SHANGHAI JIAO TONG UNIVERSITY

Worms: Identifying Impacts on Education and Health in the Presence of Treatment Externalities

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Highlights: What They Did and Found? And Why?

- They evaluate a **Primary School Deworming Project (PSDP)** in which **school-based** mass treatment with deworming.
- PSDP **reduced school** absenteeism in **treatment schools** by 1/4 (**direct**).
- PSDP **improved health and school participation** among **untreated pupils** (**externalities**).
- Deworming **did not improve academic test scores**.

Causal Relationship

PSDP (Cause)

Health and Education (Effect)

(health, school participation, test scores)

WHY Do This?

I. **Evaluate the effects of PSDP on health and education.**

II. **Solve the grand poverty problem.**

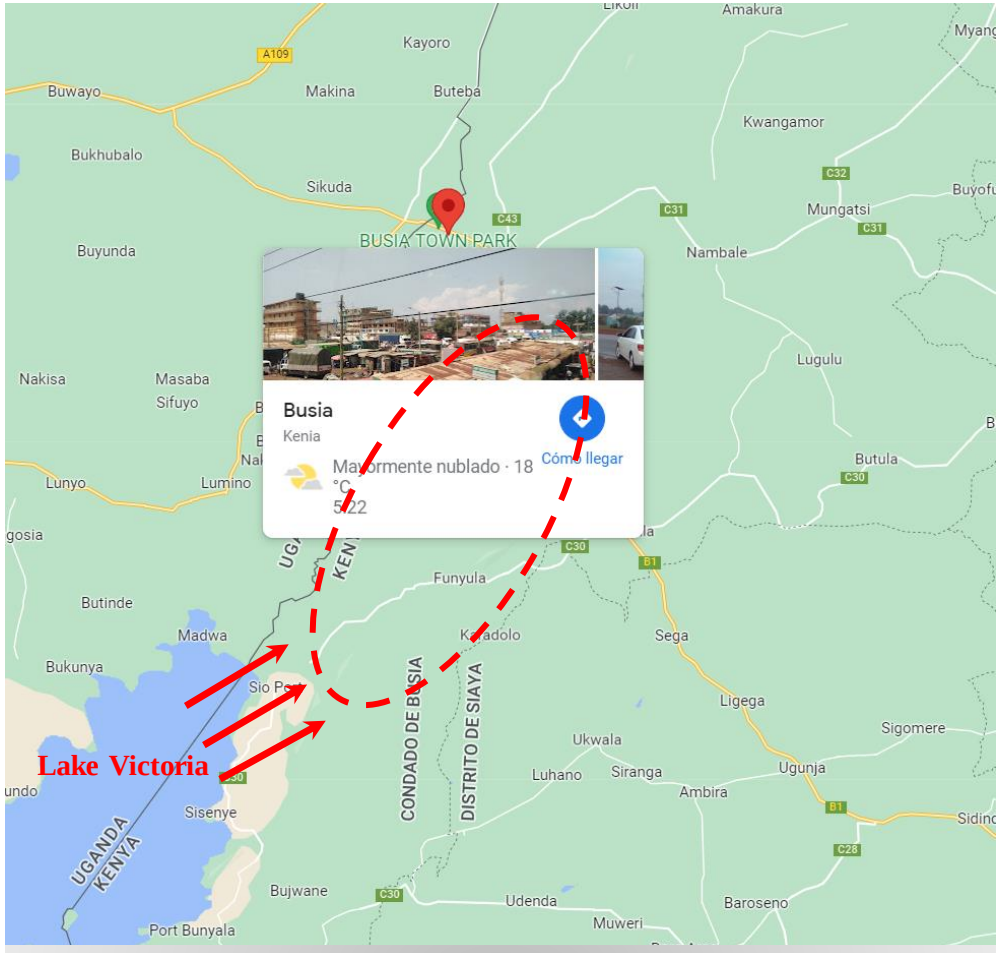
Outline

Background

- **Intestinal helminths:** infect more than **one-quarter** of the world's population.
- **PSDP: Deworming,** carried out by **Dutch nonprofit organization** (ICS) and **Busia District Ministry of Health office**.
- **Place:** **Southern Busia (Western Kenya)**, in an area with the highest helminth infection rates.
- **Intervention ways:**

  (1) **medical treatment**;

  (2) **worm prevention education**.



