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Some recent studies in India and elsewhere have suggested a positive correlation between open defecation and child stunting. Improving children's health is one of the primary motivations behind India's *Swachh Bharat* Mission under which the government is trying to eliminate open defecation by investing heavily in the construction of toilets. Through analysis of secondary data, this Highlight shows that female literacy has a more significant correlation with child stunting than open defecation does and calls for appropriate policy focus on educating women, especially on health, nutrition and hygiene.

IWMI-TATA
Water Policy Program

Water Policy Research
HIGHLIGHT

Sanitation, Female Literacy and Child Stunting

Lessons for *Swachh Bharat* Mission

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Sanitation, Female Literacy and Child Stunting*†
Lessons for *Swachh Bharat* Mission

Research highlight based on Wilhelm (2017).

1. Introduction

Prime Minister Narendra Modi launched the *Swachh Bharat Abhiyan* (Clean India Mission) (SBM) on 2nd October, 2014. The mission's activities include building toilets in private, community and public spaces, as well as solid and liquid waste management. Furthermore, the campaign tries to achieve a change in hygiene practices through information, education, communication (IEC) activities and public awareness programs (GoI 2014). Besides cleaning the streets and door-to-door trash collection, one of the major goals of SBM is to end open defecation (OD) in India by 2019. According to Census 2011, 49.8 per cent of the total households defecate in the open, majority of which live in rural areas. Human excrement acts as a host for various pathogens and can cause several diseases including cholera, typhoid, hepatitis and polio (WHO 2001). Several reports have shown a positive association between open defecation and poor health of children. In this Highlight, stunting among children under the age of five is used as an indicator of their overall health.

A 2008 paper by Jean Humphrey argues that lack of access to toilets, bad hygiene practices and unclean drinking water lead to child stunting. Stunting by definition is low height vis-à-vis age (WHO 2017). WHO published a growth reference curve to measure children's growth which is used as a standard to define stunting. Humphrey concludes that an illness called environmental enteropathy is the reason for stunting. In an unsafe and unhygienic environment, children ingest large quantities of faecal bacteria, leading to intestinal infections. Even with enough food, the body cannot digest it well. Further, a rise in calorie intake has a small effect on growth in children. As intervention strategies, safe disposal of stool, proper hand washing and improvement in safe drinking water as well as infant diet are recommended (Humphrey 2008). Fighting repetitive diseases which result in excessive energy expenditure and worm or parasite infections that reduce ability to digest food leading to malnutrition are other possible explanations of stunting (Hammer and Spears 2016).

Based on this groundwork, the Research Institute for Compassionate Economics (r.i.c.e.) analysed the correlation between open defection and child stunting in India in 112 districts using data from WHO's HUNGaMA report (Naandi Foundation 2011). Their analysis covered 100 poorly performing districts with high stunting and open defecation rates and 12 well performing ones with low stunting and OD rates. The difference in OD-intensity can explain 35 to 55 per cent of the gap in stunting. Their findings also suggest that districts with more OD have more stunting (R^2 = 34.8 per cent) and districts with higher rates of female literacy tend to have less OD (R^2 = 48.5 per cent) (Spears *et al*. 2013).

To take this investigation one step further, we use data from 640 Indian districts. Besides open defecation, our analysis includes parameters on female literacy, drinking water quality, nutrition and maternal health. Shifting the focus from the current policy of building toilets to improve children's health, we introduce a different approach to reduce stunting: investment in female literacy and awareness.

2. Methodology

For the analysis, publicly accessible data sets on selected parameters were used. Data on open defecation, drinking water sources and literacy was a part of Census 2011. These parameters were collected from April to September 2010. The census covered 640 districts with 5,767 tehsils, 7,933 towns and over 6 lakh villages (GoI 2011). Percentage of children stunted below the age of five as well as data on women's health, literacy and diet of children was sourced from the National Family Household Survey 2015-16 (NFHS-4 2016). This data was collected in different time frames for different states in 2015 and 2016. Census 2011 provided data on the number of households practicing open defecation; this number was used to calculate percentage of total households following this practice. The NFHS-4 data is already given in percentage.

