

KEY POINTS

- A critical choice facing many governments is whether to use face-to-face school closures to help control COVID-19 transmission for an extended period of time. Analysis of the policy choices involved with an epidemiological model applied to the case of the Philippines finds that school closure is of limited effectiveness compared with alternative COVID-19 control measures.
- Health behavior beyond COVID-19 is strongly conditioned by education. Results indicate that long-term mortality increases due to less effective education from face-to-face closure during January to June 2021 may be 49 times higher than the number of lives saved from COVID-19 in the short run.
- The present value costs of face-to-face closure are estimated to be very high at ₱1.9 trillion for the 2020–2021 school year (equivalent to over 10% of GDP). In a cost-benefit framework that generously values morbidity and mortality, costs are about 70 times higher than COVID-19 control benefits, even when adverse effects on non-COVID-19 health outcomes are not considered.
- There is ample scope to use targeted measures to minimize the COVID-19 risks of face-to-face classes while benefiting overall health.

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Cost-Benefit Analysis of Face-to-Face Closure of Schools to Control COVID-19 in the Philippines

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INTRODUCTION

Many policymakers around the world have faced important choices concerning the use of extended school closure to control transmission of the coronavirus disease 2019 (COVID-19). The Government of the Philippines is currently determining whether to delay face-to-face classroom learning until a vaccine for COVID-19 has been administered to a large share of the population, pending results of a pilot of limited reopening in January. While there are more than 214 COVID-19 vaccines currently in development, with 10 potential vaccines undergoing phase 3 clinical trials,³ it cannot be assumed that safe and effective COVID-19 vaccines will be authorized for use and marketing, manufactured, procured, and administered to tens of millions of people before school year 2020–2021 is completed. Accordingly, vaccination rates are likely to remain low throughout 2021 and persisting with a policy of waiting for widespread vaccination implies that face-to-face closure will remain in place throughout school year 2020–2021 and perhaps into school year 2021–2022.

At the same time, protracted school closure does not appear to be especially effective in controlling COVID-19. The pandemic risk to children is limited, as a very small share of diagnosed COVID-19 cases globally and in the Philippines is among those under 20 years of age, and severe medical outcomes, including mortality, are rare among children and adolescents. The average age of mortality of COVID-19 deaths diagnosed in the Philippines as of 26 November 2020 is 62 years. Less than 10% of diagnosed cases and 2% of COVID-19 deaths have been among those 20 years old and below, compared with 40% of the population falling into this age group. Evidence on effects on transmission to older segments of the population is less clear, but suggests limited effectiveness of school closure.

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¹ The contents of the brief reflect findings of research by the authors and do not constitute the official views of the Asian Development Bank. Results presented are based on modeling by the authors, which draws upon parameters from recently published studies on COVID-19 transmission and assumptions on policy compliance. As COVID-19 is a new disease, those parameters have some uncertainty, and may change as new scientific findings emerge. While the results presented represent scientific understanding as of early-December 2020, specific numerical results presented are subject to revision as new information becomes available and policy implementation evolves.

² The authors thank Asian Development Bank colleagues Eduardo Banzon, Kelly Bird, Rana Hasan, Ayako Inagaki, Susann Roth, and Yumiko Yamakawa for useful discussions and suggestions.

³ Milken Institute. COVID-19 Treatment and Vaccine Tracker (accessed 10 November 2020).

Although children have high contact rates with each other in schools, they also appear to have lower susceptibility, are infectious for shorter periods, and on average have lower infectivity than adults.^{4,5} A number of studies find that children are unlikely to be the drivers of the epidemic⁶ and few contact tracing studies have identified major outbreak clusters traced to student-to-student transmission within schools from COVID-19 where schools have remained open.

There is also growing appreciation of the costs of school closure to the economy in the short and long run. In the short run, costs are borne by parents, who need to limit labor force participation to care for children at home and those employed in education, who may lose jobs.⁷ These effects are substantial. For example, the effects of each day of school closure on near term gross domestic product (GDP) growth may be nearly as large as each day of workplace closure.⁸ Even more profound is the long-term effect on productivity. School closure that occurred through mid-2020 already may be sufficient to reduce lifetime earnings of current students by 3%, equivalent to a long-term reduction in GDP of 1.5% that remains in place for many decades.⁹ This is many times larger than the short-run economic effect.

The question that then arises is whether the benefits of COVID-19 control exceed the very large costs of school closure. This brief examines both the benefits and the costs.

MODELING THE EFFECTS OF FACE-TO-FACE CLOSURE

The primary intended benefits of face-to-face school closure consist of reduced COVID-19 disease burden and costs of treating those ill. To quantify these outcomes, the tool used to consider school closure is an age-structured susceptible, exposed, infected, and recovered (SEIR) model developed for analysis of COVID-19 control policies for the Philippines (Figure 1).¹⁰ This model explicitly reflects contacts between people in different age groups at home, in schools, in workplaces, and in other locations, and it draws upon many national data sets, including extensive occupational microdata and data on school settings, such as classroom sizes and numbers of students, to project these patterns for each region. Contact rates are modified to reflect social distancing policies, including historical periods representing the restrictions imposed by “community quarantine” policies. School closure is considered in the model as a modifier to the contact rates of schools.

The model uses age patterns in modeled infection to consider varied probabilities of illness severity and treatment needed based on age. Within the model, there are several “compartments” of infected people—the subclinical/asymptomatic, the symptomatic/clinical but undiagnosed, the diagnosed/ambulatory, the hospitalized, and those needing intensive care unit treatment. It separately represents each of the 17 regions of the Philippines, and it computes excess mortality when critical treatment capacity is exceeded, as well as mortality within treatment capacity. The model has been parameterized to replicate historical characteristics of COVID-19 hospitalizations and mortality by age during a reference period for which detailed data are available.

