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Original Research Article

Enablers of vitamin A coverage among children under five years of age from multi-country analyses of global demographic and health surveys in selected LMIC and LIC countries in Africa and Asia: a random forest analysis

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ABSTRACT

Background: Vitamin A deficiency is a common form of micronutrient malnutrition. The estimated relative risks associated with vitamin A deficiency in children were 1.86 (95% CI 1.32–2.59) for measles mortality, 2.15 (95% CI 1.83–2.58) for diarrhoea mortality, 1.78 (95% CI 1.43–2.19) for malaria mortality, 1.13 (95% CI 1.01–1.32) for other infectious disease mortality. Vitamin A supplementation reduces night blindness, child morbidity and mortality.
Methods: This paper tries to explore the socio-demographic causes of receipt of vitamin A in selected lower-middle-income and low income countries by analysing the data of the demographic and health surveys from 2012 and 2016 using PASW 18.0 software. Multivariate binary logistic regressions were conducted to explore the role of socio-demographic covariates in the receipt of vitamin A supplementation. In addition, random forest (RF) analyses were conducted using Python 3.6.
Results: After adjusting for related socio-economic and demographic factors, mother's work status and education and among mass media channels, exposure to television seems to play an important role in predicting receipt of vitamin A in the selected countries in Asia, while education of the mother was significantly associated with the receipt of vitamin A in the selected countries of Africa. In all the selected countries, the RF analyses revealed mother's education followed by wealth index and mass media (TV), as the variable of most importance.
Conclusions: It can be concluded that mother's education and mass media seems to be working well in making the mothers aware about the vitamin A campaign, especially, the exposure to television. It also figures in the variable importance matrix in addition to wealth index.

Keywords: Vitamin A supplementation, Vitamin A deficiency, Maternal education, Mass media, Wealth index, Demographic and health surveys

INTRODUCTION

Vitamin A deficiency (VAD) is a major public health problem in many developing countries. VAD causes xerophthalmia, a range of eye conditions from night blindness to more severe clinical outcomes such as keratomalacia and corneal scars, and permanent blindness. WHO recommends vitamin A supplementation (VAS) with a dose of 30 mg retinol equivalents in infants aged 6–11 months and 60 mg retinol equivalents at least twice a year in young children aged 12–59 months living in settings where VAD is a public health problem. A

meta-analysis of 17 trials (11 in Asia, 5 in Africa and 1 in Latin America) for all-cause mortality indicated that vitamin A reduces the overall risk of death by 24% (risk ratio (RR) 0.76; 95% confidence interval (CI) 0.69–0.83).[1,2] After considering an unpublished cluster-randomized trial involving one million children in north India (the DEVTA trial), VAS reduced the effect size of all-cause mortality from 24% to 12% (RR 0.88; 95% CI 0.84–0.94). Vitamin A programming is a prerequisite for achieving one of the sustainable development goals (SDG 3, target 3.2, indicator 3.2.1) of reducing under five mortality to at least as low as 25 per 1,000 live births by 2030. The global prevalence of VAD in children under age 5 has declined from about 39 per cent to about 30 per cent over the past two decades. However, progress has not been seen in South Asia and sub-Saharan Africa, where today, vitamin A deficiency still affects around 44 per cent and 48 per cent of children under age five years, respectively. More than 95 per cent of vitamin A-related measles and diarrhoea deaths occur in these regions – and VAS offers a powerful tool for preventing them.[3]

A literature review was undertaken to understand the determinants of VAS in other studies. Agarwal and Agarwal have shown that rural children and children of educated mothers were more likely to receive VAS than others.[4] Children born in a higher birth order (6+) and those residing in states with low levels of social and economic development were only about half as likely to receive VAS as their counterparts in a cross-sectional study of 20,802 children aged 12-35 months whose mothers participated in the third round of the National Family Health Survey (NFHS-3) conducted during 2005-2006, where the association between the socio-economic and demographic characteristics of the children, the social and economic development status of the State in which they reside and VAS status were examined by means of unadjusted and adjusted logistic regression models. Kimani-Murage et al, analyzed the data of Kenya Demographic and Health Survey 2008-09 and found a positive association between receiving VAS and stunting levels.[5] They also found a strong negative relationship between receiving vitamin A supplement and underweight status. They found that VAS may be beneficial to the growth of young children. They have also noted that the analysis was not able to establish a causal relationship, given the cross-sectional nature of the data and have thus recommended longitudinal studies to determine causal relationships. Semba et al, found that maternal education is an important factor relating to receipt of a vitamin A capsule in the BDHS 2004 data.[6] A higher level of formal education achieved by girls may be a key factor in breaking the intergenerational cycle of malnutrition and poverty. Since younger maternal age was also associated with the lower coverage, further efforts are, thus, required by the VAS programmes to reach young, uneducated primigravida mothers. Also, children of households of higher socioeconomic status were more likely to have received a vitamin A capsule. Thapa et al, have analysed the data of Nepal Demographic & Health Survey, 2001 and found that the beneficial effect of VAS on child mortality is larger than that found in most earlier clinical studies.[7] This larger effect may be due mainly to the other health related activities undertaken by the female community health volunteers who distribute vitamin A capsules.

VAS of 6-59 months old children living in areas where vitamin A deficiency is a problem can reduce their risk of dying by an average of 23%.[8] VAD was 1·5 more likely in children with anaemia than in children who did not have anaemia (95% CI 1·08–2·10; p=0·047).[9] The latest estimates (2016) tell us that 64 per cent of children in need in priority countries were reached with two doses of vitamin A – but more than 140 million children were left behind, leaving them vulnerable to disease and death. VAD affects almost half of children under 5 years in south Asia and sub-Saharan Africa.[10]

The effect of VAS on diarrhoea disease during infancy and, in particular, whether VAS would reduce rotavirus infection and morbidity, because rotavirus is one of the leading causes of life-threatening diarrhoea in infants in sub-Saharan Africa.[11] Three trials from southern Asia have reported that neonatal VAS reduced mortality by 21% in the first six months of life.[12] Globally, night blindness affects 5.2 million pre-school age children (95% CI: 2.0–8.4 million) and 9.8 million pregnant women (95% CI: 8.7–10.8 million), which corresponds to 0.9% and 7.8% of the population at risk of VAD respectively. According to current estimates, 122 countries are classified as having a moderate to severe public health problem based on biochemical VAD in preschool-age children; while 88 countries are classified as having a problem of moderate to severe public health significance with respect to biochemical VAD in pregnant women.[13] Further in 2013, VAD accounted for 2% of all deaths in children under 5 years of age in the sub-Saharan Africa region.[14] Most importantly, vitamin A supplements can improve a child's chance of survival by 12 to 24 per cent.[15]

Study objectives

The objectives of the study are to examine the association between different socio-demographic characteristics and receipt of vitamin A in selected LMIC and LIC countries in the Africa and Asia region.

