

Supplementary file

Here we describe how we selected variables to be included in the Firth penalised likelihood logistic regression analyses. First, we tested pairs of each variable to identify model collinearities and/or causal pathways (supplemental. table1).

Known risk factors for mortality like age, sex, vaccination status and clinically diagnosed pneumonia were included in the model. Duration of fever and rash before admission might indicate the delayed hospital visit/admission, which was also a factor significantly contributing to mortality. Duration of fever was more strongly associated with mortality than the duration of rash when those between 7 to 14 days group with penalized logistic regression adjusted by age, sex, residence in Manila, vitamin A supplementation and the presence of pneumonia, neurological and gastroenteritis (OR 1.97[95%CI: 1.14 - 3.39] vs 1.82 [0.78 - 4.27] respectively), so therefore duration of fever was included in the final model and the other was excluded (the two variables being highly correlated). Dehydration status, which was strongly associated with gastroenteritis ($p=0.004$), had a very low number of positive cases and was omitted from the model.

As distance from the hospital was associated with residential status (Manila/out of Manila, $p<0.001$), it was also excluded. Symptoms of cough, coryza and conjunctivitis were also strongly associated with the presence of pneumonia, and clinically thought to be on the pathway to the latter more severe condition. Admission during the epidemic period also had a significant association with mortality rate in the univariable analysis. The epidemic period is on the causal pathway from vaccination to mortality as a reduced vaccination could trigger an epidemic. Indeed, vaccinated children during the epidemic period were significantly less than those in the non-epidemic period ($p<0.001$). Hence we removed epidemic period from the final model which included age, sex, residence in Manila, duration of fever before admission, vitamin A supplementation and the presence of pneumonia, neurological and gastroenteritis.

The clinical consideration that inclusion of comorbidities as factor variables might lead to underestimation of vaccine effects as well led us to a further attempt to run a model excluding comorbidities. However in this model the odds ratio for vaccination and for other variables did not significantly change (AOR 1.53 [95% CI: 1.00-2.35], $p = 0.047$, see supplemental table 2).

Supplemental table 1. P-values of each pair of possible confounder variables.

Variables	Died	Endemic season	Age group	sex	Residence in Manila	Distance	Duration of fever	Duration of rash	Cough	Coryza	Conjunctivitis	Koplik's spots	Gastroenteritis	Pneumonia	Vit.A	Vaccine	CNS	URTI	Dehydration	UTI	
Died	-	0.009	0.078	0.8	0.038	0.6	0.001	0.001	0.077	0.6	0.4	0.2	0.001	<0.001	<0.001	0.025	0.081	1	1	1	
Endemic season	0.009	-	<0.001	0.4	0.3	0.012	0.2	0.025	<0.001	<0.001	<0.001	0.051	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1	0.2	0.1
Age group	0.078	<0.001	-	0.001	0.033	0.001	0.3	0.2	0.6	0.2	<0.001	0.3	0.6	0.002	<0.001	<0.001	0.4	0.5	0.6	0.6	
Sex	0.8	0.4	0.001	-	0.3	0.027	0.7	0.1	0.8	0.6	0.5	0.8	0.067	0.4	0.6	0.6	1	1	0.6	0.2	
Residence in Manila	0.038	0.3	0.033	0.3	-	<0.001	0.063	0.1	0.2	0.1	0.2	0.3	0.4	0.006	0.9	0.007	1	0.4	1	1	
Distance from Hospital	0.6	0.012	0.001	0.027	<0.001	-	0.006	0.1	0.2	0.9	0.4	0.085	0.7	<0.001	0.5	0.015	0.7	0.099	0.054	0.8	
Duration of fever before admission	0.001	0.2	0.3	0.7	0.06	0.006	-	<0.001	0.8	0.004	0.3	0.3	0.9	0.3	0.4	0.5	0.7	1	1	1	
Duration of rash before admission	0.001	0.025	0.2	0.1	0.1	0.1	<0.001	-	0.4	0.7	0.9	0.4	0.4	0.2	0.06	0.032	0.3	1	1	1	
Cough	0.077	<0.001	0.6	0.8	0.2	0.2	0.8	0.4	-	0.4	0.3	0.002	0.054	<0.001	0.001	0.055	1	1	1	1	
Coryza	0.6	<0.001	0.2	0.6	0.1	0.9	0.004	0.7	0.4	-	<0.001	<0.001	<0.001	<0.001	0.001	0.2	0.003	0.2	0.5	1	
Conjunctivitis	0.4	<0.001	<0.001	0.5	0.2	0.4	0.3	0.9	0.3	<0.001	-	0.001	0.033	<0.001	0.001	0.6	0.4	1	1	1	
Koplik's spots	0.2	0.051	0.3	0.8	0.3	0.085	0.3	0.4	0.002	<0.001	0.001	-	1	0.3	<0.001	0.6	0.2	1	1	1	
Gastroenteritis	0.001	<0.001	0.6	0.067	0.4	0.7	0.9	0.4	0.054	<0.001	0.033	1	-	<0.001	0.004	<0.001	<0.001	1	0.004	1	
Pneumonia	<0.001	<0.001	0.002	0.4	0.006	<0.001	0.3	0.2	<0.001	<0.001	<0.001	0.3	<0.001	-	<0.001	0.003	0.028	0.011	0.2	0.1	
Vit.A supplementation	<0.001	<0.001	<0.001	0.6	0.9	0.5	0.4	0.064	0.001	0.001	0.001	<0.001	0.004	<0.001	-	0.009	<0.001	1	0.063	0.3	
Vaccine received	0.025	<0.001	<0.001	0.6	0.007	0.015	0.5	0.032	0.055	0.2	0.6	0.6	<0.001	0.003	0.009	-	1	0.1	0.4	0.3	
CNS symptoms*	0.026	<0.001	0.3	0.9	0.5	0.8	0.5	0.3	0.6	0.001	0.3	0.2	<0.001	0.022	<0.001	0.8	-	1	1	1	
URTI*	0.7	0.6	0.4	0.8	0.4	0.006	0.4	0.8	0.8	0.1	0.9	0.8	0.7	0.004	0.5	0.057	1	-	1	1	
Dehydration*	0.8	0.057	0.8	0.4	0.5	0.041	0.5	0.8	0.8	0.5	0.6	0.8	<0.001	0.2	0.013	0.4	1	1	-	1	
UTI*	0.8	0.012	0.6	0.1	0.6	0.9	0.6	0.8	0.9	0.5	0.9	0.4	0.8	0.041	0.2	0.2	1	1	1	-	