Scenarios Considered

The modeling framework assumes that all regions of the Philippines except for the National Capital Region are in Modified General Community Quarantine (MGCQ) by November 2020, and that NCR will have MGCQ during 1–14 January 2021. From 15 January 2021, a new normal of minimum health standards is assumed to begin, in which social distancing is mainstreamed, but nearly all economic activity is allowed to resume. Under this new normal, some restrictions remain, such as on group gatherings, people are advised to limit leisure contacts, social distancing considerations are applied to all activities, those who can work from home are encouraged to do so, and masks are required in congested indoor environments. However, there are no hard restrictions on mobility. Testing, tracing, and isolation efforts continue to lead to detection and reduced transmission of 20%–25% of infections, depending on the region, but are not strongly expanded in these scenarios. In this context, school-opening scenarios vary—to have schools open from 15 January, closed until mid-August 2021, or open only for younger or older students (Table 1).¹¹

In the school-opening scenarios, effective contact rates in schools are assumed to resume at 70% of baseline levels, reflecting low-cost distancing measures that do not alter the classroom experience substantially. These measures include assigning the same seats to students in classrooms every day; shortening and/or staggering recess and breaks between class periods; assigning lunch seating; conducting physical education, sports, and recess only outdoors; improving hygiene through washing of hands or use of sanitizer before entering classrooms¹² and not physically passing objects back and forth between people frequently; ensuring that symptomatic ill students stay home; and not undertaking activities involving large gatherings, such as school assemblies and recitals. Note that all numbers assume a return to face-to-face education 5 days per week.

⁴ Davies, N. G. et al. 2020. Age-Dependent Effects in the Transmission and Control of COVID-19 Epidemics. *Nature Medicine*. 26. pp. 1205–1211. <https://doi.org/10.1038/s41591-020-0962-9>.

⁵ Dattner, I. et al. 2020. The Role of Children in the Spread of COVID-19: Using Household Data from Bnei Brak, Israel, to Estimate the Relative Susceptibility and Infectivity of Children. *medRxiv*. <https://doi.org/10.1101/2020.06.03.20121145>.

⁶ Ludvigsson, J. F. 2020. Children Are Unlikely to Be the Main Drivers of the COVID-19 Pandemic – A Systematic Review. *Acta Paediatrica*. doi: 10.1111/apa.15371.

⁷ Fuchs-Schündeln, N., M. Kuhn, and M. Tertilt. 2020. The Short-Run Macro Implications of School and Child-Care Closures. *IZA Discussion Papers*. 13353.

⁸ Chen, L. et al. 2020. What Works to Control Covid-19? Econometric Analysis of a Cross-Country Panel. *ADB Economics Working Paper Series*. Manila.

⁹ Hanushek, E. A. and L. Woessmann. 2020. *The Economic Impacts of Learning Losses*. Paris: Organisation for Economic Co-operation and Development.

¹⁰ This is the only national epidemiological model that explicitly represents the role of schools in COVID-19 transmission in the Philippines.

¹¹ All scenarios include school classrooms being closed during summer recess from 6 June to 15 August 2021.

¹² World Health Organization. 2020. Recommendations to Member States to Improve Hand Hygiene Practices to Help Prevent the Transmission of the COVID-19 Virus.

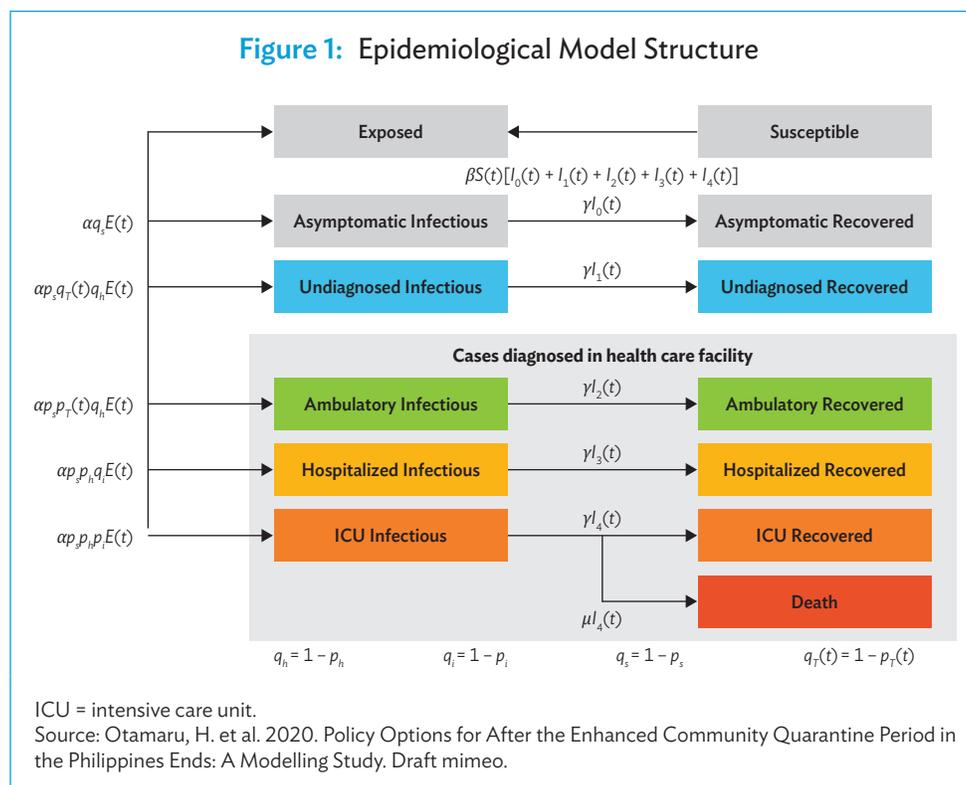


Table 1: Scenarios Compared

Scenario	School Face-to-Face Closure until August 2021 (all levels)	School Face-to-Face Closure until August 2021 (15+ year olds)	School Face-to-Face Closure until August 2021 (under 15 year olds)
“New normal” post lockdown	√	√	√
School closure under “new normal”	√		
Upper school closure under “new normal”		√	
Lower school closure under “new normal”			√

Source: Authors.

When schools are closed, modest increases in intrahousehold contacts occur, and a somewhat higher share of child contacts in other locations resume as children play together more often in time freed from the classroom.