A regression analysis was performed using the software RStudio. For analysis of every single parameter, a simple equation was used:

$$y = a \cdot x + c$$

where y denotes the percentage of children under the age of five being stunted; x denotes different parameters; a is the standard coefficient of each parameter; and c is a constant.

For every equation, the coefficient of determination (R^2) was recorded. For multiple parameter regression, the equation above was extended with the number of parameter (x_1, x_2, ...) added as presented below.

$$y = a \cdot x_{\_1} + b \cdot x_{\_2} + \cdots + z$$

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where y denotes percentage of children under the age of five being stunted; x_1, x_2, … denote different parameters; a, b, … are standard coefficients of each parameter; and z is a constant.

3. Results

Table 1 shows the single parameter analysis of different variables studied in association with stunted growth. Besides open defecation (OD) and improvement of sanitary facilities, education of women and their health appear to have a high correlation with growth of children.

For ease of comparison, the two most relevant parameters have been listed separately in Table 2 along with a simple regression between OD and female literacy. The analysis on percentage of households that practice OD and number of children under five years being stunted suggests that a 1 per cent reduction in OD will reduce child stunting by 0.2 per cent. On the other hand, a 1 per cent improvement in female literacy can reduce child stunting by 0.5 per cent and having 1 per cent less underweight women can reduce stunting by 0.7 per cent. Table 2 also suggests that improving female literacy by 1 per cent will reduce OD incidence by 1.4 per cent.

Table 3 shows the result of multiple linear regression of child stunting against parameters discussed in literature on nutrition, sanitation, female literacy and health. It is evident that among these variables, OD has the smallest impact on stunting. Female literacy affects stunting nearly five times more than OD. Besides diarrhoea, all other parameters are significant. Reducing OD by 1 per cent will reduce the percentage of stunted children by 0.04 per cent while increasing female literacy by 1 per cent can reduce stunting by 0.19 per cent. Additionally, reducing the percentage of underweight women by 1 per cent can reduce stunting by 0.31 per cent.

Table 4 only looks at the 112 districts analysed in the r.i.c.e study. Here too, OD has the smallest effect on child stunting and is not significant, with female literacy has a significant and higher correlation. Increasing female literacy by 1 per cent can reduce stunting by 0.14 per cent. Additionally, a 1 per cent improvement in women receiving extensive antenatal care can reduce stunting by 0.27 per cent, while reducing the percentage of children having diarrhoea can reduce the percentage of stunted children by half. This data only corresponds to 100 poorly performing districts (with high stunting and OD incidence) and 12 well performing ones (with low stunting and OD incidence) and does not apply to all districts of the country.

Table 5 categorizes districts into four quartiles with the first quartile constituting the highest OD incidence districts and fourth quartile with the lowest OD incidence districts, sorting data in descending order of OD incidence. Data on female literacy has also been used similarly for quartile division, with first quartile including highest female literacy districts and fourth with the least. Among the top 50 districts

Table 1: Correlations between stunting and different single parameters for 640 districts

Stunted Growth ~	Standard Coefficient	Constant	n (Districts)	R^2
OD	0.2219***	0.2464	640	0.3706
Improved drinking water sources	0.0476	0.3179	640	0.0021
Improved sanitation facilities	-0.2792***	0.4945	640	0.4103
Female literacy	-0.4631***	0.6761	640	0.4588
Women min 10 yrs. school	-0.4244***	0.5063	640	0.3834
Antenatal check up	-0.2727***	0.5237	640	02449
Antenatal care visits	-0.2232***	0.4756	640	0.3314
Mothers iron folic acid 100 days	-0.2724***	0.4453	640	0.2775
Fully antenatal care	-0.3114***	0.4270	640	0.2824
Postnatal care	-0.2541***	0.5172	640	0.2142
Children diarrhea	0.4421***	0.3227	640	0.0502
Children breastfed	-0.1810***	0.4416	640	0.0898
Children adequate diet	-0.4986***	0.4121	640	0.1815
Women overweight	0.7238***	0.1990	640	0.4253
Women overweight	-0.7166***	0.4953	640	0.4306