***** Pupils who attend schools **near Lake Victoria** also have substantially **higher rates of schistosomiasis.**

Program Introduction

Primary School Deworming Project (PSDP)

- **Subject**: 30,000 pupils from **75 schools**, **all boys and girls under 13**.
- **Subgroup**: **Randomly** devided to **3 groups**, 25 schools per group.
- **Intervention:** **School-based**, **phased** (1998, 1999, 2001) mass treated worming.
- All schools **before PSDP** have the **same average characteristics**. **(No systematic differences)**

year	1998		1999	
Intervention	Treatment Group	Control Group	Treatment Group	Control Group
Group1	√		√	
Group2		√	√	
Group3		√		√

(i) ICS's administrative (ii) financial constraints

Table I **1998** Average Pupil and School Characteristics, Pre-Treatment

	Group 1 (25 schools)	Group 2 (25 schools)	Group 3 (25 schools)	Group 1 – Group 3	Group 2 – Group 3
Panel A: Pre-school to Grade 8					
Male	0.53	0.51	0.52	0.01	−0.01
				(0.02)	(0.02)
Proportion girls <13 years, and all boys	0.89	0.89	0.88	0.00	0.01
				(0.01)	(0.01)
Grade progression (= Grade − (Age − 6))	−2.1	−1.9	−2.1	−0.0	0.1
				(0.1)	(0.1)
Year of birth	1986.2	1986.5	1985.8	0.4**	0.8***
				(0.2)	(0.2)

Identification Strategy: School-level RCT

Strategy 1: School-level RCT

- **No systematic differences**: All schools before PSDP have the same average characteristics.
- **Casual Effect**: The effects of deworming on health and education are **the difference of *pre-* and *post*-PSDP**.

Table V January to March **1999** Health and Health Behavior Differences Between Group 1 (1998 Treatment) and Group 2 (1998 Comparison) Schools

	Group 1	Group 2	Group 1 – Group 2
Panel A: Helminth Infection Rates			
Any moderate-heavy infection, January–March 1998	0.38	–	–
Any moderate-heavy infection, 1999	0.27	0.52	−0.25***
			(0.06)
Hookworm moderate-heavy infection, 1999	0.06	0.22	−0.16***
			(0.03)
Roundworm moderate-heavy infection, 1999	0.09	0.24	−0.15***
			(0.04)
Schistosomiasis moderate-heavy infection, 1999	0.08	0.18	−0.10*
			(0.06)
Whipworm moderate-heavy infection, 1999	0.13	0.17	−0.04
			(0.05)

Identification Strategy: School-level RCT

Strategy 1: School-level RCT

Why the PSDP was randomly phased into **school level**, rather than **individual level**?

Potential Reasons

Program Design: **Dutch nonprofit organization (ICS)** in cooperation with the **Busia District Ministry of Health office**.

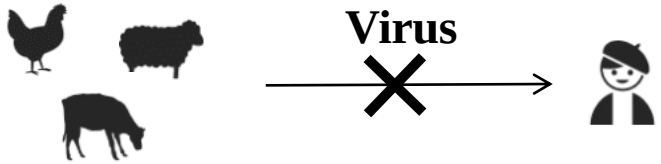
Estimators: Studies at the **individual level** potentially **doubly underestimate** the benefits of treatment.

Missing externality benefits

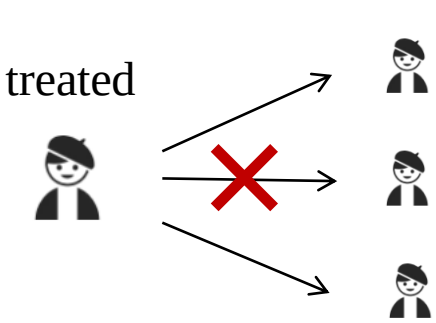
Identification Strategy: Mechanism

Mechanism: The Treatment Effect and Treatment Externalities

Direct Effect: Environment to people

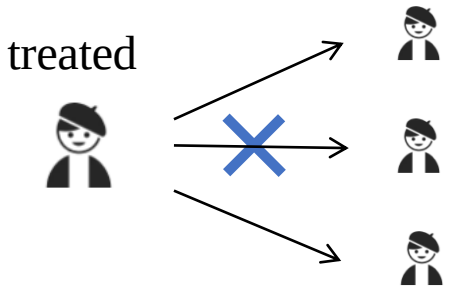


Externality Effects: People to people



Untreated in
Treated group

Within school



Untreated in
Control group

Cross school①

① Most people in this area **live on their farms** rather than being concentrated in villages, and **neighbors (and even siblings) often attend different schools** since there is typically **more than one primary school within walking distance**.

