

Is 1+1 more than 2? Joint evaluation of two public programs in Tanzania .

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June 3, 2016

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- Understanding treatment effect interactions are important.
 - Synergies or inhibitors. (Bernstam *et al.*, 2009)
 - Cost-benefit analysis.
 - External validity.
- Dynamic complementarity in human capital production function. (**We do not estimate the production function**)
 - Possibility and extent of mitigation or catchup in later life.(Hoddinott and Kinsey 2001; Alderman, Hoddinott and Kinsey 2006; Mani 2011])
 - Especially important in the context of developing countries.
- Understanding heterogeneity in treatment effect is important (Angrist, 2003)
 - No ATE but significant within effects (Kravitz, Duan & Barslow, 2004).
 - Bearing on external validity, cost-benefit analysis, etc.

- Complementarity: Cunha & Heckman(2007), Aizer & Cunha(2012).
- Treatment effect interactions: Adhvaryu et al.(2016), Rythia Afkar(2015),

- **Were there any synergies between the two shocks, ISP & PEDP, that affected human capital formation in Tanzania?**

- We exploit the variation in human capital levels and investments in Tanzania due to
 - Iodine Supplementation Program (1986-94)
 - Free Primary Education Development Program (2002)
- Data: Kagera Health and Development Survey (1991-1994 & 2004)
 - Representative of Kagera region of Tanzania.
 - Primary school starting age and migration information.
 - THBS 2007 & DHS 2010-11 used for robustness checks. (Kudo, 2015)

Tanzania's Iodine Supplementation Program

- Iodine Deficiency in the first trimester in-utero a leading cause of intellectual impairment worldwide (Merke, 1984; Delange, 2000; Haddow, 1999)
- In 1970s, 40% of Tanzania's population lived in iodine deficient areas and 25% of the population suffered from moderate to severe IDD.
- Massive supplementation intervention started in 1986 in 25 of the most affected districts encompassing 25% of the countrys population (Peterson, 2000).

Tanzania's Iodine Supplementation Program

- Ten of the districts had begun by 1988, and three did not start until 1992.
- Penetration rates ranged from 60 to 90 percent of the target population.
- Of the 380 mg of iodine administered, 323 is lost in the first month and after that it depletes hyperbolically.
- Field et al. (2009) find a large impacts - treated attained 0.35-0.56 years of schooling.
- Bengtsson et al.(2013) argue that the affect are small, mostly insignificant and not robust.

Tanzania's Primary Education Development Program

- In 2001, Tanzanian government abolished tuition fees and other mandatory cash contributions to primary schools.
- Targeted seven and eight year old in 2001 (Treatment cohorts: born in 1993 and 1994).
- Coverage of the program was extended to 12 and 13 years old in 2004. (Controls cohorts: born in 1991 and 1992)

- We use the penetration rate for each district in each year and the hyperbolic depletion formula to calculate the probability that an in-utero child had adequate stocks of iodine during the first trimester.
- We use birth year to define the exposure to free primary education program.

$$Y_{ibd} = \alpha + \beta_1 \text{Iodine}_{ibd} + \beta_2 \text{PEDP}_{ibd} + \beta_3 \text{Iodine}_{ibd} * \text{PEDP}_{ibd} + \gamma X_{ibd} + \tau_1 * t + \tau_2 * t^2 + \delta_d + \epsilon_{ibd}$$

Table: Impact of ISP and PEDP on completed years of schooling

VARIABLES	(1) Completed grades	(2) Completed grade	(3) Completed grade	(4) Completed grade
ISP	-0.8131*** (0.1378)	-0.8076*** (0.1389)	-0.8192*** (0.1330)	-0.8132*** (0.1339)
PEDP	0.2823** (0.1077)	0.2852** (0.1105)	0.2824** (0.1082)	0.2851** (0.1107)
ISP * PEDP	-0.5921** (0.2603)	-0.5800** (0.2664)	-0.5970** (0.2657)	-0.5850** (0.2730)
Religion dummy	NO	YES	NO	YES
Tribe dummy	NO	NO	YES	YES
Mean ISP treatment probability	0.3244	0.3244	0.3244	0.3244
Mean years of education	2.2011	2.2011	2.2011	2.2011
Constant	-14.0102*** (4.0734)	-14.1084*** (4.0976)	-13.9337*** (4.0269)	-14.0363*** (4.0468)
Observations	507	507	507	507
R-squared	0.3710	0.3715	0.3713	0.3717

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors in parentheses. The standard errors are clustered at geogage level where geogage are district-year of birth groups. Other controls include a quadratic in age, total land ownership of the household in which the child was born in the 1991-1994 survey, a dummy each indicating whether the mother and the father of the child had some education, gender and primary enumeration area fixed effects.

Table: Impact of ISP and PEDP on primary school starting age

VARIABLES	(1) Start age	(2) Start age	(3) Start age	(4) Start age	(5) Start age	(6) Start age	(7) Start age	(8) Start age
ISP	0.8408*** (0.1891)	0.8247*** (0.1720)	0.8414*** (0.1869)	0.8252*** (0.1692)	0.8515*** (0.1882)	0.8363*** (0.1733)	0.8530*** (0.1851)	0.8380*** (0.1697)
PEDP		-0.6181*** (0.1638)		-0.6179*** (0.1652)		-0.6185*** (0.1600)		-0.6177*** (0.1612)
ISP * PEDP		0.4141* (0.2123)		0.4152* (0.2171)		0.4233* (0.2146)		0.4266* (0.2201)
Religion dummy	NO	NO	YES	YES	NO	NO	YES	YES
Tribe dummy	NO	NO	NO	NO	YES	YES	YES	YES
Mean ISP treatment probability	0.3244	0.3244	0.3244	0.3244	0.3244	0.3244	0.3244	0.3244
Mean primary school start age	8.3984	8.3984	8.3984	8.3984	8.3984	8.3984	8.3984	8.3984
Constant	6.8993 (6.4714)	12.9154** (5.2682)	6.8827 (6.5117)	12.9063** (5.2902)	6.7259 (6.3884)	12.7702** (5.2036)	6.6879 (6.4335)	12.7426** (5.2291)
Observations	507	507	507	507	507	507	507	507
R-squared	0.1734	0.1794	0.1734	0.1794	0.1743	0.1803	0.1744	0.1803

