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On the Economic Benefits of Dengue Vaccination:

Evidence on the negative effects of dengue on socioeconomic variables in Mexico

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On the Economic Benefits of Dengue Vaccination: Evidence on the negative effects of dengue on socioeconomic variables in Mexico

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1. Background

Why study the effects of dengue on aggregate socioeconomic variables in Mexico….

1. Evidence on the impact of the incidence of dengue on GDP, employment, tourism, taxes, and other socioeconomic variables in Mexico and Latin America is lacking

2. Our study provides initial estimates of those effects

3. Our results show that in Mexico economic-related variables are negatively affected by dengue at both the state and municipality level

Source: Samaniego, Ricardo and Claudia Aburto "The impact of the incidence of dengue on aggregate socioeconomic variables in Mexico", forthcoming.

1. Background

The total number of dengue cases around the world is under reported....

1. A recent estimate (Bhatt *et al*) suggests that approximately 390 million dengue infections occur per year in the world (96 million are manifested clinically).

2. Yet, the annual number of world cases reported annually in 2010, 2013 and 2015 was about 2.4 million cases (WHO). Under reporting of actual dengue cases is broad.

3. In 2015, 2.35 million cases of dengue were reported in the Americas, of which 10,200 cases were diagnosed as severe dengue which caused 1,181 deaths (WHO).

4. Brazil reported more than 1.5 million cases in 2015, about 3 times more than in 2014 (WHO).

Bhatt S, Gething PW, Brady OJ, Messina JP, Farlow AW, Moyes CL et.al. The global distribution and burden of dengue. Nature;496:504–507

WHO, World Health Organization, Dengue and severe dengue, Fact sheet, Updated July 2016.

1. Background

The total number of dengue cases has increased in Mexico after its eradication in the 1970's….

1. In Mexico, despite initial eradication of dengue in the 1970s, transmission has since been reported in 28 of the 32 states.

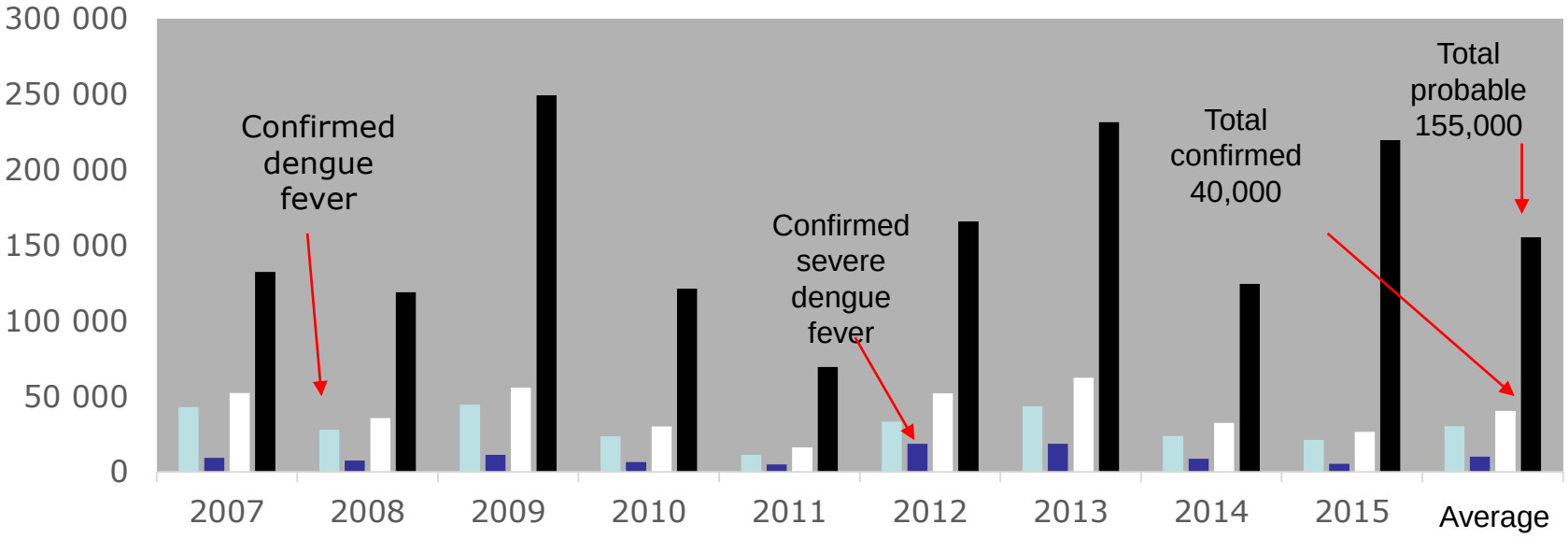
2. The highest number of confirmed dengue cases was recorded in 2013, with 62,330 cases, of which 18,667 were severe dengue (dengue hemorragic fever), and 192 deaths (for a mortality rate of 1.03%). (SINAVE).