Identification Strategy: Mechanism

Externality Benefits

- **Missing externality benefits** to the comparison group from reduced disease transmission, also **underestimating benefits for the treatment group**.
- Evaluating in **school-based level** can obtain the **OVERALL treated school effects**.

BUT IS IT ENOUGH? **NO**

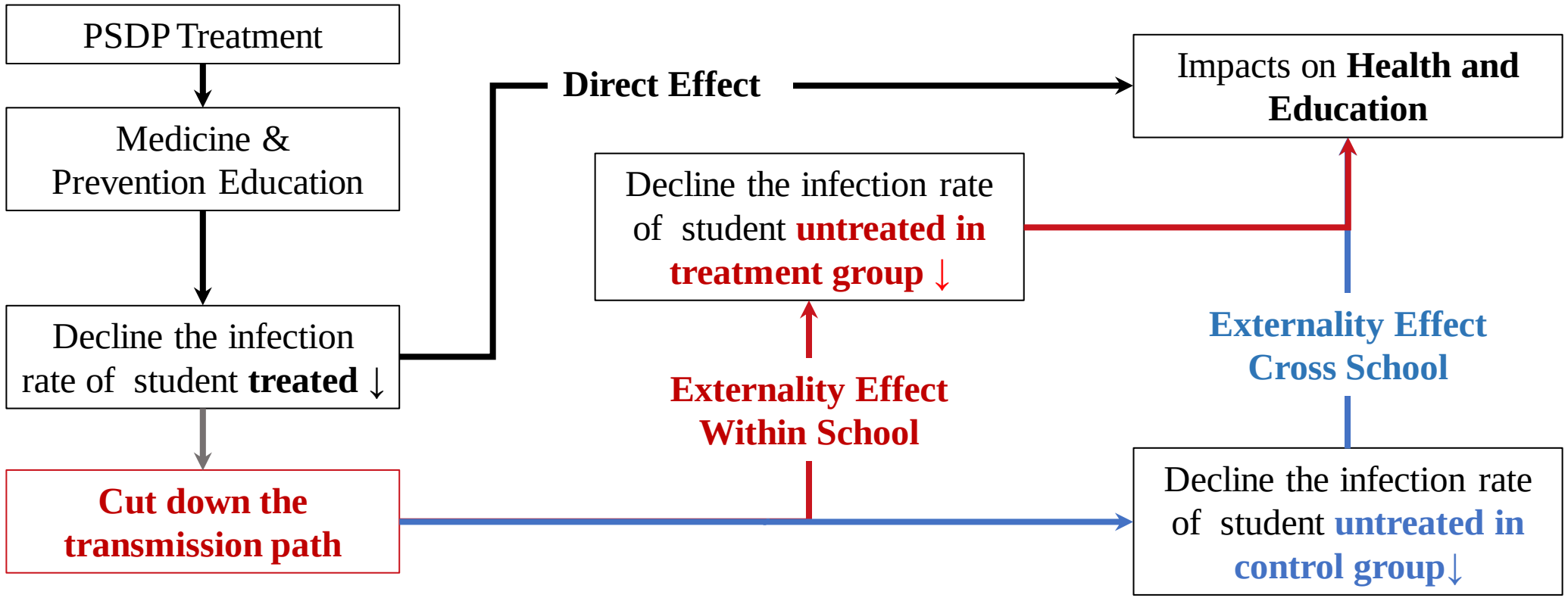
Research Innovations

Perspective: It is necessary to study **externality**.
But **empirical studies** are **rather limited**.

Estimators: Not only evaluated the **direct effects** of deworming treatment
But innovatively separated and estimated the **externalities at DIFFERENT levels**.

Identification Strategy: Mechanism

Mechanism: The Treatment Effect and Treatment Externalities



Identification Strategy: RCT + Non-experimental

Strategy 2: RCT + Non-experimental Approach

RCT + Need Decompose → **Direct Effect + Externality Effect Within School**

Decompose the effect on treated schools into a **direct effect** and **within-school externality**.

Local Treatment Density → **Externality Effect Cross School**

Variation in the local density of treatment schools induced by randomization.

Cross-school externalities **increase with** the local density of treatment school pupils.

