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Economic Burden of Dengue Virus Infection at the Household Level among Residents of Puerto Maldonado, Peru

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Abstract. Dengue virus (DENV) was reintroduced to Peru in the 1990s and has been reported in Puerto Maldonado (population ~65,000) in the Peruvian southern Amazon basin since 2000. This region also has the highest human migration rate in the country, mainly from areas not endemic for DENV. The objective of this study was to assess the proportion of household income that is diverted to costs incurred because of dengue illness and to compare these expenses between recent migrants (RMs) and long-term residents (LTRs). We administered a standardized questionnaire to persons diagnosed with dengue illness at Hospital Santa Rosa in Puerto Maldonado from December 2012 to March 2013. We compared direct and indirect medical costs between RMs and LTRs. A total of 80 participants completed the survey, of whom 28 (35%) were RMs and 52 (65%) were LTRs. Each dengue illness episode cost the household an average of US$105 (standard deviation [SD] = 107), representing 24% of their monthly income. Indirect costs were the greatest expense (US$56, SD = 87), especially lost wages. The proportion of household income diverted to dengue illness did not differ significantly between RM and LTR households. The study highlights the significant financial burden incurred by households when a family member suffers dengue illness.

BACKGROUND

Dengue virus (DENV) is a *Flavivirus* with broad global distribution and is considered as the arbovirus with the most important public health impact.[1] DENV infection is characterized by fever and other nonspecific symptoms, although it is estimated that a large proportion of infections are asymptomatic.[2–4] Infection ranges from mild to severe disease, which may lead to hospitalization. Hospital stay lasts for 6 days on average. Children and infants usually have the most severe forms of the disease in hyperendemic areas.[5] DENV is transmitted by the mosquito *Aedes aegypti* mainly in urban settings, while *Aedes albopictus* has been implicated in rural areas.[6,7] The distribution of DENV and its vectors have continued to expand across diverse environments worldwide,[8,9] changing its epidemiology and evolving into an important cause of morbidity and mortality, especially in developing countries.[1,10] The main control strategy remains focused on vector control,[9,11–14] despite growing efforts to develop a vaccine.[15,16]

Studies of cost of illness became increasingly important in the past two decades to assess the use of resources in health care and prioritize diseases with larger burdens.[17] Previous assessments that measure the economic impact of DENV have mainly focused on the burden to the health-care system, which can ascend to US$27.4 million per year.[18] Other studies have reported total costs at the societal level between US$1 and US$4 million in the period between 2000 and 2007, respectively, for all the Americas.[19] However, the perspectives of these studies, either at the societal, health-care system or at governmental level,[20] do not reflect or describe clearly the economic burden of dengue illness on the patients or their households, nor what factors may influence this burden.

DENV was reintroduced into Peru in the 1990s in the northern Amazonian region of Loreto[21,22] and has since become endemic in virtually all tropical areas of the country. The current countrywide incidence of DENV without complications has been estimated to be 94.2/100,000 people.[23–26] Madre de Dios (Figure 1) has the highest rate of migration in Peru, mainly from the neighboring regions of Cusco and Puno, for occupational perspectives.[27,28] These areas are mostly non-endemic for DENV.

Previous studies have shown the disadvantages and vulnerabilities faced by migrants in comparison to native workers in different settings, ranging from lack of health awareness, disproportionally lower income, and invisible costs shouldered by migrants such as barriers to access better-paid jobs.[29,30] The sparse information existing assessing the complex process of migration and health-related outcomes make Puerto Maldonado and its particular conditions an illustrative area of study in terms of the differential economic pressure that dengue illness may exert across the social structure of the city.

Health insurance in Peru is provided through both the public and private sector. The public sector insurance is divided into indirect (i.e., subsidized) and direct contributions. The former is inexpensive universal coverage called "Integral Health Insurance" (SIS, for the acronym in Spanish). This insurance is directed to people living in poverty (covers 36% of the population) and subsidizes outpatient visits, hospitalization, laboratory exams, and medicines. The direct contribution system is for households that contribute to social security (called EsSalud) through their employers or directly as autonomous workers (covers 23% of the population). In addition to health-care expenses, EsSalud also includes sick leave coverage and a pension. Insurance through the private sector and armed forces covers 5% of the population. The population with no coverage is approximately 36%.[31,32]