3. However, probable cases were on average more than 155 thousand annually in 2007-2015, while total confirmed cases were about 40 thousand annually.

Source: SINAVE (2016), Sistema Nacional de Vigilancia Epidemiologica, Secretaria de Salud, Mexico.

1. Background

The probable number of dengue cases in México is four times higher than confirmed cases....



Source: SINAVE, Mexico

1. Background

The cost of dengue in Mexico has been calculated using a"buttom up" approach….

1. Shepard calculated the cost of dengue in Mexico in 2011 at US$1.70 per capita.

2. Undurraga *et al* estimated the annual cost of dengue, including surveillance and vector control, at about US$170 million or $1.56 per capita (in 2012 US$)

3. Zubieta, Adriana *et al (2016)* obtained the direct costs associated with dengue management in the public health system as US$92, US$1,645 and US$9,375 per case for ambulatory, hospitalized and intensive care patients.

Shepard DS, Coudeville L, Halasa YA, Zambrano B, Dayan GH. Economic impact of dengue illness in the Americas. Am J Trop Med Hyg. 2011;84(2):200-7.

Undurraga EA, Betancourt-Cravioto M, Ramos-Castaneda J, Martinez-Vega R, Mendez-Galvan J, Gubler DJ, et al. Economic and disease burden of dengue in Mexico. PLoS Negl Trop Dis. 2015;9(3):e0003547.

Zubieta-Zavala A, Salinas-Escudero G, Ramírez-Chávez A, García-Valladares L, LópezCervantes M, López Yescas JG, et al. (2016) Calculation of the Average Cost per Case of Dengue Fever in Mexico Using a Micro-Costing Approach. PLoS Negl Trop Dis 10(8): e0004897. doi:10.1371/ journal.pntd.0004897

2. Results of a population-based study by state

We estimated the effect of the incidence of dengue by state using a "top down" approach…

1. We estimated an econometric fixed effects model:

2. $Y_{it} = \beta_i X_{it} + \alpha_i + u_{it}$

   - Y_{it} is the dependent economic variable (value added, employment and tourism) where i = state i and t = time period t.
   - β_i is the coefficient for the incidence of dengue
   - u_{it} is the error term
   - α_i (i = 1….n) is the unknown intercept for each state (n state-specific fixes effect intercepts).
   - X_{it} represents the incidence of dengue,

2. Results of a population-based study by state

Effect of dengue on socioeconomic variables by state

Socioeconomic variable	Effect	Period
GDP	– 0.027 [a]	1995–2015
Employment	– 0.0017 ***	1995–2014
Tourism (number of tourists)	– 0.156 **	2005–2011
Basic schooling dropouts	0.0771 **	1996, 2008, 2011
Revenue of federal taxes generated by state	- 0.011 [b]	1995–2015

***Statistically significant at the 99% level of confidence
**Statistically significant at the 95% level of confidence
*Statistically significant at the 90% level of confidence
a,b Statistical significance not calculated
since the effect is a weighed average of estimates

2. Results of a population-based study by state

In summary, the results by state using a "top down" approach were…

1. A 1% increase in dengue incidence would reduce GDP by 0.027% and employment by 0.0017%.
2. While the number of foreign tourists decreased by 0.156%, this was not the case for domestic tourists.
3. The incidence of dengue incidence negatively affected school achievement
4. State revenues from federal taxes decreased by 0.011%.

2. Results of a population-based study by municipality

Method to estimate the impact of dengue in municipalities with dengue surveillance

1. We estimated a fixed effects and partial adjustment model:

2. $Yit = \alpha + \beta_0 D_{it} + \beta_i X_{it} + \mu_i Y_{it-1} + u_{it}$

Y_{it} are production, value added and employment

D_{it} is the incidence of dengue

X_{it} are the control variables: Total population, Average number of occupants of a dwelling unit, Availability of piped water, Availability of drainage, Availability of electricity, Human development index, among others.

Y_{it-1} is the lagged value of the dependent variable (economic or social variable, for example, GDP, employment, etc.) where i = state i and t = time period t.