(*See Page 18.*)

Empirical Methodology: Model 1

Model 1: Estimate Effect of Treatment Schools, and Cross School Externality

Individual Health or Education Outcome

Treatment Dummy

Cross School Effect

Check Causal Effect

$$Y_{ijt} = a + \beta_1 T_{1it} + \beta_2 T_{2it} + X'_{ijt}\delta + \sum_d (\gamma_d \cdot N^T_{dit}) + \sum_d (\phi_d \cdot N_{dit})$$

Overall Treated School Effect

Covariate

N_{dit}: **total number of pupils** in primary schools at distance d from school i in year t (**0-3km**, **3-6km**)

N^T_{dit}: **total number of pupils** in primary schools, which **randomly assigned to deworming treatment**, at distance d from school i in year t (**0-3km**, **3-6km**)

β_1, β_2: the **effect of treatment in school (Direct and Within Effect Not Differentiated)**

γ_d: the **effect of treatment cross school**

Limitation

Identification Strategy: Within School Externality

Strategy 1: Randomized Controlled Trial (RCT)

- **78%** of pupils to receive treatment in **1998**
- The parental consent rules changed between **1998** and **1999**, **reduction in the fraction** of pupils receiving treatment.
- The treatment rate in **1999** was approximately **57%**.

  (59% in Group 1 and 53% in Group 2)
- The overall treatment rate (including pupils enrolled) in **1999** was approximately **72%**.

  (73% in Group 1 and 71% in Group 2)

Table III **Proportion of Pupils Receiving Deworming Treatment** in PSDP

	Group 1		Group 2		Group 3	
	Girls <13 years, and all boys	Girls ≥ 13 years	Girls <13 years, and all boys	Girls ≥ 13 years	Girls <13 years, and all boys	Girls ≥ 13 years
	Treatment		*Comparison*		*Comparison*	
Any medical treatment in 1998 (For grades 1–8 in early 1998)	0.78	0.19	0	0	0	0
Round 1 (March–April 1998), Albendazole	0.69	0.11	0	0	0	0
Round 1 (March–April 1998), Praziquantel[b]	0.64	0.34	0	0	0	0
Round 2 (Oct.–Nov. 1998), Albendazole	0.56	0.07	0	0	0	0
	Treatment		*Treatment*		*Comparison*	
Any medical treatment in 1999 (For grades 1–7 in early 1998)	0.59	0.07	0.55	0.10	0.01	0
Round 1 (March–June 1999), Albendazole	0.44	0.06	0.35	0.06	0.01	0
Round 1 (March–June 1999), Praziquantel[b]	0.47	0.06	0.38	0.06	0.01	0
Round 2 (Oct.–Nov. 1999), Albendazole	0.53	0.06	0.51	0.08	0.01	0
Any medical treatment in 1999 (For grades 1–7 in early 1998), among pupils enrolled in 1999	0.73	0.10	0.71	0.13	0.02	0
Round 1 (March–June 1999), Albendazole	0.55	0.08	0.46	0.08	0.01	0
Round 1 (March–June 1999), Praziquantel[b]	0.53	0.07	0.45	0.07	0.01	0
Round 2 (Oct.–Nov. 1999), Albendazole	0.65	0.09	0.66	0.11	0.01	0

Identification Strategy: Within School Externality

Model 2: Estimate Within Effect of Treatment Schools

Student in Group 1 who did not participate in the 1998

Student in Group 2 who did not participate in the 1999

Almost same in each situation

In the Year of 1998 to 1999

$Y_{1\ in\ 1998}$ —— **Within school effect** + Across school effect ——→ $Y_{1\ in\ 1999}$