RESULTS ON EFFECTS OF FACE-TO-FACE LEARNING ON COVID-19 MORTALITY

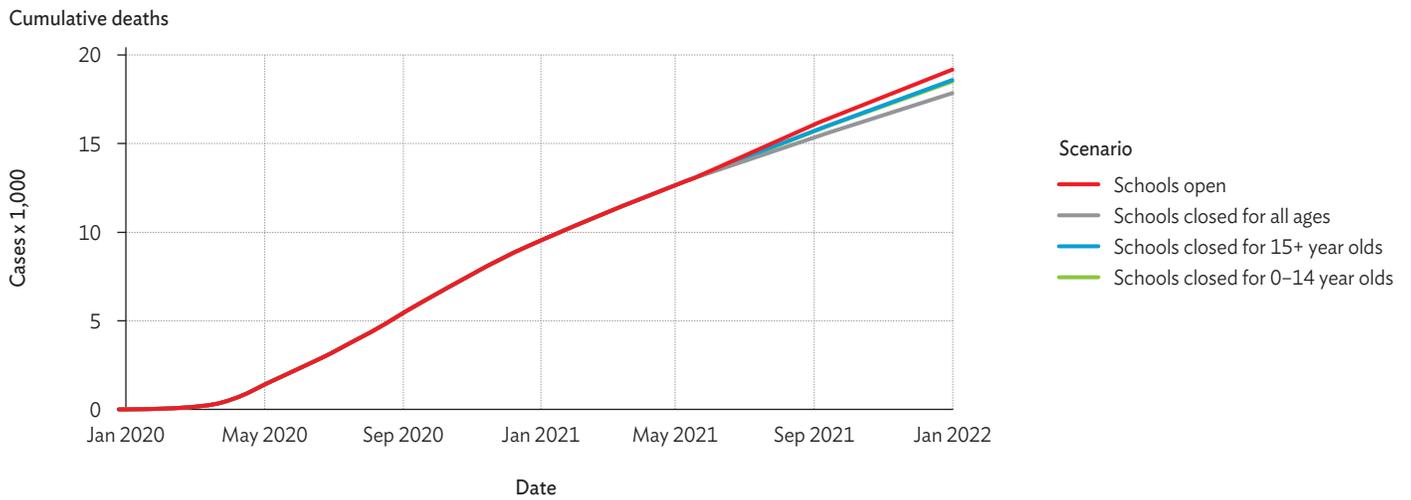
The model finds that when the new normal is maintained, overall mortality from COVID-19 from school opening is about 1,500 lives nationally, or around an 8% increase from the cumulative value simulated if schools were to remain closed (Figure 2). The average age at which these deaths occur is 63, and this figure represents 0.3% of

2019 mortality in the Philippines. Closing face-to-face schooling only for those over 15 averts 60% of those deaths, and reduces mortality to about 600 lives, while allowing 78% of learners to attend face-to-face classes.

Most risk from school opening is concentrated in the National Capital Region, and regions 3, 6, and 7 (Figure 3), which, together with 4A, account for 69% of modeled deaths, versus 50% of students. These regions usually have schools making up a larger share of contacts, more children in the population, more elderly in contact with children in households, and/or weaker medical capacity compared with possible treatment needs. Even in those higher risk regions, a minority of the risk is from students under 15. If the reopening is targeted to those below 15 years of age in the 12 low-risk regions, the modeled mortality would be about 270 lives during 2021.¹³

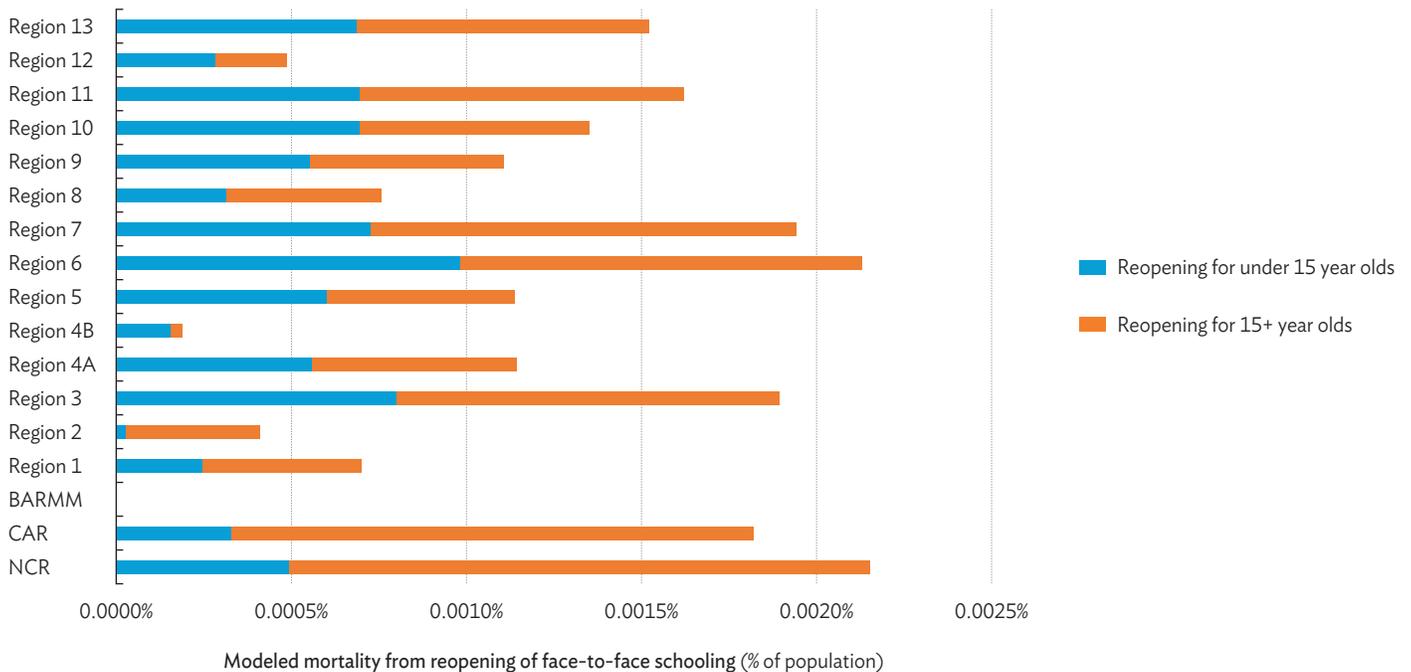
¹³ It should be noted that all numbers presented here reflect no major expansion of testing, tracing, and isolation or other control measures. Were those measures expanded, the mortality effects would be smaller than these results.