μ_i is the coefficient for the incidence of dengue

2. Results of a population-based study by municipality

Effect of dengue on socioeconomic variables by municipality

Variable	Effect	Description of the effect
Production	–0.00099**	Semi-elasticity of the incidence of dengue on production
Value added	–0.00112**	Semi-elasticity of the incidence of dengue on value added
Employment	–0.00003	Semi-elasticity of the incidence of dengue on employment

**Statistically significant at the 95% level of confidence

2. Results of a population-based study in 20 most touristic municipalities

Effect of dengue on tourism in the 20 most important tourist municipalities of Mexico

Variable	Effect	Type of effect
Domestic tourists	0.0258	Elasticity of dengue on domestic tourists
Foreign tourists	–0.0177***	Elasticity of dengue on foreign tourists
Municipal revenue from tourism	–0.0006**	Semi-elasticity of dengue on income from tourism

***Statistically significant at the 99% level of confidence

**Statistically significant at the 95% level of confidence

3. Results of a Probit model analysis

Estimation of the probability of getting ill with dengue

1. A Probit model was used to analyze the socioeconomic determinants of acquiring dengue fever in Mexico.

2. Households and individuals who acquired dengue were identified from the database of the 2012 National Health and Nutrition Survey of Mexico (ENSANUT)

3. The ENSANUT database contains information from 194,923 responses with data on 287 variables.

4. The likelihood of acquiring dengue increased for males, those previously hospitalized and those living in an urban area.

5. The likelihood of acquiring dengue decreased for those with running water and an indoor toilet.

3. Results of a Probit model analysis

Determinants of the probability of being ill with dengue

using data from the 2012 ENSANUT survey (16,168,426 observations)

Variables	Dengue	Standard error	*Z-statistic*
Age	0.075***	(0.00180)	41.8889
Age squared	–0.0015***	(3.51e-05)	42.7350
Sex	0.166***	(0.00995)	16.6834
Previously hospitalized	0.314***	(0.0150)	20.9333
Water in home	–0.329***	(0.0145)	22.6897
Indoor toilet	–0.836***	(0.0159)	52.5786
Pets	–0.579***	(0.0168)	34.4643
Urban-rural	0.271***	(0.0150)	18.0667
Number of rooms	0.047***	(0.00292)	16.0959
Constant‡	–3.48***	(0.0262)	132.8626

*** Statistically significant al the 99% level of confidence

4. Results of an incremental cost assessment of dengue during epidemics

Method to estimate the impact of dengue outbreaks on medical costs in five Mexican cities

1. Surveys in 2014 to ascertain the pattern of consultations and medical expenses during periods with and without dengue epidemics in 5 cities with diverse conditions regarding endemicity.

2. Information on 1) the infrastructure and equipment at health centers; 2) dengue cases and medical care activities; 3) medical, administrative and maintenance costs and 4) demand of medical services.

3. The sample had a margin of error of ±10% and a 95% confidence level.

4. Results of an incremental cost assessment of dengue during epidemics

Dengue outbreaks negatively affect the medical costs in health units of five Mexican cities

1. There was approximately four-fold increase overall in the average number of daily visits to all units during dengue epidemic periods compared with periods with no dengue epidemics.

2. The steepest increases during dengue epidemic periods were recorded in Guadalajara (from 1.5 to 6.4 daily cases) and Acapulco (from 2.7 to 11.6 cases).

3. We observed that the total average daily cost to healthcare facilities for ambulatory cases in the five Mexican cities increased by 142% during epidemics compared with non-epidemics.

4. Results of an incremental cost assessment of dengue during epidemics

Average daily number of ambulatory dengue cases and visits at medical units

Survey of five Mexican cities during periods without and with dengue outbreaks

City	Total		Tuxtla Gutierrez		Guadalajara		Monterrey		Acapulco		Villa Hermosa	
Out breaks	With out	With	With out	With	With out	With	With out	With	With out	With	With out	With
Cases	1.9	4.3	2.0	2.1	1.5	6.4	0.2	4.1	2.7	11.6	2.2	2.9
Visits	1.8	7.1	1.1	2.9	0.7	9.8	8.7	9.8	1.6	6.4	2.7	5.8

4. Results of an incremental cost assessment of dengue during epidemics

Average daily medical costs incurred for the treatment of ambulatory dengue cases

Survey of five Mexican cities during periods without and with dengue outbreaks

Concept	Daily cost in a week without an outbreak (Mex pesos per day)	Daily cost in a week with an outbreak (Mex pesos per day)
Diagnostic consultations	$67	$333
Diagnostic materials	$144	$668
Laboratory studies	$329	$1,574
Medicines	$88	$369
Curing materials	$351	$1,385
Medical fees	$543	$543
Payments of nurses	$384	$384
Administrative costs	$23	$23
Maintenance and cleaning costs	$422	$422
Total	**$2,352**	**$5,702**

5. Concluding remarks

The potential benefits of dengue vaccination are considerable given its significant negative effects on aggregate socioeconomic variables in Mexico

1. There is evidence that the incidence of dengue negatively affects a broad range of socioeconomic variables in Mexico.

2. The results obtained are a promising complement to traditional measurements of the costs of dengue.

3. Although additional studies are required to expand our analyses of the quantitative effects of dengue on aggregate economic variables, the estimated qualitative impacts are robust.

4. Mexico will take this approach into account when evaluating the economic impact of the forthcoming first dengue vaccination program.