$Y_{2\ in\ 1998}$ —— Across school effect ——→ $Y_{2\ in\ 1999}$

$$E(Within\ school\ effect) = E(Y_{1\ in\ 1999}) - E(Y_{2\ in\ 1998})$$

Empirical Methodology: Model 2

Model 2: Decompose Direct and Within Effect of Treatment School

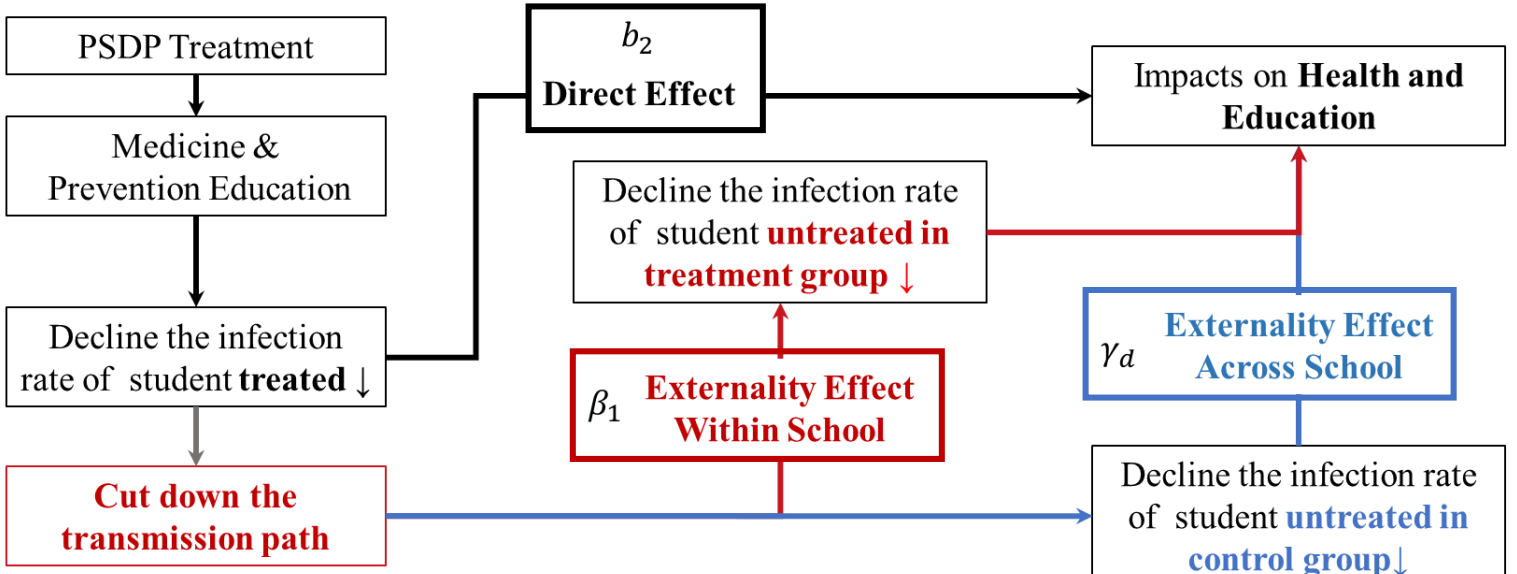
Individual Dummy

Cross School Effect

$$Y_{ijt} = a + \beta_1 T_{1it} + b_1 D_{1ij} + b_2 (T_{1it} \times D_{1ij}) + X'_{ijt}\delta + \sum_d (\gamma_d \cdot N^T_{dit}) + \sum_d (\phi_d \cdot N_{dit})$$

Within School Effect **Direct effect** (*DID estimator*)