Figure 2: Cumulative Modeled Mortality from COVID-19 under School Closure Scenarios



Notes: Blue and green shaded results may be difficult to distinguish due to the similarities of the values, so that the lines cover each other. All scenarios premised on a “new normal” of minimum health standards post community quarantine and testing, tracing, and isolation at 20%–25% of infections. School closure versus opening refers to 25 January 2021 through 5 June 2021. All scenarios reflect breaks from 6 June to 15 August, with school resuming on 16 August 2021.
Source: ADB estimates.

Figure 3: Modeled 2020–2021 COVID-19 Mortality from School Reopening



BARM = Bangsamoro Autonomous Region in Muslim Mindanao, CAR = Cordillera Administrative Region, NCR = National Capital Region.
Note: Premised on a “new normal” of minimum health standards post community quarantine and testing, tracing, and isolation at 20%–25% of infections. School closure versus opening refers to 25 January 2021 through 5 June 2021.
Source: ADB estimates.

COSTS OF SCHOOL FACE-TO-FACE CLOSURES

Distance Learning Effectiveness

There is substantial empirical evidence of a “slide” effect during breaks from education, in which children not only do not acquire additional knowledge, but they also lose knowledge that they have already acquired. This effect is substantial. During a period of school closure, it has been estimated that students lose knowledge at about the same rate as they acquire it during the year.¹⁴ This means that, for each academic year in which there is no education, students lose 2 academic years of learning, compared to when schools are open.

For the purpose of this analysis, the distance learning arrangements of the Department of Education (DepEd) are assumed to be effective. Even so, effective distance learning is not a full substitute for face-to-face education. In the context of higher average parental education and connectivity, high-quality distance education has been considered to provide 52% of face-to-face learning knowledge gains in the United States (US).¹⁵ This analysis optimistically assumes that under all conditions, distance education can offset the learning slide effect. Gains beyond the learning slide are then considered to differ according to parental education, availability of adults in the household to act as teachers, number of children to be educated, and internet connectivity. Under optimal conditions of a nonworking university educated adult in the household, two or fewer children to educate, and internet access, 60% of face-to-face learning progression is assumed. As each characteristic deviates from the optimal according to Family Income and Expenditure Survey (FIES) 2015 microdata, the gain is reduced, and these gains are calculated as weighted averages per grade level. This average ranges from 16% to 24%. The difference between this distance education learning progression and the normal learning progression is the amount of education foregone under distance arrangements, so that the vast majority of additional K-12 learning is expected to be foregone.¹⁶

Long-Term Costs to Students

A key effect of reduced education is that students have lower productivity in the workforce when adults. To capture this, wages are taken as the marginal product of labor, and effects on wages are derived from a Mincer regression using 2018 Philippine Labor Force Survey data of wages against years of

education and a quadratic term for experience, with additional controls to reduce variation. Self-selection into the workforce is addressed via a Heckman approach (see Annex 1 for details). This identifies a significant coefficient of log wages against years of education of 0.102, as well as a constant term for wages absent education or experience.¹⁷ The regression approach is a standard method for consideration of the benefits of educational policies.¹⁸

Those coefficients are applied to a cohort model of students in current education, with effects on earnings from effective education reduction affecting their future productivity over their careers. The finding is that the net present value of lost productivity¹⁹ is ₱1.68 trillion for K-12 students from a year of use of distance learning arrangements (Figure 4). An alternative model of children repeating the lost year later results in even higher costs, as workforce entry and accumulation of earnings from experience are delayed. A majority of losses (₱1.15 trillion) is for those under 15, who pose the least risk in terms of increasing the epidemic mortality.

Short-Term Costs to Parents and Teachers

School classroom closure has additional labor market consequences, both in terms of losses in employment of private school teachers and losses in income of parents who need to provide childcare. Private school enrollment has fallen by 50.4% for school year 2020–2021, according to DepEd enrollment figures as of September 2020. According to the Coordinating Council of Private Educational Associations, private schools employ 410,000 teachers and personnel. Assuming 50% of those employees lose employment, approximately 200,000 jobs will be lost with an estimated wage loss of ₱16 billion in school year 2020–2021.

To quantify losses of incomes of parents, merged data from the 2015 Labor Force Survey and FIES were used to identify all households with children below 12 whose parents are both working. To support online education, an adult with at least a high school education is needed to support the online learning of children. For households where both parents are working and where there are no grandparents under 80 with at least a high school education, it is assumed that one parent would need to stay at home. Consideration of households against these criteria using FIES shows that around 11% of the workforce would have to stop working, causing the economy a total of ₱225 billion loss for one school year (Figure 4).

¹⁴ Atteberry, A. and A. McEachin. 2016. School’s Out: Summer Learning Loss across Grade Levels and School Contexts in the United States Today. In K. Alexander, S. Pitcock, and M. Boulay, eds. *Summer Learning and Summer Learning Loss*. New York: Teachers College Press. pp. 35–54.

¹⁵ Dorn, E. et al. 2020. COVID-19 and Student Learning in the United States: The Hurt Could Last a Lifetime. McKinsey & Company. <https://www.mckinsey.com/industries/public-and-social-sector/our-insights/covid-19-and-student-learning-in-the-united-states-the-hurt-could-last-a-lifetime#>.

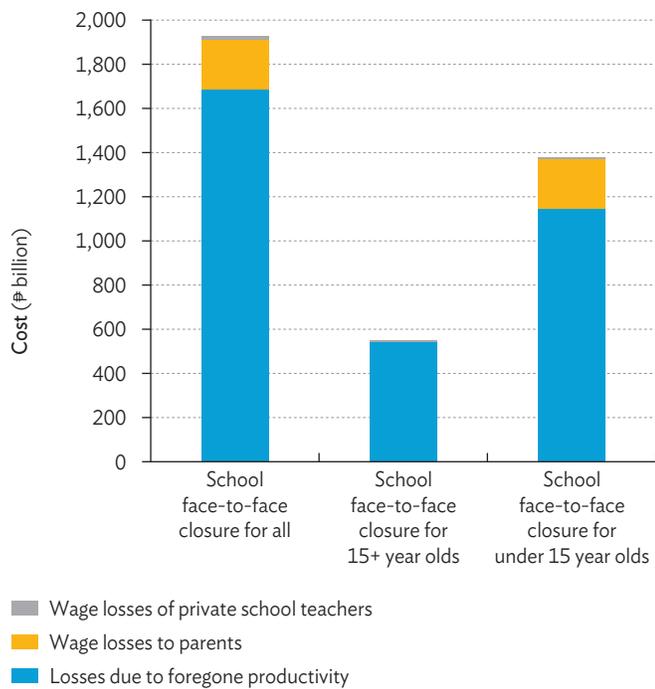
¹⁶ It should be noted that the values applied omit likely additional channels of loss, as many students who fall behind during the period of classroom closure may drop out of school or have trouble absorbing the content of higher levels. Thus, the values are inherently underestimates.