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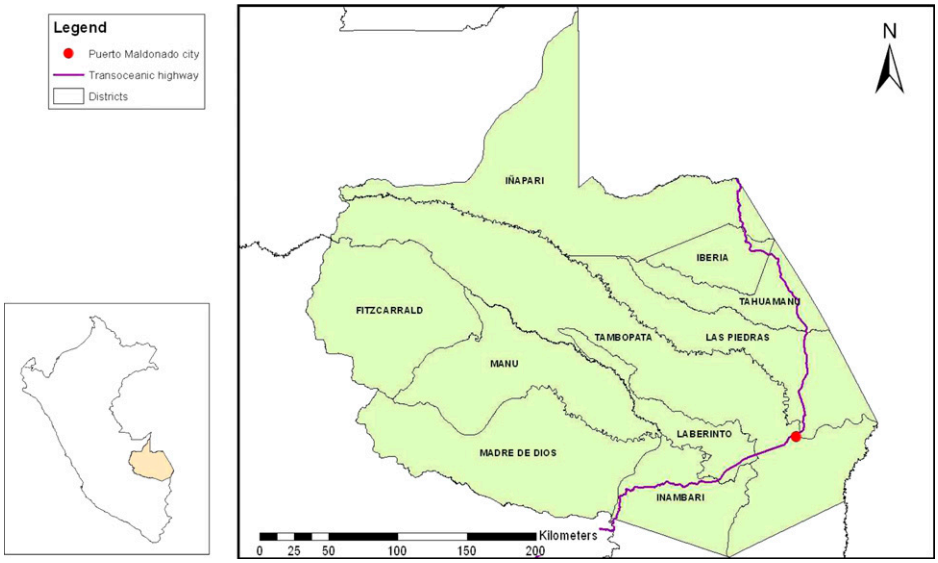

FIGURE 1. Puerto Maldonado in Madre de Dios, Peru.

The objective of this study was to assess the proportion of household income that was diverted to cover the costs incurred because of dengue illness and to compare these expenses between recent migrants (RMs) to the city and long-term residents (LTRs) in Puerto Maldonado. We speculated that RMs and LTRs may have different access to health care, possibly with fewer RMs contributing to EsSalud through the formal labor force and thus paying for health care either out of pocket or by SIS. A secondary objective was to describe the demographic and socioeconomic features of the population of Puerto Maldonado according to their migration status. Results from this study provide essential information on the economic burden of dengue illness at the household level, indicating the real impact on individuals and families, and help to assess the cost benefit of future vaccine efforts[15,16,33–35] and continuing vector control strategies.

METHODS

Data collection. Potential research subjects were identified at the local hospital where dengue cases from the area are referred. A field worker contacted patients of all ages who had been diagnosed with dengue fever, dengue with warning symptoms, or dengue hemorrhagic fever, including both hospitalized and outpatients. The field worker briefly explained the study and collected contact information with the patient's consent. The field worker then arranged a visit to the participant's home to explain the study, perform the informed consent process, and administer a standardized questionnaire on household characteristics, income, financial expenses, care-seeking behavior (i.e., where did they seek health care, how many times did they go). Visits were performed within a month since the diagnosis of dengue illness to diminish recall bias. The survey was conducted between December 2012 and March 2013, which is typically the peak season for dengue illness in the Madre de Dios Region.

RMs were defined as persons who had been living in Puerto Maldonado for fewer than 5 years and LTRs were those who had been stationed in the city for 5 years or more. This cutoff was selected on the basis of the more recent information available on migration and place of residence from a 2007 census in Peru, which had a specific question regarding place of residence in the previous 5 years.[27]

Cost-of-illness estimation. The perspective selected was that of participants and their families.[20] We estimated direct cost of medical treatment, other nonmedical direct costs, and indirect costs. Direct medical costs included out-of-pocket payments for items such as medical appointments, laboratory exams, cost of hospitalization, and medicines. Direct nonmedical costs comprised transportation to the health-care facility. Indirect costs were lost wages from the patient or, in the case of children, the caregiver. We estimated daily lost wages based on the minimum-wage in the case of nonpaid activities, such as for housewives or retirees who lacked social security or similar insurance. We used the exchange rate from the Banco Central de Reserva del Peru for the period of December 1, 2012–March 1, 2013 (www.bcrp.gob.pe), which was 2.56 Peruvian nuevos soles to 1 U.S. dollar.