METHODS

This paper uses data from Demographic and Health Surveys (DHSs) of ten countries; five countries each in Africa and Asia. The countries, for which the data has been analysed are Ethiopia (2016), Kenya (2014), Nigeria (2013), Senegal (2016) and Tanzania (2015-16) in Africa and Bangladesh (2014), India (2015-16), Indonesia (2012), Pakistan (2012-13) and Philippines (2013)in Asia. These surveys were carried out by ICF International, working in close conjunction with in-

country research institutes. We used the existing weighted data of children under five years of age for our analyses. Individual level datasets were analysed using PASW Statistics 18, Release 18.0 software.

Multivariate binary logistic regression

Multivariate Binary logistic regressions were conducted to explore factors associated with VAS. Logistic regression can be used to predict a dependent variable on the basis of independent variables and to determine the per cent of variance in the dependent variable explained by independent variables; to rank the relative importance of independents; to assess interaction effects; and to understand the impact of covariates. Logistic regression applies maximum likelihood estimation after transforming the dependent variable into a logit variable (the natural log of the odds of the dependent occurring or not). In this way, logistic regression estimates the probability of a certain event occurring. Note that logistic regression calculates changes in the log odds of the dependent, not changes in the dependent variable itself, as OLS regression does. In addition to bivariate analysis, multivariate analysis was performed to control for the effects of other factors. Binary logistic regression models were used to explore associations between the dependent variable and independent variables, adjusting for socio-demographic and economic covariates. The dependent variable was coded as 1 if the child had received vitamin A supplements in the last six months and 0 if the child had not received vitamin A supplements in the last six months. The age group has been taken as 9-59 months to give adequate exposure of 6 months to a child considering the fact that usually in some countries, vitamin A campaign rounds are held biannually every six months.

Random forest analyses (RF)

In addition, random forest analysis was used to identify feature (independent variables) importance and model accuracy for two extreme countries from Africa and Asia each. Random forest is a recently developed machine learning technique that deals with classification and clustering of data non-parametrically. It is an ensemble method that combines a number of trees by taking the same number of bootstrap samples from the original data, and growing a tree on each bootstrap sample. Tree implementations are very simple and user-friendly and require fewer techniques from the investigator. The individual trees in a random forest are not pruned and used for decision in classification or clustering. Random forest uses a randomly selected subset of predictors for splitting the root nodes in to new daughter nodes for each split. From all trees grown in this process based on the bootstrap samples, we generate a forest. From the complete forest, the response variable for an instance is predicted as an average or majority vote of the predictions of all trees. Random forest can highly increase the prediction accuracy compared to an individual tree, as the ensemble reduces the variance. The RF is one of the most effective machine learning models for predictive analytics.[16,17] The model feature importance from sklearn random forest was used to calculate feature importance. Random forest uses gini importance or mean decrease in impurity (MDI) to calculate the importance of each feature. Gini importance is also known as the total decrease in node impurity. This is how much the model fit or accuracy decreases when you drop a variable. The larger the decrease, the more significant the variable is. Here, the mean decrease is a significant parameter for variable selection. The Gini index can describe the overall explanatory power of the variables. For this RF analysis, Python 3.6 software was used.

Covariates considered in random forest and multivariate binary logistic regression model

Based on a literature review, the analysis of these survey data considered the following covariates in Figure 1.

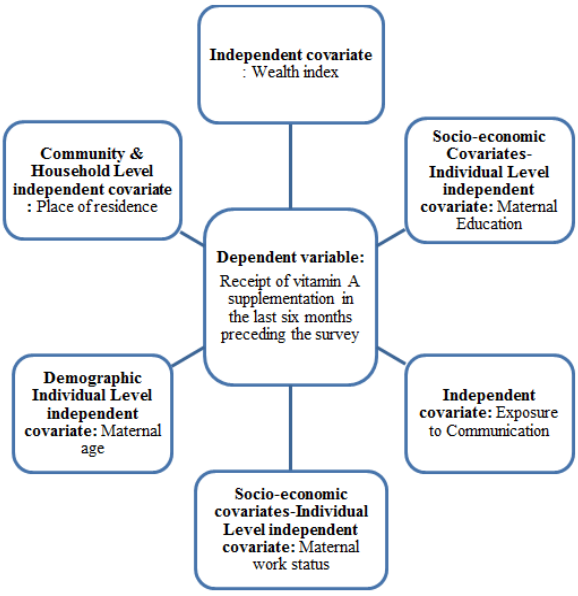

Figure 1: Conceptual framework.

Demographic and socio-economic profile of the countries

According to the World Bank classification of economies, seven of these countries belong to low-middle income countries (LMIC) (Bangladesh, Kenya, India, Indonesia, Nigeria, Pakistan and Philippines) and three belong to low income countries (LIC) (Ethiopia, Senegal and Tanzania). The population of these countries vary from about 16 million in Senegal to 1,339 million in case of India. The annual rate of population change varies from 1.2% in each in Bangladesh and India to 3.1% in Tanzania. The per cent of urban population varies from 19% in Ethiopia to 46% in Nigeria in Africa and it varies from 23% in Bangladesh to 54% in Indonesia in Asia. The under-five mortality rate varies from 51 in Senegal to

128 in Nigeria in Africa and 29 under-five deaths per thousand live births in Philippines to 87 under-five deaths per thousand live births in Pakistan in Asia.