p-value 0*** 0.001** 0.01* 0.05. 0.1

Table 2: Correlation between stunting, open defecation (OD) and female literacy

	Standard Coefficient	Constant	n (Districts)	R^2
Stunted ~ OD	0.2219***	0.2464	640	0.3706
Stunted ~ Female literacy	0.4631***	0.6761	640	0.4588
OD ~ Female literacy	-1.3682***	1.4458	640	0.5309

p-value 0*** 0.001** 0.01* 0.05. 0.1

Table 3: Multiple parameter regression on stunting using data from 640 districts

Stunted Growth ~	Standard Coefficient	Constant	n (Districts)	R^2
Open defecation	0.0386 *	0.4298	640	0.5787
Female literacy	-0.1907***			
Fully antenatal care	-0.0863***			
Women underweight	0.3089***			
Child diarrhea	0.0863			
Child adequate diet	-0.1606***			
p-value	0***	0.001**	0.01*	0.05. 0.1

with lowest stunting rates, 62 per cent fall in the fourth quartile of data sorted by OD incidence rates while 81 per cent of those fall in the first quartile of data sorted by female literacy. Further, of the 50 districts with highest stunting rates, only 54 per cent fall in the first quartile of data sorted based on OD incidence while 80 per cent fall in the fourth quartile of female literacy based dataset.

Table 6 categorizes districts with a stunting rate above the average (> 36 per cent) as high stunting and the rest as low stunting districts; districts falling in the last quartile as low OD and districts falling in the first quartile as high OD, sorting data in descending order of OD incidence rates and the same definition applies for female literacy. Of the 320 districts considered, the stunting pattern in 271 can be explained with OD, whereas 287 of the former by female literacy level. Thus, while OD is a relevant parameter while looking at child stunting, female literacy appears to have an even higher relevance.

Figure 1 visualizes the results of Table 6, with the same definition of high and low rates and every dot symbolizing a district. The red dots categorize the districts of high and low OD overlapping with above or below average (36 per cent) of stunted children, whereas the same definition for female literacy applies for the blue dots. Of the 320 districts considered, 85 per cent of stunting pattern can be explained with OD, whereas 90 per cent of the same can be explained by female literacy rates. Hence, female literacy performs better in explaining child stunting than OD incidence.

4. Discussion

Incidence of open defecation is one explanation for stunting. In households with no open defecation, children grow taller, as they do in villages with higher latrine use compared to children growing in an environment with high open defecation in private and community space. Even when the household itself has a toilet, any other person in the village defecating in the open may harm the overall welfare of the community by exposing them to pathogens and diseases. However, scientists have not been able to statistically establish any causal relationship between open defecation and child stunting (Spears *et al*. 2013). The bacteria in human faeces causes intestinal infections, which leads to diarrhoea and is one of the leading arguments explaining the relationship between stunted child growth and open defecation (Coffey and Spears 2017). Our multiple parameter

Table 4: Multiple parameter regression on stunting with data from 100 low performing districts with high stunting and open defecation rates and 2 high performing ones with low rates of the former.

Stunted Growth~	Standard Coefficient	Constant	n (Districts)	R^2
Open defecation	0.0262	0.4298	640	0.5787
Female literacy	-0.1356 *			
Fully antenatal care	-0.2704***			
Women underweight	0.2831			
Child diarrhea	0.5155***			
Child adequate diet	-0.0622			
p-value	0***	0.001**	0.01*	0.05. 0.1

Table 5: Percentage of the top 50 districts with low/high stunting falling in the first to last quartile sorting the data in descending order of open defecation (OD) or female literacy.