¹⁷ This value is very consistent with a broad range of studies on returns to education. Some criticism has been made in the literature that ability bias can skew upward Mincer estimates, but many others also contend that many channels of benefits from education are also omitted, so that estimates are downward biased. See Psacharopoulos, G. and H. A. Patrinos. 2018. Returns to Investment in Education: A Decennial Review of the Global Literature (English). *Policy Research Working Paper*. WPS 8402. Washington, DC: World Bank Group. <http://documents.worldbank.org/curated/en/442521523465644318/Returns-to-investment-in-education-a-decennial-review-of-the-global-literature>.

¹⁸ Psacharopoulos, G. and H. A. Patrinos. 2018. Returns to Investment in Education: A Decennial Review of the Global Literature. *Education Economics*. 26(5). pp. 445–458.

¹⁹ Under a 3% real discount rate typical for health investments.

Figure 4: Economic Costs of School Face-to-Face Closure during School Year 2020–2021



Source: ADB estimates.

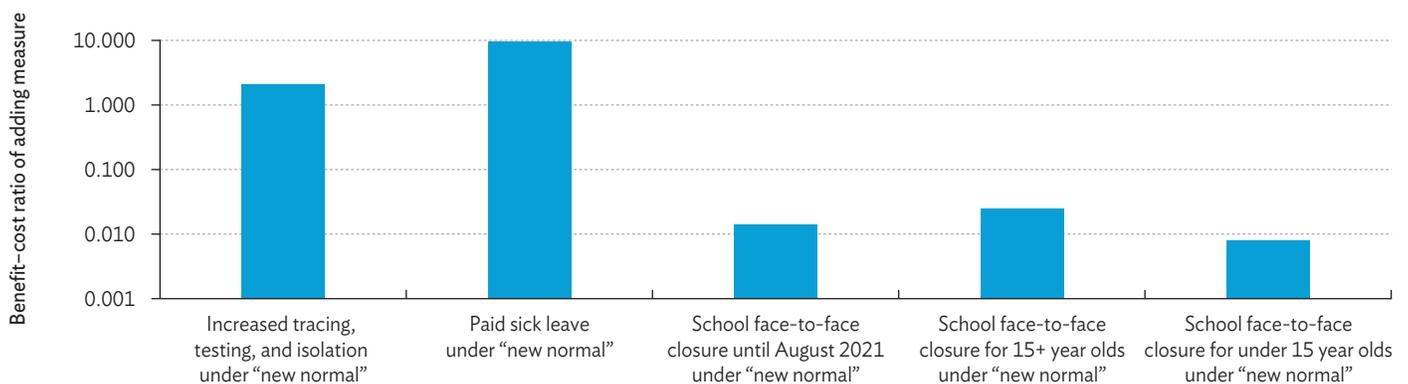
COST-EFFECTIVENESS AND COST-BENEFIT ANALYSIS

The total cost of ₱1.93 trillion (10% of GDP) described in the previous section is for one school year of face-to-face closure. To match the scenarios, costs are prorated to the share of the school year that would occur during 15 January to 5 June, out of the 2020–2021 school year spanning 5 October to 5 June. The result is a cost of ₱1.15 trillion for closure at all levels, of which ₱329 billion is the cost due to closure for 15+ year olds and ₱820 billion is the cost from closure for those under 15.

Considering the mortality results, this equates to ₱768 million per life saved for closure at all levels, ₱366 million per life saved from closure for 15+ year olds, and ₱1.38 billion per life saved from closure for those under 15 years of age. These costs are far higher than is typically considered acceptable for public policy. In addition, there are alternative means by which many more lives may be saved at much lower cost from other health problems, such as vaccine preventable diseases, if the priority policy objective is to minimize mortality.²⁰

If a more typical value for averted mortality is applied, in which an average life expectancy is 160 times gross national income,²¹ prorated to the years of life saved, and the benefits of reduced morbidity are also included, it becomes clear that the costs of school closure far exceed the benefits (Figure 5). The costs are 70 times higher than the benefits in this framework for closure at all levels, 41 times higher for closure for 15+ year olds, and 125 times higher for under 15 year olds.

Figure 5: Benefit–Cost Ratios of School Face-to-Face Closure versus Other COVID-19 Control Measures in the Philippines



Note: All scenarios premised on “new normal” of minimum health standards post community quarantine and testing, tracing, and isolation at 20%–25% of infections.

Source: ADB estimates.

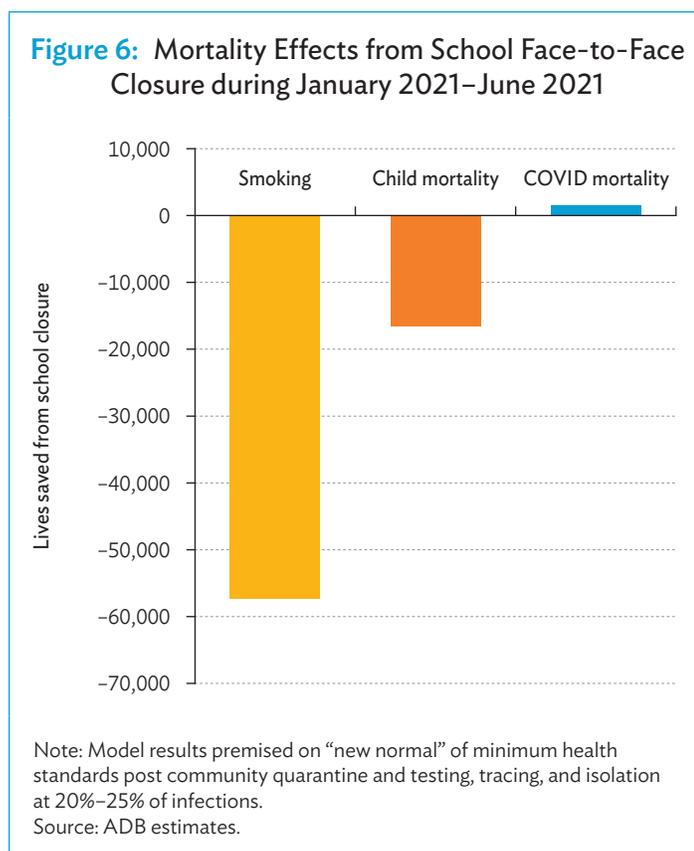
²⁰ Brenzel, L. et al. 2006. Vaccine-Preventable Diseases. In D. T. Jamison, et al. eds. *Disease Control Priorities in Developing Countries*. 2nd edition. Washington, DC: The World Bank.