Statistical analysis. The proportion of household income devoted to dengue illness expenses by migration status was appraised. Data were initially evaluated using descriptive

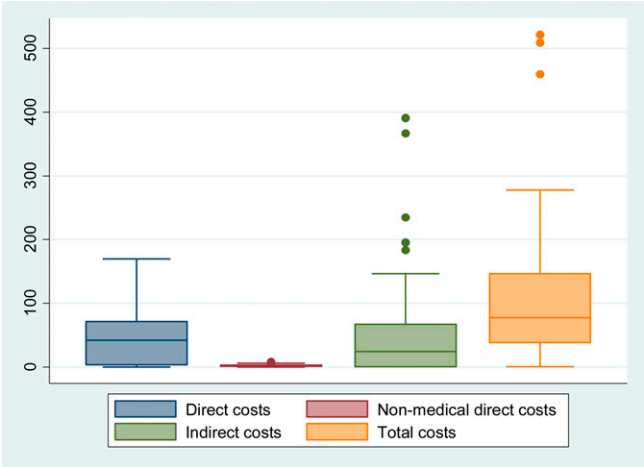

FIGURE 2. Total costs incurred by patients (in U.S. dollar).

statistics. We used the Shapiro–Wilk test to assess for normality. K-sample and Mann–Whitney non-parametric tests were performed to assess differences in median and average income and cost of illness between RMs and LTRs. Also, χ^2 analysis, with Fisher's exact adjustment as appropriate, was used to test the associations with occupation of participants as well as the severity of dengue illness. A wealth index (WI) was created to assess household wealth and included variables related to resources, construction materials of the house, and access to services such as running water, sewer, and garbage collection (see Supplemental Appendix 1 for details).[36–38] Higher values indicated more affluence. Statistical analysis was performed using Stata version 12.1 (StataCorp LP, College Station, TX).

Ethical aspects. Informed consent was obtained from all adult participants and from the parents or legal guardians of minors. The study was approved by the Institutional Review Boards from the Naval Medical Research Unit No. 6 and Johns Hopkins Bloomberg School of Public Health.

RESULTS

General characteristics of the study population. A total of 80 subjects participated in the survey; Table 1 shows the general demographic characteristics of the study population. Of the study participants, 26 (32%) were native to Puerto Maldonado, but only 28 (35%) of those who were nonnative met the criterion for RM classification.

Among the participants who were nonnative to Puerto Maldonado, the majority migrated from Cusco (33%), other areas in Madre de Dios (22%), and Puno (10%). On average, current residents who were nonnative to Puerto Maldonado have been living in the city for 9.5 years (median = 5.2 years, standard deviation [SD] = 11.4). There was no difference in mean age regarding migration status ($P = 0.117$). However, median age was lower among RMs (23.5, SD = 20.3) than LTRs (31.5, SD = 16.1), which was significant using the K-sample test for the equality of medians ($P = 0.035$).

Income, occupation, assets, and WI. Approximately half (25/52) of LTRs and one-third (9/28) of RMs had received payment for their main occupation in the week before administration of the questionnaire, but this difference was not statistically significant ($P = 0.122$). The average monthly household income for participants was US$618.2, ranging from US$39.1 to US$1,562.6. Nonetheless, the average household income for RMs was approximately US$507.8, about US$136.7 lower than that of LTR families ($P = 0.041$). Neither the household heads nor the cases interviewed showed a significant difference in education level associated with their RM or LTR status ($P = 0.651$ and 0.283, respectively).

RMs and LTRs showed differences in access to public services and household construction materials (Table 2): RMs were more likely to lack running water ($P = 0.020$) and garbage collection services ($P = 0.010$). They more frequently reported burning or burying garbage and using a latrine in contrast to having indoor plumbing, although this was not significant ($P = 0.066$). The WI ranged between 0.410 and 1.868 with a mean of 1.319 for RMs, in contrast to 1.471 for LTRs ($P = 0.003$).