	Top 50 districts with low stunting		Top 50 districts high stunting	
	OD	female literacy	OD	female literacy
Quartile 1	0%	81%	54%	4%
Quartile 2	14%	6%	36%	4%
Quartile 3	24%	8%	10%	12%
Quartile 4	62%	2%	0%	80%

Table 6: Number of districts with a stunting rate below or above stunting and open defecation (OD)/literacy in the lowest or highest quartile sorted in descending order.

	high stunting		
low OD	24	135	high literacy
	136	25	
	low stunting		

	high stunting		
low literacy	144	19	high literacy
	17	143	
	low stunting		

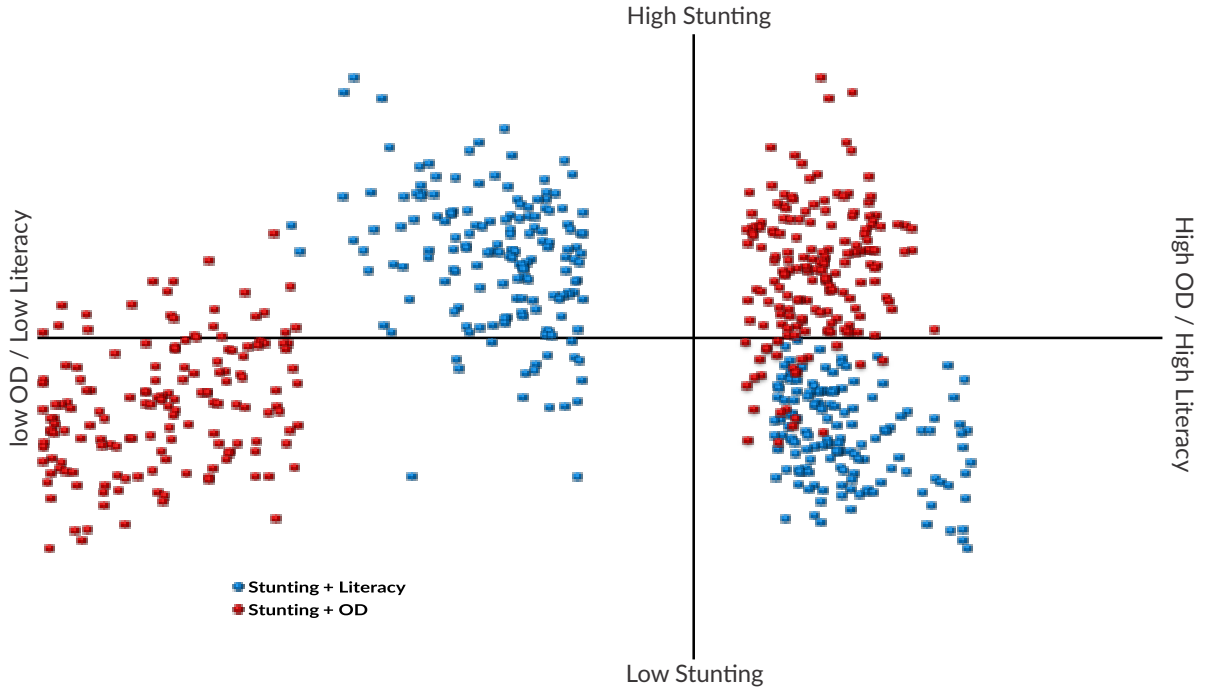

Figure 1: Distribution of the number of districts with a stunting rate below or above stunting and open defecation (OD)/literacy in the lowest or highest quartile sorted in descending order.

analyses (Table 3), however, shows that diarrhoea incidence is not significantly correlated with child stunting.

Our analysis suggests that female literacy is a more relevant influencing parameter compared to open defecation when looking at child stunting rates. Reason for low literacy level amongst women are many: early marriage, poverty, unwillingness of the parents to educate girl child or no support in continuing study after marriage, lack of enabling school facilities like latrines or female teachers (Velkoff 1998).

A study in West Bengal identified literacy as a determinant of nutritional awareness amongst mothers (Gupta *et al*. 2017). *The Lancet*, a British Medical journal, published in 2008 a series of papers which addressed maternal and child malnutrition highlighting that breastfeeding promotion has a large effect on survival but not on stunting of children. Data analysis seconds the results of this claim, as results show a low significance of breastfeeding on stunting (R^2 = 8.9 per cent). In general interventions such as maternal nutrition or feeding strategies reduce stunting at 36 months by 36 per cent. The series also suggested that for long term improvements, underlying factors of under-nutrition such as poverty, education and lack of women's empowerment have to be taken into account (Bhutta *et al*. 2008), also seconded by the findings of this paper.