Ethical approval

Procedures and questionnaires for standard DHS surveys have been reviewed and approved by ICF Institutional Review Board (IRB). Additionally, country-specific DHS survey protocols are reviewed by the ICF IRB and typically by an IRB in the host country. ICF IRB ensures that the survey complies with the U.S. Department of Health and Human Services regulations for the protection of human subjects (45 CFR 46), while the host country IRB ensures that the survey complies with laws and norms of the nation: https://dhsprogram.com/What-We-Do/Protecting-the-Privacy-of-DHS-Survey-Respondents.cfm.

Table 1: Socio-demographic profile of the selected countries in Africa and Asia.

Sl. No.	Indicators	Africa					Asia				
		Ethiopia	Kenya	Nigeria	Senegal	Tanzania	Bangladesh	India	Indonesia	Pakistan	Philippines
1	Population(in million), 1st July'2017 (Projected)	104.96	49.70	190.89	15.85	57.31	164.67	1,339.17	262.99	197.02	104.92
2	Annual rate of population change (2017) (%) (Estimated	2.6	2.7	2.7	3.0	3.1	1.2	1.2	1.3	2.1	1.6
3	Urban population (%)	19	25	46	43	30	23.3	31.2	54	32.5	44
4	Population density (persons per sq. km.)	100	83	199	78	61	1238	382	143	246	341
5	Total fertility rate(lifetime births per woman)	4.63	4.10	5.74	5.0	5.24	2.22	2.3	2.6	3.8	3.05
6	Crude birth rate (no. of live births per 1000 mid-year population)	33.6	33.1	40.5	37.6	39.8	20.2	20.8	20.4	29.8	24.1
7	Neonatal mortality rate (no. of neonatal deaths per 1000 live births) (SDG3, Target 3.2, Indicator 3.2.2)	28	22	34	21	19	23	26	14	46	13
8	Infant mortality rate (no. of infant deaths per 1000 live births)	41	36	51	34	40	34	43	22	64	22
9	Under-five mortality rate (no. of under-5 deaths per 1000 live births) (SDG 3, Target 3.2, Indicator 3.2.1)	58	49	91	47	57	28	35	26	79	27
10	Maternal mortality ratio (no. of maternal deaths per 100,000 live births) (SDG 3, Target 3.1, Indicator 3.1.1)	412	362	576	315	530	176	167	126	178	120
11	Status of Human Development Index (in rank), UNDP	172	146	152	162	151	139	131	113	147	116
12	GDP per capita (Current USD)	768	1,508	1,969	1,033	936	1,384	1,940	3,847	1,548	2,989
13	World Bank Classification	Low income	Lower middle income	Lower middle income	Low income	Low income	Lower middle income	Lower middle income	Lower middle income	Lower middle income	Lower middle income

Source: Demographic and Health Surveys 2007-16, United Nations[18], HDR 2016[19], UNICEF, 2018[20]

RESULTS

The comparative analyses of the ten countries reveal that children 9 to 59 months of age, who received vitamin A varies from 41.8% in Nigeria to 81.3% in Senegal in Africa. It varies from 58.8% in India to 77.0% in Philippines in Asia. The trends in vitamin A coverage in the several rounds of demographic and health surveys vary from an average annual rate of increase (AARI) of -7.4% in Tanzania from 2010 to 2015-16 to 18.8% in Kenya from 2008-09 to 2014 in Africa and -0.3% in Bangladesh from 2007 to 2014 to 14.2% in case of India during 2005-06 to 2015-16. Receipt of VAS does not vary much by sex of the child.

Results of the bivariate analyses

A bivariate analysis was conducted for the receipt of vitamin A with several covariates. The variables considered for analysis were various background level and individual level socio-demographic and socio-economic covariates. Results indicate that a significantly higher proportion of mothers of children residing in urban areas received vitamin A as compared to rural areas

across all countries similarly, receipt of vitamin A was also found to be higher among the literates, higher among those who had two or less two children, higher among the households belonging to the higher socio-economic status, higher among those who were exposed to mass media communication channels of newspaper, radio and television.

Table 2: Trends in per cent of children receiving vitamin A supplementation in the selected countries in Africa and Asia: DHS, 2007- 16.

Sl. No	Region	Country	DHS rounds	% of children age 6 to 59 months who received vitamin A supplements in the six months preceding the survey	Average annual rate of increase (AARI (%))
1	Africa	Ethiopia	2011	53.1	-3.4
			2016	44.7	
2		Kenya	2008-09	30.3	18.8
			2014	71.7	
3		Nigeria	2008	25.8	9.9
			2013	41.3	
4		Senegal	2010-11	78.4	-0.2
			2012-13	83.7	
			2014	88.6	
			2015	88.4	
			2016	77.5	
5		Tanzania	2010	60.8	-7.4
			2015-16	41.3	
6	Asia	Bangladesh	2007	83.5	-0.3
			2011	62.1	
			2014	60.9	
7		India	2005-06	15.6	14.2
			2015-16	59.1	
8		Indonesia	2007	68.5	-2.3
			2012	61.1	
9		Pakistan	2006-07	60.2	3.1
			2012-13	72.1	
10		Philippines	2008	75.9	1.9
			2013	85.2	

Sources: Demographic & Health Surveys, 2007-16.

Table 3: Per cent of children age 6 to 59 months who received VAS in the six months preceding the survey by sex in the selected countries in Africa and Asia: DHS, 2012- 16

Sl. No	Region	Country	DHS Rounds	Children (6 to 59 months)	Boys (6 to 59 months)	Girls (6 to 59 months)	Gender Parity Index in VAS coverage*
1	Africa	Ethiopia	2016	44.7	44.9	44.5	0.99
2		Kenya	2014	71.7	71.6	71.9	1.00
3		Nigeria	2013	41.3	41.5	41.1	0.99
4		Senegal	2016	77.5	77.4	77.6	1.00
5		Tanzania	2015-16	41.3	41.9	40.6	0.97
6	Asia	Bangladesh	2014	60.9	61.7	60.0	0.97
7		India	2015-16	59.1	59.1	59.1	1.00
8		Indonesia	2012	61.1	60.5	61.8	1.02
9		Pakistan	2012-13	72.1	72.1	72.1	1.00
10		Philippines	2013	85.2	84.1	86.4	1.03

Note: * Gender Parity Index in vitamin A supplementation = (% of Girls received supplements /% of Boys received supplements).
Sources: Demographic & Health Surveys, 2012-16

Table 4: Socio-demographic and economic characteristics of the mothers in the selected countries in Africa and Asia, DHS (2012-16) (%).