Dengue illness, use of and access to health care. About a quarter of all DENV episodes were classified as dengue with

TABLE 1
General characteristics of the study population

	Total		RM		LTR		
	N	%	*N*	%	*N*	%	*P* value
Sex							1.000
Female	44	55	18	64	26	50	
Male	36	45	10	36	26	50	
Age							
N	80		28		52		0.117
Mean, median, SD	32.1, 27.0, 17.6		29.7, 23.5, 20.3		33.3, 31.5, 16.1		
Occupation							0.012
Housewife	21	26	7	25	14	27	
Student	15	19	10	36	5	10	
Other	11	14	0	0	11	21	
Professional activity	10	13	4	14	6	12	
Mining	7	9	3	11	4	8	
Agriculture	6	8	3	11	3	6	
Administrative/technical activity	6	8	1	4	5	10	
Forestry	4	5	0	0	4	8	
Education							0.283
None	6	8	4	14	2	4	
Elementary school	17	21	6	21	11	21	
Middle and high school	36	45	12	43	24	46	
Technical school	9	11	1	4	8	15	
University	12	15	5	18	7	13	
Dengue diagnosis							0.171
Dengue fever	59	74	18	64	41	79	
Dengue with alarm signs*	20	25	9	32	11	21	
Dengue hemorrhagic fever	1	1	1	4	0	0	
Origin							–
Natives to Puerto Maldonado†	26	33	2	8	24	46	
Nonnatives to Puerto Maldonado	54	68	24	92	28	54	

LTR = long-term residents; RM = recent migrants; SD = standard deviation.
*Dengue with warning signs: abdominal pain, persistent vomiting, clinical fluid accumulation, mucosal bleed, lethargy/restlessness, liver enlargement of more than 2 cm and an increase in hematocrit plus decrease in platelet count.
†Two participants were born in PEM and had returned within the previous 5 years.

TABLE 2
Household characteristics and access to utilities by migration status

	Total (N = 80)		RM (N = 28)		LTR (N = 52)		
	N	%	N	%	N	%	P value*
Services							
In-house water plumbing	63	79	18	64	45	87	0.020
Garbage collection service	64	80	18	64	46	88	0.010
Sewage connection	56	70	16	57	40	77	0.066
Shared bathroom with other family or business	12	15	4	14	8	15	1.000
Flooring material							
Wood	6	8	5	18	1	2	0.018
Dirt	18	23	8	29	10	19	0.340
Cement/concrete	49	61	14	50	35	67	0.130
Tiles	7	9	1	4	6	12	0.412
Roofing material							
Cement/concrete	6	8	1	4	5	10	0.659
Corrugated iron	72	90	26	93	46	88	0.706
Palm trees	2	3	1	4	1	2	1.000
Wall material							
Wood	51	64	18	64	33	63	0.942
Cement/concrete	23	29	8	29	15	29	0.979
Other	6	8	2	7	4	8	1.000

*χ^2 or Fisher's exact test.

warning signs (Table 3),with no differences in the frequency of underlying health problems between RMs and LTRs (P = 0.287). RMs required caregivers more frequently than LTRs (P = 0.082). Approximately 64% of participants reported being incapacitated because of illness. The number of days lost (from work, housework, or school) for each dengue illness episode averaged 5.1, ranging from 1 to 30 days.

More than 60% of respondents did not have health insurance, a slightly higher proportion among RMs, but nonsignificant. There were no significant differences between groups with regard to frequency of utilization of health services or the types of services used.

Cost of illness. Each dengue episode cost an average of US$105.3: US$47.6 direct costs, US$2.3 nonmedical direct costs (transportation), and US$55.5 indirect costs (Table 4).

The larger proportion of expenses was aggregated in direct costs (49%) and indirect costs (35%). However, indirect costs—which were wages lost because of illness—were more than half of total expenses (52%) when these costs were reported (Figure 2). Costs incurred by RMs and LTRs were similar (Table 4). The mean total cost for patients who were hospitalized was US$149.7, in contrast to US$68.8 for outpatients (P < 0.001). Direct medical costs, direct nonmedical costs, and indirect costs were US$29.3, US$2.4, and US$35.5, respectively, for outpatients, while it averaged US$68.8, US$2.2, and US$78.7, respectively, for hospitalized cases. Participants who had health insurance had fewer expenses than those who did not have it (P = 0.010), but the difference was not relevant after controlling for severity of illness (P = 0.060.) The main difference between insured and uninsured patients were direct costs, which came up to almost US$60 for those who did not have any kind of insurance compared with ~US$30 on average for participants who had coverage (P < 0.001). The mean total cost for patients with dengue without warning signs was US$97.4 and those with warning signs was US$127.5 ($P$ = 0.122) (Table 5).