The results of statistical analysis in Table 2 encompass, besides feeding strategies, women's health and level of education and are able to explain 58 per cent data patterns on stunted children. The analysis of the National Family Health Survey 2005-2006 (NFHS-3) data by Corsi *et al*. (2016) showed similar results. As important risk factors for stunting, maternal status, education, household wealth, dietary diversity and maternal body mass index (BMI) are listed with an R^2 of 67.2 per cent.

Ghosh *et al*. (2013) surveyed 256 mothers in the rural community of Darjeeling district and pointed out that 75.8 per cent of the literate women had health-care seeking behaviour, while only 24.2 per cent illiterate mothers showed the same behaviour regarding their children's health. A study in two resource-poor Indian populations with 1773 mother-child pairs emphasized the association of female health literacy and child stunting rate. Children of mothers with high maternal health literacy were found to be only half likely to be stunted than children of mothers with poor health literacy (Johri *et al*., 2016).

Our analysis also shows that improving female literacy will have a significant impact on eliminating open defecation. Water Aid (2016) evaluated Kerala as one of the best performing states in sanitation coverage. Kerala has a high female literacy rate and one of the leading reasons for huge success of sanitation implementation was high participation of educated women in the process. Banerjee *et al*. (2016) through analysis of the NFHS-3 data showed that educated women and households where women at least attended preschool are more likely to use a toilet. Further, the quality of sanitation facilities improves steadily with women's education. Female literacy accounts for 24.3 per cent of the variation in the distribution of toilet facilities (Wei *et al*. 2014).

The *Swachh Bharat* Mission focuses on building toilets while its Information, Education and Communication activities aim to bring about behavioural change in health and hygiene practices to trigger greater demand for sanitary facilities (GoI 2014). Female literacy is not part of the campaign. As the regression results show, improving the literacy level of women impacts reduction of open defecation positively. Policy makers should take these findings as new motivation to bring the existing *Saakshar Bharat* Mission on a new level and strongly focus on education of women and improving their literacy.

5. Conclusion

Our analysis of data from 640 districts shows a high and significant negative correlation between female literacy and incidence of stunting among children. The analysis also shows a significant role of female literacy in reducing open defecation. We argue that the efforts of *Swachh Bharat* Mission and related programs towards building toilets will be rendered futile unless sufficient attention is also paid to female literacy. Appearing as an important success parameter for open defecation reduction as well as children health programs, policy makers must focus on an integrated approach which includes increasing awareness of women and educating them as a part of such programs. Such a focus on educating women, especially on health, nutrition and hygiene, is very likely to assure reduction in incidence of OD and child stunting in India.

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The IWMI-Tata Water Policy Program (ITP) was launched in 2000 as a co-equal partnership between the International Water Management Institute (IWMI), Colombo and Sir Ratan Tata Trust (SRTT), Mumbai. The program presents new perspectives and practical solutions derived from the wealth of research done in India on water resource management. Its objective is to help policy makers at the central, state and local levels address their water challenges – in areas such as sustainable groundwater management, water scarcity, and rural poverty – by translating research findings into practical policy recommendations. Through this program, IWMI collaborates with a range of partners across India to identify, analyze and document relevant water management approaches and current practices. These practices are assessed and synthesized for maximum policy impact in the series on Water Policy Highlights and IWMI-Tata Comments.

Water Policy Highlights are pre-publication discussion papers developed primarily as the basis for discussion during ITP's Annual Partners' Meet. The research underlying these Highlights was funded with support from International Water Management Institute (IWMI), Tata Trusts, CGIAR Research Program on Water, Land and Ecosystems (WLE) and CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). However, the Highlights are not externally peer-reviewed and the views expressed are of the author/s alone and not of ITP or any of its funding partners.

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