Chi-square test was used to evaluate the correlation between the paired variables. * Fisher's exact test was used because of a smaller number of observations. CNS: central nervous system. URTI: upper respiratory tract infection. UTI: urinary tract infection

Supplemental table 2. Associations with mortality, adjusted by age, vaccine, sex, location, duration of fever and vitamin A supplementation.

	n	Died(%)	Crude OR	P-value	Adjusted OR*	P-value
Age group(months)						
<3	94	2 (2.1)	1.07 (0.29-3.90)	0.919	1.21(0.32-4.53)	0.830
3 – 5	715	31 (4.3)	1.82 (1.13-2.93)	0.013	1.74(1.03-2.94)	0.040
6 – 8	1,280	40 (3.1)	1.29 (0.83-2.01)	0.256	1.35(0.83-2.20)	0.223
9 – 11	765	21 (2.7)	1.14 (0.67-1.94)	0.622	1.11(0.61-2.00)	0.739
12 – 24	1,066	44 (4.1)	1.72 (1.12-2.66)	0.014	1.52(0.93-2.48)	0.098
> 24	1,642	40 (2.4)	Ref		Ref	
				0.890		0.003
Sex						
Male	3,062	100 (3.3)	Ref		Ref	
Female	2,500	78 (3.1)	0.96 (0.71-1.29)	0.765	0.94(0.68-1.31)	0.724
Region of residence						
In NCR	4,706	140 (3)	Ref		Ref	
Outside NCR	670	30 (4.5)	1.55 (1.04-2.31)	0.032	1.53(1.00-2.35)	0.050
Vaccine status						
Vaccinated (≥ 1dose)	847	16 (1.9)	Ref		Ref	
Non-vaccinated	4,600	154 (3.3)	1.75 (1.05-2.93)	0.032	1.79(1.01-3.19)	0.047
Duration between fever onset and admission (days)						
0 – 3	4,757	136 (2.9)	Ref		Ref	
4 – 6	580	30 (5.2)	1.44 (1.01-2.05)	0.044	1.46(0.99-2.15)	0.058
7 – 14	112	11 (9.8)	2.45 (1.58-3.78)	<0.001	2.43(1.50-3.92)	<0.001
> 14	16	0 (0)	1.81 (0.35-9.53)	0.480	0.66(0.04-11.03)	0.772
				0.001		0.0003
No vitamin A supplementation						
	4,600	154 (3.3)	1.75 (1.05-2.93)	0.032	1.87(1.27-2.75)	0.002

OR=odds ratio. *Adjusted for age, vaccine, sex, location, duration of fever, vitamin A supplementation. Individual and overall (LRT) p-values are presented for categorical variables