Socio-demographic and economic characteristics	Africa					Asia				
	Ethiopia	Kenya	Nigeria	Senegal	Tanzania	Bangladesh	India	Indonesia	Pakistan	Philippines
DHS rounds	2016	2014	2013	2016	2015-16	2014	2015-16	2012	2012-13	2013
N (Weighted cases)	8,392	15,262	23,314	4,694	7,481	6,635	201,758	16,948	3,420	6,982
Community level covariates										
Place of residence										
Rural	89.1	65.5	63.8	62.9	73.7	74.8	71.3	50.4	69.5	53.3
Urban	10.9	34.5	36.2	37.1	26.3	25.2	28.7	49.6	30.5	46.7
Individual level covariates										
Maternal education										
Non-literate	67.4	12.2	48.6	65.0	21.7	16.7	30.1	2.2	56.1	1.6
Literate	32.6	87.8	51.4	35.0	78.3	83.3	69.9	97.8	43.9	98.4
Demographic covariates										
Maternal age (years)										
15-24	19.4	26.5	22.4	21.1	26.9	46.3	32.0	21.8	22.2	26.4
25-34	54.4	52.7	50.7	50.8	45.9	45.6	58.9	52.6	56.0	47.5
35-49	26.2	20.8	26.9	28.1	27.2	8.2	9.0	25.6	21.8	26.1
Socio-economic covariates										
Maternal work status										
Not working currently	71.5	68.9	30.0	57.7	20.0	72.7	96.9	52.3	72.5	61.0
Working currently	28.5	31.1	70.0	42.3	80.0	27.3	3.1	47.7	27.5	39.0
Wealth index										
Poorest	23.9	24.1	23.0	25.1	24.3	23.0	24.9	22.0	23.1	27.4
Poorer	22.9	21.0	22.3	22.5	21.4	18.7	21.7	19.2	20.2	21.8
Middle	21.0	18.1	19.0	19.4	19.6	19.1	19.8	19.5	17.8	20.0
Richer	18.0	17.2	18.0	17.9	18.4	20.2	18.5	20.3	22.5	17.4
Richest	14.2	19.5	17.7	15.2	16.3	19.0	15.1	19.0	16.3	13.3
Communication exposure – Mass media										
Newspaper										
Never read Newspaper	93.6	71.4	85.9	88.6	64.5	85.7	67.3	52.4	76.4	40.5
Read Newspaper	6.4	28.6	14.1	11.4	35.5	14.3	32.7	47.6	23.6	59.5
Radio										
Never listened to Radio	74.0	21.9	39.4	16.3	25.9	95.3	86.7	49.0	84.0	20.6
Listened to Radio	26.0	78.1	60.6	83.7	74.1	4.7	13.3	51.0	16.0	79.4
Television										
Never watched TV	82.5	57.7	53.6	31.0	58.7	41.9	30.6	4.9	36.9	10.1
Watched TV	17.5	42.3	46.4	69.0	41.3	58.1	69.4	95.1	63.1	89.9

Continued.

Socio-demographic and economic characteristics	Africa					Asia				
	Ethiopia	Kenya	Nigeria	Senegal	Tanzania	Bangladesh	India	Indonesia	Pakistan	Philippines
Vitamin A receipt among 9-59 months of children (weighted)										
Did not receive Vitamin A in the last six months	55.2	28.1	58.2	18.7	57.9	36.4	41.2	36.6	26.0	23.0
Received Vitamin A in the last six months	44.8	71.9	41.8	81.3	42.1	63.6	58.8	63.4	74.0	77.0

Table 5: Receipt of vitamin A in the last six months by socio-demographic and economic characteristics in selected countries in Africa, DHS.

Socio-demographic and economic characteristics	Ethiopia, 2015-16			Kenya, 2014			Nigeria, 2013			Senegal, 2016			Tanzania, 2015-16		
	Vitamin A non-receivers (%)	Vitamin A receivers (%)	Prob.	Vitamin A non-receivers (%)	Vitamin A receivers (%)	Prob.	Vitamin A non-receivers (%)	Vitamin A receivers (%)	Prob.	Vitamin A non-receivers (%)	Vitamin A receivers (%)	Prob.	Vitamin A non-receivers (%)	Vitamin A receivers (%)	Prob.
N (weighted cases)	4,631	3,761		4,288	10,974		13,565	9749		878	3,816		4,328	3,152	
Community level covariates															
Place of residence															
Rural	57.0	43.0		30.0	70.0		64.9	35.1		20.0	80.0		59.7	40.3	
Urban	40.4	59.6	0.000	24.5	75.5	0.000	46.3	53.7	0.000	16.6	83.4	0.004	52.8	47.2	0.000
Individual level covariates															
Maternal education															
Non-literate	58.6	41.4		40.3	59.7		74.7	25.3		20.3	79.7		71.2	28.8	
Literate	48.1	51.9	0.000	26.4	73.6	0.000	42.6	57.4	0.000	15.7	84.3	0.000	54.2	45.8	0.000
Demographic covariates															
Maternal age(years)															
15-24	57.4	42.6		28.6	71.4		64.8	35.2		24.3	75.7		59.1	40.9	
25-34	54.4	45.6		27.8	72.2		56.1	43.9		20.0	80.0		57.5	42.5	
35-49	55.3	44.7	0.115	28.2	71.8	0.696	56.5	43.5	0.000	12.3	87.7	0.000	57.2	42.8	0.398
Socio-economic covariates															
Maternal work status															
Not working currently	57.6	42.4		29.3	70.7		66.2	33.8		21.0	79.0		57.2	42.8	
Working currently	49.0	51.0	0.000	25.4	74.6	0.000	54.7	45.3	0.000	15.6	84.4	0.000	58.0	42.0	0.554
Wealth index															
Poorest	59.5	40.5		35.7	64.3		78.7	21.3		25.1	74.9		69.9	30.1	
Poorer	58.5	41.5		28.3	71.7		68.8	31.2		19.4	80.6		60.2	39.8	
Middle	56.8	43.2		27.2	72.8		56.1	43.9		16.2	83.8		54.2	45.8	
Richer	54.4	45.6		23.9	76.1		46.2	53.8		15.3	84.7		50.5	49.5	
Richest	41.2	58.8	0.000	22.9	77.1	0.000	32.5	67.5	0.000	14.3	85.7	0.000	49.6	50.4	0.000

Continued.

