

## Appendix: Partial Spearman's Correlation

Consider state-specific private-sector Hib vaccine coverage to be variable 'X' and the socio-economic factor to be variable 'Y'. Using R statistical software<sup>1</sup>, we calculated simple bivariate Spearman's correlation  $\rho(X,Y)$  between X and Y variables using the following code:

```
cor.test(X, Y, method = "spearman")
```

However, per-capita GDP is a significant driver of health spending in India and the private-sector Hib vaccines are primarily paid out-of-pocket<sup>2-5</sup>. Therefore we suspect the per-capita GDP 'Z' can also explain associations between the private-sector Hib vaccine coverage 'X' and other socio-economic factors 'Y'. We performed partial Spearman's correlational analysis<sup>6,7</sup> to test if per-capita GDP explains an association, even in part, between the state-specific private-sector Hib vaccine coverage and the socio-economic factors. We calculated partial correlations  $\rho(X,Y|Z)$  by controlling for per-capita GDP 'Z' (i.e. statistically holding Z as constant) using R 'ppcor package'.<sup>6</sup> See R code below:

```
pcor.test(X, Y, Z, method = c("spearman"))
```

We conclude that Z has a mediating effect if  $\rho(X,Y)$  is relatively large, but  $\rho(X,Y|Z)$  is much smaller or close to zero. In most cases, we found that per-capita GDP 'Z' explained, at least in part, the observed associations between the private-sector Hib coverage X and the socio-economic factors Y (see Table below).

**Note:** These tests only relate to correlational relationship between the private-sector coverage and socioeconomic factors, and does not refer to any causal relationships. The drop in magnitude of correlation coefficients, on controlling for per-capita GDP Z, does not imply that there is no association in private-sector Hib coverage X and socio-economic factor Y. Instead it means that both per-capita GDP and the socio-economic factor together drive the private-sector Hib vaccine coverage.

## Correlation: Private-sector Hib coverage and socioeconomic factors

Socio-economic factors 'X'	Bivariate Spearman's Correlation	Partial Spearman's Correlation : holding per-capita GDP 'Z' constant
	State-wide Hib Coverage (%) 'Y' $\rho(X,Y)$ (p-value)	State-wise Hib coverage (%) 'Y' $\rho(X,Y Z)$ (p-value)
Per-capita state GDP <sup>a</sup>	0.65 (0.01)*	--
Urbanization (%) i.e. proportion of population living in urban areas <sup>b</sup>	0.57 (0.03) *	-0.04 (0.86)
Schedule Caste population (%) <sup>b</sup>	-0.30 (0.28)	-0.08 (0.79)
Population living below poverty line (%) <sup>c</sup>	-0.65 (0.01) *	0.18 (0.53)
Female Literacy rate (%) <sup>b</sup>	0.38 (0.16)	-0.12 (0.68)
Birth in private-sector health facilities (%) <sup>d</sup>	0.72 (0.004) *	0.46 (0.07)
Private pediatricians per 1,000 children <sup>e</sup>	0.66 (0.01) *	0.25 (0.37)
Proportion of children who received any vaccine in private health facility <sup>e</sup>	0.48 (0.08) *	0.01 (0.72)
Full immunization coverage rate (%) <sup>d,f,g</sup>	0.60 (0.02) *	0.18 (0.52)
Private-sector vaccine share in coverage against primary childhood diseases (%) <sup>h</sup>	0.83 (<0.001) *	0.68 (0.51)

$\rho$  (rho) = Spearman's correlation coefficient; \* Statistically significant ( $p < 0.05$ )

**Sources:** <sup>a</sup> Unidow Analytic Services 2014; <sup>b</sup> 2011 Census of India; <sup>c</sup> GOI Planning Commission 2013; <sup>d</sup> UNICEF 2009; **Notes:** <sup>e</sup> Considers state-wise membership of Indian Academy of Pediatrics as proxy for availability of pediatricians (IAP 2012); <sup>f</sup> Average of full coverage rates reported by DHS/NFHS-3 and UNICEF CES 2009; <sup>g</sup> proportion of children who received one dose of BCG and measles, and three doses of DPT and polio vaccines; <sup>h</sup> refers to the percentage of vaccinated children who received a given vaccine (BCG, measles, DPT and oral polio vaccine) in India's private-sector market: authors' unpublished calculations.

## References:

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