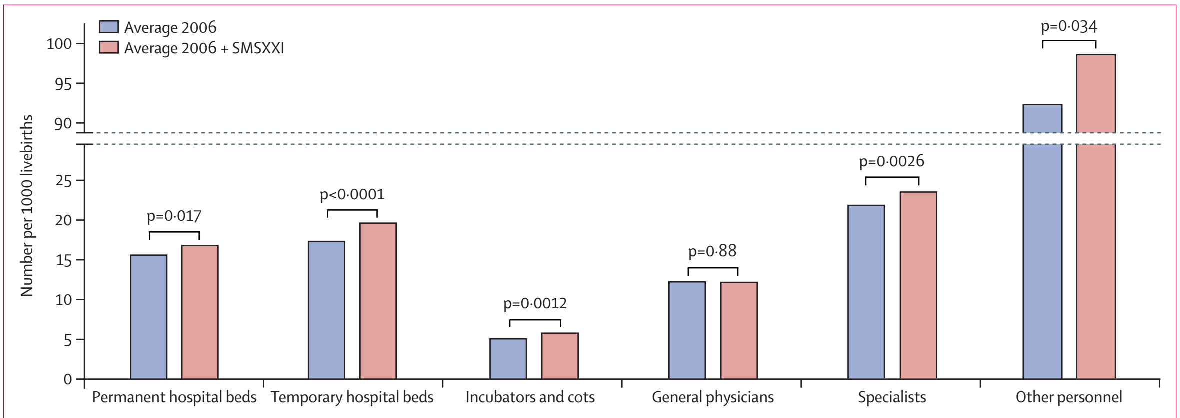

Figure 2: **Average increase in hospital resources in jurisdictions with SMSXXI per 1000 livebirths**
Based on the Subsistema de Información de Equipamiento, Recursos Humanos e Infraestructura para la Atención de la Salud dataset. The numbers are based on estimations of a double-difference model where we regress each hospital resource outcome against a binary indicator for whether the jurisdiction entered SMSXXI. The blue bars correspond to the average of each outcome in 2006, the baseline year. The red bars add the coefficient of this regression to the average of 2006. SMSXXI=Medical Insurance Century XXI.

7% (1–13) with respect to pretreatment levels. The number of general physicians did not change.

Discussion

This study builds on the published literature on universal health insurance in middle-income countries that examines access, health outcomes, and financial protection.[27–30] Existing evidence suggests that universal health insurance improves access to health care but with considerable variation depending on the severity of the conditions covered, because some are less sensitive to changes in price, and must be included in the packages of benefits because of the high health risks that patients may suffer if untreated (eg, neonatal asphyxia).[31–33]

We found that SMSXXI reduced late neonatal mortality (7%) and infant mortality (5%) related to conditions covered. This is consistent with Seguro Popular promoting increased access to antenatal care.[34,35] These results are also consistent with similar studies, in which universal health insurance schemes in developing countries improved birthweight and reduced neonatal and maternal mortality.[36–39] SMSXXI had no effect on early neonatal mortality, which is mostly due to prematurity, infections, and congenital malformations in Mexico. There are pervasive constraints to reducing early neonatal deaths: absence of programmes to identify congenital conditions during pregnancy, poor quality of intrapartum care beyond the indication of caesarean section, a primary risk factor for many unsafe events,[40] and scarcity of standards of quality of care for neonates with severe conditions at neonatal intensive care units.[41] Seguro Popular facilitates access to obstetric services; therefore, it is a contributing factor in reducing the risk of preterm delivery in vulnerable women.[42] However, reinforcing quality of care has the potential to provide a wide margin for improvement in these areas; up to 50% of early neonatal deaths could be averted.[35]

SMSXXI had a large effect on long-term health as measured by reported health status of children and anthropometric measures of height-for-age Z scores. Improvements in height reflect improvements in nutrition and health status, particularly early in life. The results in this paper also show that effects on mortality and long-term health are concentrated in vulnerable population groups, consistent with the programme's target population. Demand-side incentives that boost use of health services by the poor have found effect sizes of a similar magnitude.[43–45]

SMSXXI contributed to financial protection by reducing OOPHE by 15·6% and even more for expenditures related to neonates with critical conditions. Previous studies found that Seguro Popular reduced the likelihood of OOPHE by 3·6%.[46–48] Nonetheless, interventions to further reduce OOPHE are still needed, given overall OOPHE in Mexico represents 45% of total health-care expenditure.[49] Further reductions in OOPHE would require a more systemic approach (in addition to Seguro Popular) and careful analysis of what is being purchased through OOPHE and whether effective coverage is being provided through publicly funded health insurance.