The proportion of monthly household income that was diverted to dengue-related expenses or lost wages because of illness was approximately 24% (SD 36.0), ranging from no expenses to spending all household income on a dengue illness

TABLE 3
Characteristics of dengue illness episodes

	Total (N = 80)		RM (N = 28)		LTR (N = 52)		
	N	%	N	%	N	%	P value
Dengue diagnosis							
Dengue fever	59	74	18	64	41	79	0.171
Dengue with alarm signs*	20	25	9	32	11	21	
Dengue hemorrhagic fever	1	1	1	4	0	0	
Underlying conditions							
Presence	16	20	4	14	12	23	0.397
Absence	64	80	24	86	40	77	
Need for caregiver							
Yes	29	36	13	46	16	31	0.223
No	51	64	15	54	36	69	
Type of care							
Outpatient	37	46	12	43	31	60	0.167
Hospitalization	43	54	16	57	21	40	

LTR = long-term residents; RM = recent migrants.
*Dengue with alarm signs: abdominal pain, persistent vomiting, clinical fluid accumulation, mucosal bleed, lethargy/restlessness, liver enlargement of more than 2 cm, and an increase in hematocrit plus decrease in platelet count.

TABLE 4
Detail of direct and indirect costs (in US$) by migration status

Type of cost	Total				RM				LTR				
	Mean	SD	Median	IQR	Mean	SD	Median	IQR	Mean	SD	Median	IQR	*P* value
Direct costs	47.6	42.5	42.3	67.3	47.3	42.4	32.4	60.8	47.7	42.9	43.5	64.8	0.911
Nonmedical direct costs	2.3	1.6	1.6	1.9	2.3	1.5	1.6	1.9	2.3	1.7	1.7	1.9	0.931
Indirect costs	55.5	86.5	24.4	67.1	48.4	58.3	24.4	67.1	59.3	98.8	24.4	67.1	0.622
Total costs	105.3	106.1	77.6	108.8	97.9	72.1	92.8	108.0	109.3	120.9	75.9	104.4	0.705

IQR = interquartile range; LTR = long-term residents; RM = recent migrants; SD = standard deviation.

episode. The proportion of monthly household income per dengue illness episode was similar between LTRs and RMs ($P = 0.462$), although RMs diverted a higher proportion of their income in each dengue episode (31%). We did not find any difference in the proportion of expenses by severity of disease. Only one participant reported incurring in debt because of dengue illness.

Finally, with the average cost of each dengue illness episode, we estimated the total cost of reported dengue cases for the region of Madre de Dios in 2012, which had the second highest annual incidence rate in the country: 1,604/100,000 people.[39] The total cost was US$216,076, burdened by the households of 2,052 dengue cases reported for Madre de Dios.

DISCUSSION

Despite previous larger studies to assess the economic burden of DENV in Latin America,[10,40] there is sparse information regarding DENV costs at the household level in the region. Similarly, there has not been a previous assessment of expenses incurred because of DENV in Peru, although certain regions, such as Madre de Dios, have a disproportionate burden of the disease when compared with national rates.[26]

We found no significant differences between the costs incurred by RMs and LTRs. Direct medical costs were approximately US$48, which was higher than the total costs (US$27, approximately 23% of the average monthly income[41]) estimated in a study from Kampong Cham Province, Cambodia,[42] and higher than US$35 averaged for direct costs of hospitalized cases of dengue illness in Colombia.[43] It is also in excess of the highest cost for hospitalization with dengue hemorrhagic fever (US$39.1, approximately 12% of the average monthly income[44]) as reported from a cohort of children in Thailand[45] or the average cost (approximately US$24) for a population of children and adults in the same country.[46] In contrast, these costs were much lower than those reported for Puerto Rico ranging from US$1,764 to US$764 for hospitalized patients and ambulatory cases, respectively, or for Colombia where ambulatory cases averaged US$154.8 and hospitalized cases US$270.8.[43,47] The direct costs of dengue illness that we calculated were similar to those estimated in the state of Zulia, Venezuela,[48] and were less than those estimated for Peru by Shepard and others since they used a societal perspective. The latter study calculated US$259 for outpatients and US$723 for hospitalized cases.[19] A study performed in Vietnam estimated total costs at US$167.8 per hospitalized case,[49] closer to the findings in this study for patients who required hospitalization (US$135.8). It is remarkable, though that research conducted in southeast Asia reported a large proportion of participants contracting debt.[42] This is in contrast to the findings in this study, in which only one patient from Puerto Maldonado contracted debt because of dengue illness.