Table: Impact of ISP on height of the child (Height-for-age) in 2004

VARIABLES	(1) HAZ	(2) HAZ	(3) HAZ	(4) HAZ
ISP	-0.5381** (0.2559)	-0.5367** (0.2549)	-0.5491** (0.2503)	-0.5480** (0.2494)
Religion dummy	NO	YES	NO	YES
Tribe dummy	NO	NO	YES	YES
Mean ISP treatment probability	0.3244	0.3244	0.3244	0.3244
Mean HAZ	-1.7365	-1.7365	-1.7365	-1.7365
Constant	-1.5384*** (0.3653)	-1.5227*** (0.3324)	-1.3637*** (0.3854)	-1.3541*** (0.3607)
Observations	491	491	491	491
R-squared	0.0520	0.0520	0.0543	0.0544

Notes: WHO Child Growth Charts and WHO Reference 2007 Charts were used for height-for-age analysis.

Table: Impact of ISP on height of the child (Height-for-age) in 1991-1994

VARIABLES	(1) Height_91	(2) Height_92	(3) Height_93	(4) Height_94
ISP	3.2323 (2.4296)	2.1530 (2.6457)	-0.8428 (1.1906)	-2.8199*** (0.6930)
Religion dummy	YES	YES	YES	YES
Tribe dummy	YES	YES	YES	YES
Mean ISP treatment probability	0.3244	0.3244	0.3244	0.3244
Mean HAZ	-.7736	-1.3433	-1.5310	-1.7399
Constant	-0.5633 (1.5280)	-1.6430* (0.8660)	-0.7650 (0.6224)	-0.5963 (0.6684)
Observations	146	175	218	231
R-squared	0.1155	0.0834	0.0317	0.1002

Notes: Observations with body mass index of more than 100 were not used for the analysis.

Table: Role of primary school start age.

VARIABLES	(1) Yos	(2) Yos	(3) Yos	(4) Yos	(5) Yos	(6) Yos	(7) Yos	(8) Yos
ISP	-0.8131*** (0.1378)	-0.3174** (0.1299)	-0.8076*** (0.1389)	-0.3115** (0.1293)	-0.8192*** (0.1330)	-0.3165** (0.1256)	-0.8132*** (0.1339)	-0.3092** (0.1249)
PEDP	0.2823** (0.1077)	-0.0893 (0.1077)	0.2852** (0.1105)	-0.0862 (0.1112)	0.2824** (0.1082)	-0.0894 (0.1076)	0.2851** (0.1107)	-0.0863 (0.1107)
ISP * PEDP	-0.5921** (0.2603)	-0.3432 (0.2304)	-0.5800** (0.2664)	-0.3304 (0.2317)	-0.5970** (0.2657)	-0.3425 (0.2321)	-0.5850** (0.2730)	-0.3285 (0.2337)
Primary starting age		-0.6011*** (0.0405)		-0.6011*** (0.0409)		-0.6012*** (0.0403)		-0.6013*** (0.0407)
Mean ISP treatment probability	0.3244	0.3244	0.3244	0.3244	0.3244	0.3244	0.3244	0.3244
Mean primary school start age	8.3984	8.3984	8.3984	8.3984	8.3984	8.3984	8.3984	8.3984
Mean years of education	2.2011	2.2011	2.2011	2.2011	2.2011	2.2011	2.2011	2.2011
Constant	-14.0102*** (4.0734)	-6.2469** (2.8187)	-14.1084*** (4.0976)	-6.3498** (2.8743)	-13.9337*** (4.0269)	-6.2566** (2.8181)	-14.0363*** (4.0468)	-6.3737** (2.8747)
Religion dummy	NO	NO	YES	YES	NO	NO	YES	YES
Tribe dummy	NO	NO	NO	NO	YES	YES	YES	YES
Observations	507	507	507	507	507	507	507	507
R-squared	0.3710	0.6317	0.3715	0.6322	0.3713	0.6317	0.3717	0.6322

Complementarity in Human Capital Formation

$$\frac{\partial(\text{years of schooling})}{\partial(\text{school starting age})} = \frac{\partial(\text{years of schooling})}{\partial(\text{treatment})} * \frac{\partial(\text{treatment})}{\partial(\text{school starting age})}$$

Table: Converting an additional year at school into completed years of schooling

Treatment	School entering age	Years of schooling	$\frac{\partial(\text{years of schooling})}{\partial(\text{school starting age})}$
PEDP only	-0.6177	0.2851	-0.46
ISP only	0.8380	-0.8132	-0.97
ISP & PEDP	0.4266	-0.5850	-1.37

Conclusion

- PEDP had a positive impact on years of schooling mainly via reducing school starting age.
- The direct effect of ISP treatment seems to have been positive and, perhaps, through improving cognition.
- ISP treatment motivated compensatory parental investment in untreated children.
- Dynamic complementarity between the two treatment (synergies).
- The direct positive effect of ISP seems to have nullified the impact of compensatory investment over the years.