Socio-demographic and economic characteristics	Ethiopia, 2015-16			Kenya, 2014			Nigeria, 2013			Senegal, 2016			Tanzania, 2015-16		
	Vitamin A non-receivers (%)	Vitamin A receivers (%)	Prob.	Vitamin A non-receivers (%)	Vitamin A receivers (%)	Prob.	Vitamin A non-receivers (%)	Vitamin A receivers (%)	Prob.	Vitamin A non-receivers (%)	Vitamin A receivers (%)	Prob.	Vitamin A non-receivers (%)	Vitamin A receivers (%)	Prob.
Communication exposure- Mass media															
Newspaper															
Never read Newspaper	56.3	43.7		29.8	70.2		62.2	37.8		19.2	80.8		63.0	37.0	
Read Newspaper	38.8	61.2	0.000	23.7	76.3	0.000	33.5	66.5	0.000	14.6	85.4	0.009	48.6	51.4	0.000
Radio															
Never listened to Radio	58.2	41.8		33.4	66.6		70.7	29.3		23.3	76.7		64.8	35.2	
Listened to Radio	46.5	53.5	0.000	26.6	73.4	0.000	50.0	50.0	0.000	17.8	82.2	0.000	55.5	44.5	0.000
Television															
Never watched TV	57.0	43.0		31.2	68.8		70.3	29.7		24.9	75.1		61.5	38.5	
Watched TV	46.7	53.3	0.000	23.9	76.1	0.000	44.1	55.9	0.000	16.0	84.0	0.000	52.7	47.3	0.000

Prob.: Probability value.

Table 6: Receipt of Vitamin A in the last six months by socio-demographic-economic variables in the countries in Asia, DHS

Socio-demographic and economic characteristics	Bangladesh, 2014			India, 2015-16			Indonesia, 2012			Pakistan, 2012-13			Philippines, 2013		
	Vitamin A Non-receivers (%)	Vitamin A receivers (%)	Prob.	Vitamin A Non-receivers (%)	Vitamin A receivers (%)	Prob.	Vitamin A Non-receivers (%)	Vitamin A receivers (%)	Prob.	Vitamin A Non-receivers (%)	Vitamin A receivers (%)	Prob.	Vitamin A Non-receivers (%)	Vitamin A receivers (%)	Prob.
N	2,417	4,218		83,024	118,733		6,199	10,749		889	2,531		1,604	5,378	
Community level covariates															
Place of residence															
Rural	37.5	62.5		42.3	57.7		39.1	60.9		23.4	76.4		22.8	77.2	
Urban	33.4	66.6	0.003	38.4	61.6	0.000	34.0	66.0	0.000	31.9	68.1	0.000	23.1	76.9	0.783
Individual level covariates															
Maternal education															
Non-literate	41.4	58.6		49.9	50.1		73.7	26.3		27.0	73.0		34.8	65.2	
Literate	35.4	64.6	0.000	37.4	62.6	0.000	35.8	64.2	0.000	24.7	75.3	0.120	22.8	77.2	0.003
Demographic covariates															
Maternal age (years)															
15-24	37.2	62.8		39.6	60.4		40.8	59.2		24.7	75.3		28.6	71.4	
25-34	35.5	64.5		41.1	58.9		36.5	63.5		26.4	73.6		22.0	78.0	
35-49	37.3	62.7	0.357	47.4	52.6	0.000	33.2	66.8	0.000	26.0	74.0	0.664	19.2	80.8	0.000

Continued.

Socio-demographic and economic characteristics	Bangladesh, 2014			India, 2015-16			Indonesia, 2012			Pakistan, 2012-13			Philippines, 2013		
	Vitamin A Non-receivers (%)	Vitamin A receivers (%)	Prob.	Vitamin A Non-receivers (%)	Vitamin A receivers (%)	Prob.	Vitamin A Non-receivers (%)	Vitamin A receivers (%)	Prob.	Vitamin A Non-receivers (%)	Vitamin A receivers (%)	Prob.	Vitamin A Non-receivers (%)	Vitamin A receivers (%)	Prob.
Socio-economic covariates															
Maternal work status															
Not working currently	35.8	64.2		41.2	58.8		37.6	62.4		25.7	74.3		25.5	74.5	
Working currently	38.0	62.0	0.093	40.7	59.3	0.512	35.5	64.5	0.006	26.7	73.3	0.572	19.0	81.0	0.000
Wealth index															
Poorest	42.6	57.4		48.0	52.0		46.1	53.9		31.6	68.4		27.8	72.2	
Poorer	36.6	63.4		43.0	57.0		38.2	61.8		18.8	81.2		20.5	79.5	
Middle	35.8	64.2		39.3	60.7		34.2	65.8		27.9	72.1		21.2	78.8	
Richer	36.7	63.3		35.6	64.4		31.6	68.4		23.2	76.8		20.2	79.8	
Richest	29.3	70.7	0.000	36.4	63.6	0.000	31.6	68.4	0.000	28.5	71.5	0.000	23.4	76.6	0.000
Communication exposure- Mass media															
Newspaper															
Never read Newspaper	38.1	61.9		44.7	55.3		38.6	61.4		26.5	73.5		25.0	75.0	
Read Newspaper	26.3	73.7	0.000	33.8	66.2	0.000	34.3	65.7	0.000	24.5	75.5	0.269	21.6	78.4	0.001
Radio															
Never listened to Radio	36.7	63.3		42.1	57.9		38.6	61.4		26.1	73.9		27.6	72.4	
Listened to Radio	31.0	69.0	0.041	35.1	64.9	0.000	34.6	65.4	0.000	25.5	74.5	0.755	21.8	78.2	0.000
Television															
Never watched TV	41.2	58.8		49.4	50.6		56.3	43.7		27.7	72.3		33.9	66.1	
Watched TV	33.0	67.0	0.000	37.5	62.5	0.000	35.6	64.4	0.000	25.0	75.0	0.086	21.7	78.3	0.000

Prob.: Probability value

Table 7: Adjusted odds ratio from the multivariate binary logistic regression of factors associated with receipt of vitamin A in the last six months in the selected countries in Africa. (Dependent variable: Receipt of Vitamin A).