The total expenditure for DENV episode accounted for approximately a quarter of the monthly household income, on average. This proportion was lower than 37% as reported for Thailand,[46] but comparable to Vietnam.[49] This research, however, was unable to find or link a higher proportion of monthly household income diverted to DENV expenditures from RM households compared with LTR households. Data collected from the investigation suggested that households of LTRs have higher income than RMs, similar to previous findings.[29]

The length of dengue illness per episode was comparable to what has been reported in other studies.[45,46] Similarly, the number of contacts a dengue patient makes with health-care facilities for each episode of dengue, 1.5 on average, is similar to what has been estimated before in different settings as well.[42] In terms of severity, almost half of dengue cases were hospitalized (46%). Although this percentage is lower than what has been shown in similar studies,[42] hospitalization was related only to having been diagnosed with dengue with warning signs, but not with the preexistence of a chronic condition (i.e., diabetes, hypertension). According to the World Health Organization Guidelines for Diagnosis, Treatment, Prevention and Control of Dengue, the presence of comorbidities corresponds to admission criteria for dengue treatment.[9] Therefore, this concerning finding should be evaluated through different means to assess the protocol and practices in place for the hospitalization of patients with dengue.

Finally, the availability of public services such as garbage collection, running water, and connection to sewers was different between RMs and LTRs, with insufficient coverage among RMs. This is probably related to the settling areas

TABLE 5
Detail of direct and indirect costs (in U.S. dollar) by diagnosis

Type of cost	Total				Classic dengue				Dengue with warning signs or severe				
	Mean	SD	Median	IQR	Mean	SD	Median	IQR	Mean	SD	Median	IQR	*P* value
Direct costs	47.6	42.5	42.3	67.3	41.2	38.7	33.2	50.0	65.5	48.3	70.1	114.6	0.033
Nonmedical direct costs	2.3	1.7	1.6	1.9	2.1	1.5	1.6	2.3	2.7	1.9	1.6	1.6	0.260
Indirect costs	55.5	86.5	24.4	67.1	54.1	86.2	24.4	73.2	59.3	89.4	24.4	36.6	0.413
Total costs	105.3	106.1	77.6	108.8	97.4	102.3	69.1	109.0	127.5	115.5	98.2	70.1	0.122

IQR = interquartile range; SD = standard deviation.

of RMs, which may be in newer locations in the city and grow in an unplanned manner similar to other urban areas in developing countries.[50–52] Differential risk of dengue because of location in urban settings has been described before in other studies[3,30,53–56] and has been assessed with countrywide data in Peru, linking poor access to running water as a risk factor for DENV.[26]

This study has several limitations, including a small sample size. It was originally estimated to detect a 10% difference in the proportion of income diverted to dengue between RMs and LTRs. Although approximately 20% of household income is diverted to dengue in LTR households and 31% for RM households, this difference was not significant in the study. Similarly, we lacked data to assess expenditures of the household for more comprehensive and detailed understanding of the impact of dengue illness. Similarly, the information collected for this study pertains to cases with enough symptoms to seek health care. Therefore, this is a lower-bound estimate of the true impact since some illness may not be reported but may influence productivity and household income. Similarly, there may be economic barriers to accessing health care in the first place that this study was not designed to address, but should be evaluated.

This is the first study within the country to describe the economic impact of dengue at the household level. The total cost for the households of the dengue cases in the region for 2012 was US$216,076. Approximately half of these costs, US$106,000, corresponds to direct costs, and approximately US$75,500 were indirect costs. Similar studies are needed to improve our understanding of the burden of this disease, especially in the face of current efforts to develop a vaccine[57] and cost-effectiveness studies that may be needed to correctly assess the impact of these strategies.[35]

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