Mechanism & Identification



PSDP's Effect: Health

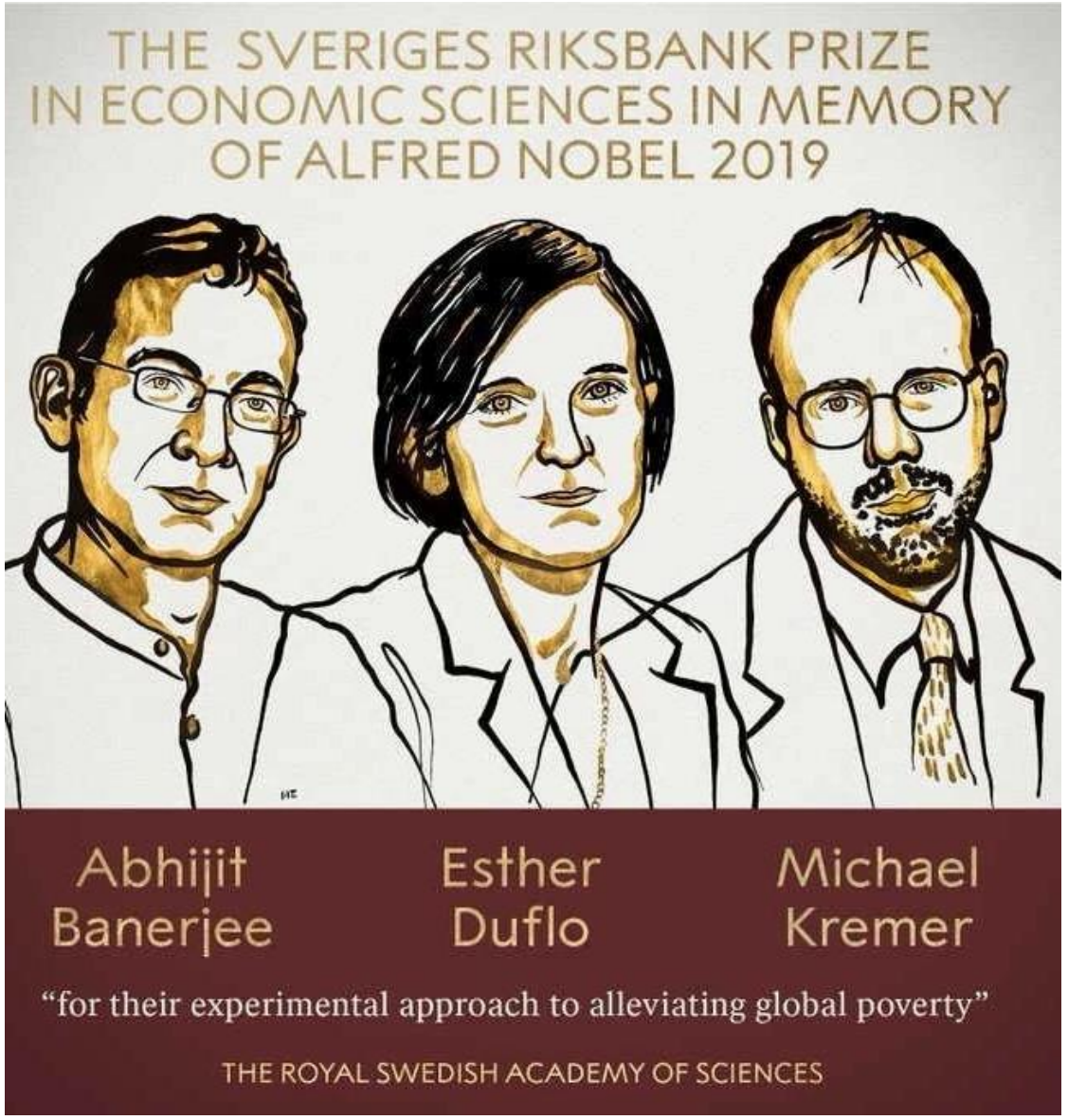
Table VII Deworming **Health** **Externalities Within and Cross Schools**, January to March 1999

	Any moderate-heavy helminth infection, 1999			Moderate-heavy schistosomiasis infection, 1999			Moderate-heavy geohelminth infection, 1999		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Indicator for Group 1 (1998 Treatment) School	−0.25***	−0.12*	−0.09	−0.03	−0.02	−0.07	−0.20***	−0.11**	−0.03
	(0.05)	(0.07)	(0.11)	(0.03)	(0.04)	(0.06)	(0.04)	(0.05)	(0.09)
Group 1 pupils within 3 km (per 1000 pupils)	−0.26***	−0.26***	−0.11	−0.12***	−0.12***	−0.11**	−0.12*	−0.12*	−0.01
	(0.09)	(0.09)	(0.13)	(0.04)	(0.04)	(0.05)	(0.06)	(0.07)	(0.07)
Group 1 pupils within 3–6 km (per 1000 pupils)	−0.14**	−0.13**	−0.07	−0.18***	−0.18***	−0.27***	0.04	0.04	0.16
	(0.06)	(0.06)	(0.14)	(0.03)	(0.03)	(0.06)	(0.06)	(0.06)	(0.10)
Total pupils within 3 km (per 1000 pupils)	0.11***	0.11***	0.10**	0.11***	0.11***	0.13***	0.03	0.04	0.02
	(0.04)	(0.04)	(0.04)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
Total pupils within 3–6 km (per 1000 pupils)	0.13**	0.13**	0.12*	0.12***	0.12***	0.16***	0.04	0.04	0.01
	(0.06)	(0.06)	(0.07)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
Received first year of deworming treatment, when offered (1998 for Group 1, 1999 for Group 2)		−0.06*			0.03**			−0.04**	
		(0.03)			(0.02)			(0.02)	
(Group 1 Indicator) ∗ Received treatment, when offered		−0.14*			−0.02			−0.10***	
		(0.07)			(0.04)			(0.04)	
(Group 1 Indicator) ∗ Group 1 pupils within 3 km (per 1000 pupils)			−0.25*			−0.04			−0.18**
			(0.14)			(0.07)			(0.08)
(Group 1 Indicator) ∗ Group 1 pupils within 3–6 km (per 1000 pupils)			−0.09			0.11			−0.15
			(0.13)			(0.07)			(0.10)
Grade indicators, school assistance controls, district exam score control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	2328	2328	2328	2328	2328	2328	2328	2328	2328
Mean of dependent variable	0.41	0.41	0.41	0.16	0.16	0.16	0.32	0.32	0.32

Contributions & Comments

- Introduce **RCT** and **Nonexperimental approach** to evaluate the causal effects of intervention policies.
- Emphasize and provide a framework to measure the **externality**.
- **Reshape the research paradigm** of development economics.