²¹ Robinson, L., J. Hamitt, and L. O’Keefe. 2019. Valuing Mortality Risk Reductions in Global Cost-Benefit Analysis. *Journal of Benefit–Cost Analysis*. 10 (S1). pp. 15–55.

Put another way, school face-to-face closure would need to save over 100,000 lives, rather than 1,500 lives for benefits to match costs—an effect that is unlikely no matter how the epidemic is modeled. In contrast, alternative measures for comparison, such as increasing testing, tracing, and isolation, or introducing paid sick leave, have benefits far in excess of costs.

HEALTH EFFECTS BEYOND COVID-19

This analysis considers only effects on COVID-19 health outcomes. However, education is critically important to health in other ways, as there are well-documented relationships between health outcomes and education levels. Less educated individuals undertake more risky behavior, such as substance abuse, and invest less in preventative health care.^{22,23} In addition, when schools are closed, there is increased risk of abusive and exploitative behavior.²⁴



To capture a subset of these effects, the analysis estimates the association between education and smoking rates, as well as between maternal education and child mortality. The regressions use FIES 2015 and the Demographic and Health Survey 2017, and control for income and other confounding factors to find very significant associations (Annex 2 provides further details). These associations are used in cohort models of children when they reach adulthood to project mortality outcomes. The results of this modeling suggest that long-term increased mortality from school closure may be 49 times higher than the number of lives saved from COVID-19 under the modeled scenarios (Figure 6). Again, this analysis is conservative, in that there are many additional channels by which education affects health beyond those quantified here.

POLICY RECOMMENDATIONS

Recognize the costs of face-to-face closure

This analysis reveals that school face-to-face closure has enormous economic and social costs. The long-run costs can adversely affect the prospects for future economic growth, while even the short-run costs to economic growth are substantial. If the policy objective is to save lives, many more lives can be saved at the same cost through other measures to address COVID-19 and via measures to address other health problems in the Philippines. For the benefits of blanket face-to-face closure to exceed costs would depend on those measures both saving 70 times as many lives as this modeling indicates is likely and on not creating the other adverse health impacts modeled. On balance, face-to-face closure is not only very costly, but it is also likely to lead to substantially more overall mortality and morbidity in the long run.

For these reasons, most of the world has now chosen to at least partially reopen schools to face-to-face learning. In mid-April 2020, blanket school closure was implemented in 166 countries, affecting nearly 85% of enrolled students, but by the end of November, only 23 countries still had such policies, with only 13% of students affected.²⁵ Within developing Asia, by that point only the Philippines, Bangladesh, Myanmar, and the Kyrgyz Republic still had all schools closed. If policy is continued well into 2021, the Philippines may be the only country in Asia pursuing this costly approach.

Prioritize lower-cost control measures

Other policy instruments have the potential to save many more lives from COVID-19 than school closures, at much lower cost. A paid sick leave policy and expanded testing, tracing, and isolation are found to have the potential to save hundreds of times as many lives per unit of economic cost. Moreover, these are “no-regret” options that have co-benefits and few serious adverse effects.

²² Heckman, J. J., J. E. Humphries, and G. Veramendi. 2018. Returns to Education: The Causal Effects of Education on Earnings, Health, and Smoking. *Journal of Political Economy*. 126 (S1). pp. S197–S246.
²³ Andriano, L. and C. W. S. Monden. 2019. The Causal Effect of Maternal Education on Child Mortality: Evidence from a Quasi-Experiment in Malawi and Uganda. *Demography*. 56 (5). pp. 1765–1790.
²⁴ Selbervik, H. 2020. Impacts of School Closures on Children in Developing Countries: Can We Learn Something from the Past?. Chr. Michelsen Institute Brief. No. 2020:05. Bergen.
²⁵ UNESCO. 2020. Global Tracking of COVID-19 Caused School Closures and Reopenings. Database available at: <https://en.unesco.org/covid19/educationresponse>.

For example, paid sick leave helps to prevent transmission of other communicable diseases and provides social protection.^{26,27} To minimize the economic cost of COVID-19 control policies, only once lower-cost options are exhausted should more costly options such as school restrictions be considered, and within school restrictions, lower-cost measures should be prioritized.

Reduce risks outside the classroom

There is much scope for targeted control measures within schools that do not create the costs found in this analysis by disrupting learning. Much risk from schools relates to contacts that occur outside of the classroom. Contact rates in school settings have been shown in high resolution empirical studies to spike during breaks between classes, recess, and lunch, when students freely associate.^{28,29} Those breaks can be reduced in duration, staggered, controlled, and/or conducted outdoors. Contact rates in classrooms can be substantially reduced through assigned seating and minimized classroom rotation. At grade levels or in schools where classroom rotation is more frequent, one course at a time scheduling can help to make rotation limited. These measures can reduce transmission without adversely affecting the classroom learning experience.

Target restrictions to older students

The results indicate that the risks from reopening schooling are greater for older students than for younger students. This is because older students are somewhat more susceptible and symptomatic, and it is because higher school levels have more classroom rotation that mixes students to increase contact rates. Older students also have better ability to manage their own learning, so higher-level closure has fewer effects on parental labor force participation. This limits the cost relative to closure for younger students. For these reasons, many developed countries have prioritized reopening of education for younger ages first.³⁰

Target geographies for school restrictions

COVID-19 risk is not uniform across the Philippines, and most cases have been concentrated in a few more urban areas. The risk from school reopening is similarly not uniform. Much of the Philippines can reopen schools without substantial risk, as the risk is concentrated in a few areas. In areas where the risk is greater, more measures merit the costs involved. In risky areas and/or for higher levels, a blended learning approach, in which students attend classes at 50% frequency and undertake remote learning during 50% of school days, could be used to manage risks. Most countries that have reopened schools in developing Asia and in the world have taken such a geographically targeted approach. Even where countries have no widespread closures, temporary closure at very localized levels remains a common practice when clusters are identified, in response to feedback from the contact tracing system.