Predictors used in the model	Africa									
	Ethiopia, 2015-16		Kenya, 2014		Nigeria, 2013		Senegal, 2016		Tanzania, 2015-16	
	Adjusted Odds ratio (95% CI)	Prob.	Adjusted Odds ratio (95% CI)	Prob.	Adjusted Odds ratio (95% CI)	Prob.	Adjusted Odds ratio (95% CI)	Prob.	Adjusted Odds ratio (95% CI)	Prob.
N (Weighted cases)	8,392		15,262		23,314		4,694		7,480	
N (Unweighted cases)	8,053		16,480		22,923		5,176		7,644	
Community level covariates										
Place of residence										
Rural [Ref]										
Urban	1.221 (0.995-1.498)	0.056	1.056 (0.957-1.165)	0.278	0.782 (0.725-0.842)	0.000	0.717 (0.575-0.894)	0.003	0.864 (0.743-1.006)	0.059
Individual level covariates										
Maternal education										
Non-literate [Ref]										
Literate	1.311 (1.176-1.461)	0.000	1.461 (1.295-1.647)	0.000	2.120 (1.974-2.277)	0.000	1.220 (1.005-1.481)	0.044	1.567 (1.373-1.788)	0.000
Demographic covariates										
Maternal age (years)										
15-24 [Ref]										
25-34	1.163 (1.031-1.311)	0.014	1.020 (0.936-1.111)	0.651	1.158 (1.076-1.247)	0.000	1.235 (1.031-1.480)	0.022	1.081 (0.963-1.214)	0.185
35-49	1.210 (1.055-1.388)	0.007	1.064 (0.957-1.182)	0.251	1.249 (1.150-1.357)	0.000	2.186 (1.742-2.743)	0.000	1.201 (1.055-1.369)	0.006
Socio-economic covariates										
Maternal work status										
Not working currently [Ref]										
Working currently	1.261 1.143-1.391)	0.000	1.147 (1.059-1.242)	0.001	1.206 (1.130-1.286)	0.000	1.276 (1.090-1.493)	0.002	0.971 (0.861-1.095)	0.631
Wealth Index										
Poorest [Ref]										
Poorer	0.992 (0.873-1.128)	0.908	1.177 (1.052-1.317)	0.004	1.370 (1.251-1.501)	0.000	1.264 (1.021-1.565)	0.031	1.459 (1.262-1.685)	0.000
Middle	1.024 (0.897-1.168)	0.728	1.208 (1.071-1.363)	0.002	1.935 (1.751-2.138)	0.000	1.531 (1.097-1.922)	0.009	1.749 (1.508-2.028)	0.000
Richer	1.019 (0.884-1.174)	0.798	1.356 (1.183-1.555)	0.000	2.447 (2.176-2.751)	0.000	1.595 (1.156-2.198)	0.004	1.975 (1.672-2.332)	0.000
Richest	1.401 (1.143-1.717)	0.001	1.318 (1.120-1.551)	0.001	3.721 (3.253-4.257)	0.000	1.699 (1.188-2.430)	0.004	1.981 (1.597-2.458)	0.000

Continued.

Predictors used in the model	Africa									
	Ethiopia, 2015-16		Kenya, 2014		Nigeria, 2013		Senegal, 2016		Tanzania, 2015-16	
	Adjusted Odds ratio (95% CI)	Prob.	Adjusted Odds ratio (95% CI)	Prob.	Adjusted Odds ratio (95% CI)	Prob.	Adjusted Odds ratio (95% CI)	Prob.	Adjusted Odds ratio (95% CI)	Prob.
Communication Exposure-Mass Media										
Newspaper										
Never read Newspaper [Ref]										
Read Newspaper	1.174 (0.955-1.445)	0.128	1.117 (1.023-1.220)	0.014	1.286 (1.176-1.406)	0.000	0.981 (0.730-1.317)	0.897	1.422 (1.275-1.586)	0.000
Radio										
Never listened to Radio [Ref]										
Listened to Radio	1.379 (1.228-1.548)	0.000	1.018 (0.925-1.121)	0.716	1.346 (1.258-1.440)	0.000	1.166 (0.958-1.419)	0.125	1.085 (0.963-1.222)	0.179
Television										
Never watched TV [Ref]										
Watched TV	0.847 (0.729-0.984)	0.030	1.129 (1.022-1.246)	0.017	1.024 (0.945-1.110)	0.558	1.386 (1.119-1.716)	0.003	1.004 (0.893-1.128)	0.948

CI: Confidence Interval, [ref] Refers to Reference Category. Prob.: Probability value

Table 8: Adjusted odds ratio from the multivariate binary logistic regression of factors associated with receipt of vitamin A in the last six months in the selected countries in Asia. (Dependent variable: Receipt of Vitamin A).

Predictors used in the model	Asia									
	Bangladesh, 2014		India, 2015-16		Indonesia, 2012		Pakistan, 2012-13		Philippines, 2013	
	Adjusted Odds Ratio (95% CI)	Prob.	Adjusted Odds Ratio (95% CI)	Prob.	Adjusted Odds Ratio (95% CI)	Prob.	Adjusted Odds Ratio (95% CI)	Prob.	Adjusted Odds Ratio (95% CI)	Prob.
N (weighted cases)	6,634		201,757		16,948		3,420		6,982	
N (unweighted cases)	6,462		208,785		18,021		3,372		7,216	
Community level covariates										
place of residence										
Rural [Ref]										
Urban	0.987 (0.862-1.129)	0.845	0.953 (0.931-0.976)	0.000	0.981 (0.912-1.055)	0.606	0.485 (0.391-0.601)	0.000	0.849 (0.747-0.964)	0.011
Individual level covariates										
Maternal education										
Non-literate [Ref]										
Literate	1.097 (0.949-1.267)	0.211	1.310 (1.279-1.341)	0.000	3.659 (2.864-4.675)	0.000	1.084 (0.865-1.359)	0.484	1.289 (0.851-1.952)	0.230

Continued.