- **Decomposing** the grand poverty problem into **more precise problems** related to individuals or groups.
- **More specific public policies** (deworming, books, lunch, teacher, *etc.*) be suggested to **anti-poverty**.



Identification Strategy: Cross-school Externality

Strategy 2: RCT + Non-experimental Method

- **The assigned deworming treatment group** is **NOT** significantly associated with the density of other local treatment school pupils.
- **1998 and 1999 deworming compliance rates** are **NOT** significantly associated with the local density of treatment school pupils.

Table I **1998** School Characteristics, Pre-Treatment

Panel C: School characteristics					
District exam score 1996, grades 5–8[b]	−0.10	0.09	0.01	−0.11 (0.12)	0.08 (0.12)
Distance to Lake Victoria	10.0	9.9	9.5	0.6 (1.9)	0.5 (1.9)
Pupil population	392.7	403.8	375.9	16.8 (57.6)	27.9 (57.6)
School latrines per pupil	0.007	0.006	0.007	0.001 (0.001)	−0.000 (0.001)
Proportion moderate-heavy infections in zone	0.37	0.37	0.36	0.01 (0.03)	0.01 (0.03)
Group 1 pupils within 3 km[c]	461.1	408.3	344.5	116.6 (120.3)	63.8 (120.3)
Group 1 pupils within 3–6 km	844.5	652.0	869.7	−25.1 (140.9)	−217.6 (140.9)
Total primary school pupils within 3 km	1229.1	1364.3	1151.9	77.2 (205.5)	212.4 (205.5)
Total primary school pupils within 3–6 km	2370.7	2324.2	2401.7	−31.1 (209.5)	−77.6 (209.5)

Appendix Table AII Local Densities of Other Primary Schools and **Deworming Compliance Rates**

	Dependent variable:	
	1998 Compliance rate (any medical treatment) OLS (1)	1999 Compliance rate (any medical treatment) OLS (2)
Treatment school pupils within 3 km (per 1000 pupils)	−0.04 (0.06)	−0.08 (0.09)
Treatment school pupils within 3–6 km (per 1000 pupils)	0.04 (0.07)	−0.01 (0.05)
Total pupils within 3 km (per 1000 pupils)	0.05 (0.05)	0.05 (0.08)
Total pupils within 3–6 km (per 1000 pupils)	−0.06 (0.06)	−0.02 (0.05)
Grade indicators, school assistance controls, district exam score control	Yes	Yes

- **Cross-school deworming externalities INCREASE WITH** the local density of treatment school pupils.

PSDP's Effect: School Participation

Table VIII **School Participation**, School-Level Data

	Group 1 (25 schools)	Group 2 (25 schools)	Group 3 (25 schools)		
Panel A: *First year post-treatment* *(May 1998 to March 1999)*	*1st Year Treatment*	*Comparison*	*Comparison*	*Group 1 – (Groups 2 & 3)*	*Group 2 – Group 3*
Girls <13 years, and all boys	0.841	0.731	0.767	0.093***	−0.037
				(0.031)	(0.036)
Girls ≥13 years	0.864	0.803	0.811	0.057**	−0.008
				(0.029)	(0.034)
Preschool, Grade 1, Grade 2 in early 1998	0.795	0.688	0.703	0.100***	−0.018
				(0.037)	(0.043)
Grade 3, Grade 4, Grade 5 in early 1998	0.880	0.789	0.831	0.070***	−0.043
				(0.024)	(0.029)
Grade 6, Grade 7, Grade 8 in early 1998	0.934	0.858	0.892	0.059***	−0.034
				(0.021)	(0.026)
Recorded as "dropped out" in early 1998	0.064	0.050	0.030	0.022	0.020
				(0.018)	(0.017)
Females[b]	0.855	0.771	0.789	0.076***	−0.018
				(0.027)	(0.032)
Males	0.844	0.736	0.780	0.088***	−0.044
				(0.031)	(0.037)