Take a whole of government approach

Although the modeled effects on COVID-19 mortality from school opening are very small, the findings also do not mean that there will be no effect on numbers of infections. Rather, after schools open, the modeling indicates it is likely that there will be COVID-19 clusters related to schools found within the Philippines. Addressing those clusters quickly with targeted measures, such as classroom or individual school level closure, can help to reduce COVID-19 mortality to well below the modeled levels. However, identifying clusters and managing school responses depend on more than the schools themselves. Detecting the clusters and appraising risk should be the role of public health authorities. Appropriate responses to identified risks should be the role of local government authorities. Implementation of the decisions should be the role of schools. The public health and social measures framework of the World Health Organization is an example of how a joint interagency group composed of DepEd, Department of Health, Department of Interior and Local Government, mayors, school principals, and parent representatives, can determine the situation in the area, so that responsibility is shared.³¹ A coordinated approach with shared responsibility can help to keep COVID-19 controlled without sacrificing the welfare of future generations.

²⁶ Pichler, S., K. Wen, and N. R. Ziebarth. 2020. Positive Health Externalities of Mandating Paid Sick Leave. *IZA Discussion Papers*. 13530. Institute of Labor Economics (IZA) (accessed 10 August 2020).

²⁷ Pichler, S. and N. R. Ziebarth. 2017. The Pros and Cons of Sick Pay Schemes: Testing for Contagious Presenteeism and Noncontagious Absenteeism Behavior. *Journal of Public Economics*. 171 (March 2019). pp. 86–104. <http://doi.org/10.1016/j.jpubeco.2017.07.003>.

²⁸ Stehlé, J. et al. 2011. High-Resolution Measurements of Face-to-Face Contact Patterns in a Primary School. *PLoS ONE* 6(8). e23176. <https://doi.org/10.1371/journal.pone.0023176>.

²⁹ Salathé, M. et al. 2010. A High-Resolution Human Contact Network for Infectious Disease Transmission. *Proceedings of the National Academy of Sciences of the United States of America*. 107. pp. 22020–22025.

³⁰ Guthrie, B. L. et al. 2020. Summary of School Re-Opening Models and Implementation Approaches During the COVID 19 Pandemic. Draft from COVID-19 Literature Report Team: University of Washington.

³¹ World Health Organization. 2020. Considerations for Implementing and Adjusting Public Health and Social Measures in the Context of COVID-19.

ANNEX 1: DESCRIPTION OF BASIS FOR ESTIMATING FOREGONE PRODUCTIVITY

1. **The Mincerian earnings function.**¹ The private rates of returns on investing in education are estimated via the basic Mincerian earnings function (*equation 1*), which models wage income as a function of schooling and experience, expressed as follows:

$$\ln(w) = \ln(w_0) + \alpha s + \beta_1 x + \beta_2 x^2 \quad (1)$$

where, w is earnings, $(\ln(w_0))$ is the level of earnings of individuals without schooling and experience), s is the years of schooling, and x is years of work experience. The parameters α , β_1 , and β_2 , are the rates of returns to school, experience, and experience squared, respectively.

2. **Heckman selection model.**² A lack of labor market observations for those who are not employed, however, introduces sample selection bias that can influence the estimates. In order to address this concern, a Heckman selection model is used. It involves a 2-step estimation process where the first stage models probability of being employed (*equation 3*) through a probit regression, and the second stage (*equation 2*) uses estimates from the first stage plus the variables identified in the Mincerian earnings function. The approach used is very common for returns to education, but does have the limitation that it cannot account for unobserved differences that condition educational choices. The Heckman selection model developed within the context of a wage equation is expressed as follows:

The Wage Equation

$$W_i = \beta X_i + \varepsilon_i \quad (2)$$

where W_i is the wage, X_i observed variables relating to the i th person's productivity, and ε_i is an error term. W is observed only for workers, i.e., only people in work receive a wage.

The Selection Equation (i.e., being in the labor force or employed so W is observed)

$$E_i^* = Z_i \gamma + u_i \quad (3)$$

where $E_i^* = W_i - E_i'$ is the difference between the wage and the reservation wage E_i' . The reservation wage is the minimum wage at which the i th individual is prepared to work. If the wage is below that they choose not to work. We observe only an indicator variable for employment defined as $E = 1$ iff $E_i^* > 0$, i.e., if $Z_i \gamma + u_i > 0$ and $E = 0$ otherwise.

The Heckman model assumes that both error terms are normally distributed with mean 0, variances as indicated and the error terms are correlated, where $\rho_{\varepsilon u}$ indicates the correlation coefficient (*equation 4*):

$$(\varepsilon, u) \sim N(0, 0, \sigma_\varepsilon^2, \sigma_u^2, \rho_{\varepsilon u}) \quad (4)$$

and that the error terms (ε, u) are independent of both sets of explanatory variables X and Z . It also normalizes the variance of the error term in the probit regression.

3. **Data and key variables.** This study uses the pooled Labor Force Survey quarterly data from 2018 from the Philippine Statistical Authority (formerly National Statistics Office). The survey covers around 51,000 in each of the four quarters. It includes employment status and highest educational attainment of members 5 years of age and over, basic pay per day of members 15 years and over (excluding those who are self-employed without any paid employee, or employer or worker without pay in own family-operated farm or business, or those who work on commission basis), and age of each member of the family.

¹ Mincer, J. 1958. Investment in Human Capital and Personal Income Distribution. *Journal of Political Economy*. 66 (4). pp. 281–302. doi:10.1086/258055; Mincer, J. 1974. *Schooling, Experience and Earnings*. New York: National Bureau of Economic Research.

² Heckman, J. et al. 2003. Fifty Years of Mincer Earnings Regressions. *NBER Working Papers*. 9732. National Bureau of Economic Research, Inc.; Heckman, J. 1979. Sample Selection Bias as a Specification Error. *Econometrica*. 47. pp. 153–161.