Predictors used in the model	Asia									
	Bangladesh, 2014		India, 2015-16		Indonesia, 2012		Pakistan, 2012-13		Philippines, 2013	
	Adjusted Odds Ratio (95% CI)	Prob.	Adjusted Odds Ratio (95% CI)	Prob.	Adjusted Odds Ratio (95% CI)	Prob.	Adjusted Odds Ratio (95% CI)	Prob.	Adjusted Odds Ratio (95% CI)	Prob.
Demographic covariates										
Maternal age (years)										
15-24 [Ref]										
25-34	1.100 (0.987-1.225)	0.084	0.969 (0.949-0.988)	0.002	1.135 (1.047-1.231)	0.002	0.937 (0.769-1.142)	0.517	1.404 (1.230-1.604)	0.000
35-49	1.090 (0.894-1.329)	0.395	0.859 (0.830-0.889)	0.000	1.354 (1.233-1.487)	0.000	0.963 (0.759-1.222)	0.756	1.703 (1.452-1.998)	0.000
Socio-economic covariates										
Maternal work status										
Not working currently [Ref]										
Working currently	0.924 (0.825-1.036)	0.176	1.048 (0.995-1.105)	0.077	1.092 (1.024-1.165)	0.008	1.024 (0.854-1.228)	0.796	1.337 (1.183-1.512)	0.000
Wealth index										
Poorest [Ref]										
Poorer	1.212 (1.036-1.417)	0.016	1.007 (0.979-1.035)	0.634	1.234 (1.116-1.364)	0.000	2.048 (1.590-2.638)	0.000	1.395 (1.174-1.657)	0.000
Middle	1.127 (0.954-1.332)	0.160	1.030 (0.998-1.062)	0.065	1.445 (1.302-1.604)	0.000	1.290 (0.990-1.683)	0.060	1.328 (1.106-1.595)	0.002
Richer	1.025 (0.859-1.222)	0.788	1.113 (1.074-1.152)	0.000	1.590 (1.425-1.773)	0.000	1.939 (1.437-2.617)	0.000	1.385 (1.135-1.691)	0.001
Richest	1.268 (1.033-1.557)	0.066	1.002 (0.963-1.042)	0.938	1.546 (1.375-1.737)	0.000	1.788 (1.238-2.583)	0.002	1.050 (0.849-1.298)	0.655
Communication exposure- Mass media										
Newspaper										
Never read Newspaper [Ref]										
Read Newspaper	1.453 (1.230-1.717)	0.000	1.251 (1.222-1.281)	0.00	0.972 (0.904-1.044)	0.046	1.049 (0.828-1.328)	0.692	1.034 (0.909-1.176)	0.613
Radio										
Never listened to Radio [Ref]										
Listened to Radio	1.146 (0.893-1.471)	0.284	1.171 (1.140-1.204)	0.000	1.072 (1.001-1.148)	0.046	0.959 (0.771-1.192)	0.704	1.189 (1.026-1.377)	0.021
Television										
Never watched TV [Ref]										
Watched TV	1.280 (1.126-1.454)	0.000	1.305 (1.274-1.337)	0.000	1.533 (1.311-1.791)	0.000	1.157 (0.955-1.402)	0.135	1.528 (1.252-1.866)	0.000

CI: Confidence Interval, [ref] Refers to Reference Category. Prob.: Probability value

	Africa					Asia				
Variable	Ethiopia	Kenya	Nigeria*	Senegal**	Tanzania	Bangladesh	India*	Indonesia	Pakistan	Philippines**
Maternal age	10	10	5	15	12	12	7	12	9	15
Place of residence	11	14	4	10	12	13	6	10	21	10
Maternal education	12	19	29	13	14	10	30	20	10	6
Exposure to new spaper	9	9	7	10	11	11	18	8	9	9
Exposure to radio	11	10	9	13	10	14	6	8	10	10
Exposure to television	18	16	17	14	10	13	12	16	11	18
Wealth index	15	11	23	13	21	12	12	14	19	14
Maternal w ork status	14	11	7	12	10	15	8	13	11	17
Total	100	100	100	100	100	100	100	100	100	100
Training Accuracy	*59*	*68*	*67*	*73*	*63*	*61*	*84*	*63*	*62*	*80*
Test Accuracy	*56*	*66*	*66*	*74*	*64*	*59*	*84*	*62*	*60*	*80*
Coverage of vitamin A supplementation	45	72	42	81	42	64	59	63	74	77

Figure 2: Random forest (RF) analyses using Python of assessment of variable importance in the selected ten countries in Africa and Asia (%).

Note: *Low Coverage Country; ** High Coverage Country.