	Group 1 (25 schools)	Group 2 (25 schools)	Group 3 (25 schools)		
Panel B: *Second year post-treatment* *(March to November 1999)*	*2nd Year Treatment*	*1st Year Treatment*	*Comparison*	*Group 1 – Group 3*	*Group 2 – Group 3*
Girls <13 years, and all boys	0.713	0.717	0.663	0.050*	0.055*
				(0.028)	(0.028)
Girls ≥14 years[c]	0.627	0.649	0.588	0.039	0.061*
				(0.035)	(0.035)
Preschool, Grade 1, Grade 2 in early 1998	0.692	0.726	0.641	0.051	0.085**
				(0.034)	(0.034)
Grade 3, Grade 4, Grade 5 in early 1998	0.750	0.774	0.725	0.025	0.049**
				(0.023)	(0.023)
Grade 6, Grade 7, Grade 8 in early 1998	0.770	0.777	0.751	0.020	0.026
				(0.027)	(0.028)
Recorded as "dropped out" in early 1998	0.176	0.129	0.056	0.120*	0.073
				(0.063)	(0.053)
Females[b]	0.716	0.746	0.648	0.067**	0.098***
				(0.027)	(0.027)
Males	0.698	0.695	0.655	0.043	0.041
				(0.028)	(0.029)

PSDP's Effect: School Participation

Table IX School Participation, Direct Effects and Externalities
(Dependent Variable: Average Individual School Participation, by Year)

	OLS (1)	OLS (2)	OLS (3)	OLS (4) May 98–March 99	OLS (5) May 98–March 99	OLS (6) May 98–March 99	IV-2SLS (7) May 98–March 99
Moderate-heavy infection, early 1999						−0.028***	−0.203*
						(0.010)	(0.094)
Treatment school (T)	0.051***						
	(0.022)						
First year as treatment school (T1)		0.062***	0.060***	0.062*	0.056***		
		(0.015)	(0.015)	(0.022)	(0.020)		
Second year as treatment school (T2)		0.040*	0.034*				
		(0.021)	(0.021)				
Treatment school pupils within 3 km (per 1000 pupils)			0.044**		0.023		
			(0.022)		(0.036)		
Treatment school pupils within 3–6 km (per 1000 pupils)			−0.014		−0.041		
			(0.015)		(0.027)		
Total pupils within 3 km (per 1000 pupils)			−0.033**		−0.035*	0.018	0.021
			(0.013)		(0.019)	(0.021)	(0.019)
Total pupils within 3–6 km (per 1000 pupils)			−0.010		0.022	−0.010	−0.021
			(0.012)		(0.027)	(0.012)	(0.015)

(Con't)

Indicator received first year of deworming treatment, when offered (1998 for Group 1, 1999 for Group 2)					0.100***		
					(0.014)		
(First year as treatment school Indicator) * (Received treatment, when offered)					−0.012		
					(0.020)		
1996 district exam score, school average	0.063***	0.071***	0.063***	0.058	0.091**	0.021	0.003
	(0.021)	(0.020)	(0.020)	(0.032)	(0.038)	(0.026)	(0.023)
Grade indicators, school assistance controls, and time controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.23	0.23	0.24	0.33	0.36	0.28	–
Root MSE	0.273	0.272	0.272	0.223	0.219	0.150	0.073
Number of observations	56487	56487	56487	18264	18264	2327	49 (schools)
Mean of dependent variable	0.747	0.747	0.747	0.784	0.784	0.884	0.884

PSDP's Effect: Test Scores

Table X **Academic Examinations**, Individual-Level Data

	Dependent variable: ICS Exam Score (normalized by standard)		
	(1)	(2)	(3) Among those who filled in the 1998 pupil survey
Average school participation (during the year of the exam)	0.63***		
	(0.07)		
First year as treatment school (T1)		−0.032	−0.030
		(0.046)	(0.049)
Second year as treatment school (T2)		0.001	0.009
		(0.073)	(0.081)
1996 District exam score, school average	0.74***	0.71***	0.75***
	(0.07)	(0.07)	(0.07)
Grade indicators, school assistance controls, and local pupil density controls	Yes	Yes	Yes
R^2	0.14	0.13	0.15
Root MSE	0.919	0.923	0.916
Number of observations	24958	24958	19072
Mean of dependent variable	0.020	0.020	0.039