ANNEX 2: DESCRIPTION OF BASIS FOR ESTIMATING INDIRECT MORTALITY EFFECTS OF SCHOOL CLOSURE

Child Mortality

The approach is to build a regression model to empirically estimate the association between years of maternal schooling and child mortality and then to employ the estimates in a cohort model that projects the implications of reduced years of schooling due to distance learning.

1. The Regression Model

Using the 2017 Philippines National Demographic and Health Survey (2017 NDHS), fractional logit regression is applied to determine the relationship between maternal schooling and the proportion of her children dying between the ages of 0 and 14. The outcome variable is measured as a share of deceased children to total number of children ages 0 to 14 (M), while control variables include years of schooling completed by the mother (E), age of the mother (A), predicted household income (I), type of residence (urban or rural) (U), and location (region) dummy variables (L), as follows:

$$M = \beta_0 + \beta_1 E + \beta_2 A + \beta_3 I + \beta_4 U + \beta_5 L \quad (1)$$

In lieu of actual income being included in the NDHS, a predicted household income variable is derived by approximating the income of households with the same asset characteristics of households from the 2015 Family Income and Expenditure Survey. These include material of outer walls, roof material, electricity, radio, television, non-mobile telephone, computer or laptop, refrigerator, washing machine, air conditioner, DVD player, audio component or karaoke machine, mobile phone, motorcycle, motor scooter or tricycle, motorized boat or banca and car, truck, jeep or van, and province of residence variables.

Highly significant ($p < 0.01$) regression results indicate that child mortality decreases with the education of mothers, so that each year of education reduces the probability of premature child death by 0.14 percentage points.

The predicted share of prematurely deceased children per woman is then computed based on the estimated model using (i) current education levels of the mother, in terms of years of schooling; and (ii) current education of the mother less 0.78, which is the average years of education reduction due to reliance on distance education during school year 2020–2021. The difference in the predictions is the predicted child mortality effect of the loss in effective education expected from reliance on distance learning for the offspring of given current female student.

2. The Cohort Model

A cohort model is built to project implications at the population level. This starts with the estimated population of students for each grade level in the K-12 program of the Department of Education. Next, the numbers of female cohort children over time were computed by multiplying the number of students per year with the share of females per grade level, until the year when these students will reach the age of 49, when fertility usually ends. The number of offspring born to female cohort children per grade level is projected annually beginning in 2020 as the number of female cohort children multiplied by the “average birth rate” per age level, adjusted for declining trends in fertility over time. The children born are then multiplied by the effects on child mortality predicted to result from the decline in education using the regression model. Child mortality is modeled as occurring 8 years after birth, as the average age of premature child mortality in the Demographic and Health Survey 2017 data set is 8.21 years.

This analysis finds that a year of reliance on distance education or equivalent of 0.78 fewer years of effective schooling of current children translates to about 28,000 additional deaths of their children in the future accounting for declining fertility rates. If there will be no changes in current fertility rates, child mortality could reach around 40,000 additional child deaths.

Smoking

The approach is to build a regression model to empirically estimate the association between years of schooling and smoking rates and then to employ the estimates in a cohort model that projects the implications of reduced years of schooling due to distance learning on smoking induced mortality.

1. The Regression Model

Using the 2015 Family Income and Expenditure Survey (FIES), a binary variable (T) is created based on expenditures of the survey respondents: an observation is considered a “smoking” family (value of 1) if at least a peso is spent on tobacco, and “non-smoking” family (value of 0) if no tobacco expenditures were reported. This outcome variable was then regressed against the (i) average years of education completed by family members who are at least 15 years old (E), (ii) share of female to total family members (W), (iii) total annual family income (I), (iv) average age of family members who are at least 15 years old (A), (v) residence of the family (urban or rural) (U), and (vi) region dummy variables (L). The regression equation is as follows:

$$T = \beta_0 + \beta_1 E + \beta_2 W + \beta_3 I + \beta_4 A + \beta_5 U + \beta_6 L \quad (2)$$

Overall, the highly significant ($p < 0.01$) regression results indicate that household tobacco use declines by 2.7 percentage points per year of education of household adults. Tobacco use rates are predicted based on the estimated model using two definitions of education: (i) average years of education completed by family members who are at least 15 years old, and (ii) average years of education completed by family members minus the 0.78 years of education lost due to face-to-face closure for one school year. The difference from the predictions is the change in tobacco rates due to lost education at the family level. The relative increase in tobacco use is then calculated by dividing this change in predicted use rates by the baseline rate and is assumed to apply to smoking.

2. The Cohort Model

A cohort model is then used to project baseline future numbers of smokers in each year in each age group. This starts with the reported population of students for each grade level in the K-12 program of the Department of Education. Smoking rates (T_j) were determined using the published data of the 2009 Philippine's Global Adult Tobacco Survey (GATS).³ These rates were adjusted to reflect the age distribution of smoking rates and the decline in smoking rates over time based on recent trends in smoking rates reported in the World Development Indicators for the Philippines over the 2010 to 2016 period. Using the numbers of cohort children in and the adjusted smoking rates, baseline numbers of “future smokers” from the current cohort of students were projected per year based on projected baseline smoking rates.

These baseline rates are multiplied by the predicted relative difference in tobacco use rates from the OLS regression described earlier to give increases in smoking rates. In each year from 2020 to 2086, the numbers of additional smokers are multiplied by the mortality risk of smoking for the age of the cohort. This is based on the Global Burden of Disease (GBD) estimates⁴ on the smoking risk factor for the Philippines in year 2017 and the number of smokers by age group computed using projected data from the 2009 GATS. The average increases in probability of mortality from smoking were computed by dividing the 2017 GBD estimates of smoking-caused deaths for each age group by the estimated numbers of smokers by age group in 2017. This analysis finds 97,000 additional smoking deaths from reliance on distance education during the 2020–2021 school year.

³ Department of Health and the National Statistics Office. 2010. 2009 Philippines' Global Adult Tobacco Survey: Country Report. https://www.who.int/tobacco/surveillance/2009_gats_report_philippines.pdf?ua=1.

⁴ Global Health Data Exchange. GBD Results Tool. <http://ghdx.healthdata.org/gbd-results-tool>.

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