Countries	DHS round	% of children age 6 to 59 months who received vitamin A supplements in the six months preceding the survey	Countries	DHS round	% of children age 6 to 59 months who received vitamin A supplements in the six months preceding the survey
Afghanistan	2015 DHS	47.5	Myanmar	2015-16 DHS	54.4
Angola	2015-16 DHS	6.0	Namibia	2013 DHS	83.6
Bangladesh	2014 DHS	60.9	Nepal	2016 DHS	82.5
Benin	2011-12 DHS	48.6	Niger	2012 DHS	59.6
Burundi	2016-17 DHS	68.7	Nigeria	2013 DHS	41.3
Cambodia	2014 DHS	69.6	Pakistan	2012-13 DHS	72.1
Chad	2014-15 DHS	44.1	Peru	2012 DHS	4.5
Comoros	2012 DHS	48.5	Philippines	2013 DHS	85.2
Congo Democratic Republic	2013-14 DHS	70.4	Rwanda	2014-15 DHS	86.4
Cote d'Ivoire	2011-12 DHS	60.8	Senegal	2016 DHS	77.5
Dominican Republic	2013 DHS	34.2	Sierra Leone	2013 DHS	83.2
Egypt	2014 DHS	16.7	Tajikistan	2012 DHS	76.5
Ethiopia	2016 DHS	44.7	Tanzania	2015-16 DHS	41.3
Gabon	2012 DHS	53.8	Timor-Leste	2016 DHS	64.5
Gambia	2013 DHS	68.7	Togo	2013-14 DHS	81.7
Ghana	2014 DHS	65.2	Uganda	2016 DHS	61.6
Guatemala	2014-15 DHS	49.7	Yemen	2013 DHS	55.2
Guinea	2012 DHS	40.8	Zambia	2013-14 DHS	76.5
Haiti	2012 DHS	44.4	Zimbabwe	2015 DHS	67.4
India	2015-16 DHS	59.1			
Indonesia	2012 DHS	61.1			
Jordan	2012 DHS	11.0			
Kenya	2014 DHS	71.7			
Kyrgyz Republic	2012 DHS	43.8			
Lesotho	2014 DHS	61.3			
Liberia	2013 DHS	60.2			
Malawi	2015-16 DHS	64.2			
Mali	2012-13 DHS	60.8			

Figure 3: Per cent of children 6 to 59 months who received vitamin A supplements in the six months preceding the survey in selected countries around the world in recent DHS surveys.

Source: Stat compiler, ICF, 2015.

Results of the multivariate binary logistic regression analyses

Predictors used in the model: Background community level and individual level socio-demographic and economic covariates, which are expected to be associated with vitamin A receipt have been entered in the model. The predictors used in the model are the place of residence, age of the woman, education of the mother, current work status of the mother, possession of household assets used in the construction of wealth quintile and exposure to mass media.

Education and working status of mothers was found to play a significant role; as a significant proportion of working mothers reported that the child received vitamin A as compared to non-working mothers and educated mothers reported that the child had received vitamin A compared to non-literate mothers. Examining the exposure to different mediums of communication, it was found that a significant proportion of mothers who watched television were more likely to have received vitamin A with the adjusted odds ratio ranging from 1.157 times to 1.528 times in the five countries in Asia. Mother's education was found to be significantly associated with the receipt of vitamin A in all the five countries in Africa with adjusted odds ratio ranging from 1.220 times to 1.567 times.

Results of the random forest analyses

Predictors used in the model: The same list of background community level and individual level socio-demographic and economic covariates used what has been used for multivariate binary logistic regression. Analysis was carried out for all the ten countries including the lowest and highest vitamin A coverage countries; India and Philippines from Asia; and Nigeria and Senegal from Africa. Mother's education was found to be one of the most important variable followed by wealth index and exposure to television, which was strongly associated with the receipt of vitamin A. It was found to have higher importance (>25%) in model score compared to other factors.

Levels and trends in vitamin A around the world in DHS countries: Among the 47 DHS countries, the most recent rounds of DHS surveys reveal that the vitamin A coverage varies from as low as 4.5% in Peru in the 2012 DHS to as high as 86.4% in Rwanda in the 2014-15 DHS round.

DISCUSSION

VAS has been around for many years in different countries of the world. Education and working status of mothers was found to play a significant role; as a significant proportion of working mothers reported that the child received vitamin A as compared to non-working mothers and educated mothers reported that the child had received vitamin compared to non-literate mothers. Current paper is an effort to assess or find out the factors that may affect the uptake of vitamin A among children under five years of age across countries and regions of Asia and Africa. In addition to bivariate, multivariate analysis by considering the receipt of vitamin A in last six months as the dependent variable and different socio-economic and demographic covariates as predictors revealed that place of residence of mothers is significantly associated the receipt of vitamin A among the children across the regions and countries, except Philippines, where place of residence did not play any significant role and receipt of vitamin A was almost equal among rural and urban children. Covariates like mothers' education, economic status of the mothers as well as exposure to mass media i.e. Television has significantly influenced the receipt of vitamin A across regions. This indicates that children of literate mothers, belonging to better off section of the society and having access to medium of communication like TV were having higher probability of receiving vitamin A. Work status of mother was found to have more of its impact on vitamin A coverage in African countries indicating that children of working mothers had a higher probability of vitamin A receipt. In few countries of both the regions it was found that probability of receiving the vitamin A by children increased with age of the mother. Results from the multivariate binary logistic regression depicts that education of mother and exposure to Television were the most significant factors affecting uptake of vitamin A, which corroborates the findings of Semba et al, who found that maternal education is an important factor relating to receipt of a vitamin A capsule in the BDHS 2004 data and that children belonging to households with higher socioeconomic status were more likely to have received a vitamin A capsule.[6] Proximity of the mothers to the health facility, proper positioning of the VAS in the country health programs, frequent supplementation rounds as well as sweeping strategies post round also plays key role in enhancing the coverage. For assessing these factors there is a need to look upon country specific vitamin A programs and their strategies to bring in the more vulnerable sections of the population in geographical and social terms.

CONCLUSION

Earlier clinical trials have already established the fact that VAS can substantially reduce the mortality from all causes among the children. Review of available literature and results from analysis of the current study shows that for a mother residing in an urbanized area, having formal education, exposure to medium of communication (TV) positively affect the uptake of vitamin A for their child. This section of the society is already getting benefitted by the program, thus, in addition to the current program strategies, there is need to mould the program components and strategies in a way that they also focus

young mothers, not formally educated or illiterate mothers and mothers residing in rural areas. This can be achieved by training community health workers extensively to counsel about the benefits of vitamin A, conducting more localized and intensified behaviour change communication activities and most importantly by doing frequent supplementation rounds with extensive sweeping plans. Lessons from other health programs i.e. polio eradication can be considered as the best practice where extensive planning is done and an effort is made to not leave even a single child. Exposure to mass media seems to be a good predictor of VAS in the countries of Asia and mother's education seems to be a good predictor in the countries of Africa. The need of the hour to is to use more and more mass media to communicate messages regarding the bi-annual vitamin A campaign in the countries of Asia and stress on mothers' education in the countries of Africa.

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