SMSXXI promoted increased supply and quality of care in hospitals through improvements in infrastructure (ie, more neonatal care units) and specialised staff. However, there were no effects on use as measured by hospital admissions. Null effects in hospital admissions are consistent with at least three mechanisms related to the programme's implementation. First, SMSXXI, along with the coverage that FPGC provides for neonatal conditions, might have modified the frequency of referrals to specific hospitals, and not overall hospitalisations, because the programme promotes hospitals to invest in equipment and human resources. Second, conditions covered by SMSXXI might be sensitive to the fulfilment of unmet needs of human and physical resources and, to a lesser extent, to price changes, because most neonatal critical conditions are associated with a high risk of death. Third, SMSXXI assures access to interventions by guaranteeing reimbursement and by encouraging better primary care through additional funds from capita payments. Thus, access to SMSXXI coverage (ie, increase in hospital admissions) might in part be offset by the efficiency effects of primary care (ie, reduced preventable hospitalisations).

This study aimed at ascertaining the effects of SMSXXI on health outcomes and OOPHE, but it is not possible to separate effects of SMSXXI from the FPGC and CAUSES, particularly for longer-term effects, such as child height, because SMSXXI was also intended to increase enrolment in Seguro Popular. The identification of effects uses non-random variation in the roll-out of SMSXXI across Mexico over time, and changes to covered health conditions. A causal interpretation requires the parallel trends assumption, which is not directly testable; however, we find no evidence against it. Another limitation is that birth and death certificates are commonly underreported in low-income and middle-income countries.[50] For estimates of mortality, infection, and death at discharge, estimates of SMSXXI effects remain unbiased if underreporting does not change over time within a specific municipality-mortality cause combination. However, underreporting would result in a bias towards the null hypothesis of no effect, whereby estimates represent a lower bound of the effect of the SMSXXI on mortality. This underreporting problem is discussed further in the appendix (pp 15–16).

In summary, Mexico has continued efforts to expand public health-care insurance for its vulnerable populations. This study provides evidence of the effects of SMSXXI, a programme that offered financial resources to cover the health care of children younger than 5 years old who do not have social security. The results are consistent with previous studies focusing on Seguro Popular,[51] and signal that efforts to reach universal health coverage are on the right track. Uninsured children and those living in more vulnerable areas with above-median neonatal and infant mortality rates benefited the most. Different countries are introducing universal health coverage schemes, but there is still a need for rigorous evidence on their long-term effects on health.[52] The design of a universal health coverage scheme should both promote health insurance coverage for the population and attain better health and provide high quality of services through increased financing targeted to key interventions. The benefits associated with Seguro Popular, through SMSXXI, suggest that such a design has the potential to result in large and sustained health gains for the population.

Contributors

PC, SM, and RP-C conceived and designed the study. All authors discussed, critically revised, and approved the study protocol. SM and RP-C were responsible for the organisation and conduct of the study and supervised it. PC was responsible for the statistical analysis. MM and MP contributed to data analysis. PC, SM, MM, and RP-C drafted the first version of the manuscript. All authors elaborated, discussed, and approved the final version of the manuscript for publication.

Declaration of interests

SM and RP-C were Inter-American Development Bank staff at the time of the study's conception and implementation, and PC, MM, and MP were paid consultants. We declare no competing interests in the results of the study. All opinions in this paper are those of the authors and do not necessarily represent the views of the National Commission for Social Protection in Health, of the Government of Mexico, or of the Inter-American Development Bank, its Executive Directors, or the governments they represent.

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