Deworming as HIV Prevention for Young Women: Evidence from Zimbabwe

Jon Denton-Schneider (Clark)

January 26, 2023

My Research Agenda

Job market paper: Shows that colonial-era labor policies in Mozambique shape the country's HIV epidemic today

- Internal border: Divided southern Mozambique into 2 labor regimes
- HIV prevalence: Much lower just on one side of border

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Are we prisoners of the past? Or can we reduce major HIV risk factor with historical / cultural roots (i.e., partner age gaps)?

This Paper

HIV status

↑

Marriage market matching (partner age gap)

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Childhood health (very cheap and effective interventions!)

Can cheap improvements in girls' health (e.g., deworming) reduce their chances of contracting HIV as young women?

Roadmap

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   - Theory and evidence: Worms (schistosomiasis) $\rightarrow$ HIV

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   - Rapid morbidity decline in high-schisto schools

3. **Compare: Pre- vs post-deworming in high- vs low-schisto**
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Nationwide Helminthiasis Prevalence Survey (2010-11)

Prevalence Category	*S. haematobium*	*S. Mansoni*	Hookworm	*A. lumbricoides*	*T. trichiura*
Overall prevalence (95%CI)n	18.0 (17.38–18.71) 13037	7.2 (6.74–7.77) 12249	3.2 (2.91–3.54) 12252	2.5 (2.20–2.76)	0.1 (0.07–2.12)
By gender					
Males	20.8 (19.80–21.80) 6417	7.5 (8.82–8.16) 6040	3.4 (3.00–3.90) 6042	2.4 (2.06–2.85)	0.2 (0.1–0.34)
Females	15.4 (14.52–16.27) 6620	6.9 (6.31–7.59) 6209	3.0 (2.62–3.48) 6210	2.5 (2.12–2.92)	0.01 (0.02–0.16)
Rural based Province					
Manicaland	12.8 (11.33–14.30) 2006	14.3 (12.79–15.93) 1978	2.9 (2.19–3.72) 1978*	1.9 (1.32–2.37) *	0.4 (0.17–0.80)*
Mashonaland East	28.1 (25.72–30.54) 1379	6.4 (5.11–7.88) 1268	1.0 (0.55–1.75) 1269	17.8 (15.74–20.03)	0.2 (0.02–0.57)
Mashonaland Central	26.1 (23.46–28.90) 1034	20.4 (18.00–23.04) 1018	0.6 (0.68–0.22) 1018	1.0 (0.47–1.80)	0.4 (0.11–1.00)
Mashonaland West	22.6 (20.35–20.05) 1259	1.1 (0.56–1.79) 1237	1.6 (0.99–2.48) 1238	1.1 (0.56–1.79)	0.0
Masvingo	27.6 (25.68–29.59) 2054	13.9 (13.40–15.48) 1995	6.0 (5.00–7.10) 1995	0.1 (0.01–0.36)	0.1 (0.01–0.36)
Matabeleland North	3.3 (2.29–4.57) 1032	0.5 (0.17–1.20) 967	14.1 (11.93–16.41) 967	(0.0)*	0.0
Matabeleland South	8.7 (6.95–10.65) 946	0.2 (0.03–0.82) 881	(0.0)** 881	(0.0)*	0.0
Midlands	30.5 (27.76–33.42) 1048	0.3 (0.07–0.97) 896	2.7 (1.72–3.96) 896	0.2 (0.03–0.80)	0.0
Urban Based (metropolitan) Provinces					
Harare	9.6 (7.97–11.46) 1154	0.3 (0.06–0.89) 979	1.5 (0.86–2.51) 980	0.5 (0.17–1.29)	0.0
Bulawayo	3.2 (2.09–4.56) 856	0.6 (0.20–1.43) 815	0.1 (0.00–0.68) 815	0.4 (0.08–1.07)	0.0
Chitungwiza	4.8 (2.60–8.12) 269	0.5 (0.01–2.56) 215	1.4 (0.29–4.02) 215	1.9 (0.51–4.69)	0.0

* = For each province, the number of participants screened for hookworms, *A. lumbricoides* and *T. trichiura* was the same.
** = The prevalence of parasite species was 0%, 95%CI could therefore not be calculated.
doi:10.1371/journal.pntd.0003014.t002

Source: Midzi et al. (2014)

Findings: By far, schistosomiasis most common infection ▸ Rural

Rates of Heavy Schistosome Infection

Prevalence Category	*S. Haematobium* infection intensity		*S. mansoni* infection intensity		
	Light	**Heavy**	**Light**	**Moderate**	**Heavy**
Overall prevalence	12.4 (13037)*	5.6	3.6 (12062)*	1.4	0.3
By Gender					
Males	13.9 (6417)	6.8	3.6 (5951)	1.4	0.3
Females	11.0 (6620)	4.4	3.6 (6111)	1.4	0.3
Rural Provinces					
Manicaland	8.6 (2006)	4.2	8.8 (1939)	0.4	0.3
Mashonaland East	19.0 (1378)	9.1	3.7 (1257)	0.8	0.3
Mashonaland Central	18.2 (1034)	7.9	8.9 (1016)	4.5	1.3
Mashonaland West	16.1 (1259)	6.4	0.3 (1197)	0.0	0.1
Masvingo	18.4 (2054)	9.2	5.0 (1916)	1.9	0.6
Matabeleland North	2.8 (1032)	0.5	0.2 (965)	0.0	0.3
Matabeleland South	6.1 (946)	2.5	0.2 (871)	0.0	0.1
Midlands	20.8 (1048)	9.7	0.1 (892)	0.0	0.0
Urban Provinces					
Harare	6.8 (1155)	2.9	1.2 (979)	0.0	0.0
Bulawayo	2.8 (856)	0.5	0.6 (815)	0.0	0.0
Chitungwiza¤	3.7 (267)	0.4	0.9 (215)	0.0	0.0

Source: Midzi et al. (2014)

Heavy infection: Causes most morbidity → *S. haematobium* (urogenital schisto) matters most

Theory: Urogenital Schistosomiasis → HIV

Disease: Inflammatory response to worm eggs getting trapped in nearby tissues → "anaemia, growth stunting, impaired cognition, ... organ-specific effects such as ... urogenital inflammation and scarring" (Colley et al., 2014, p. 2253)

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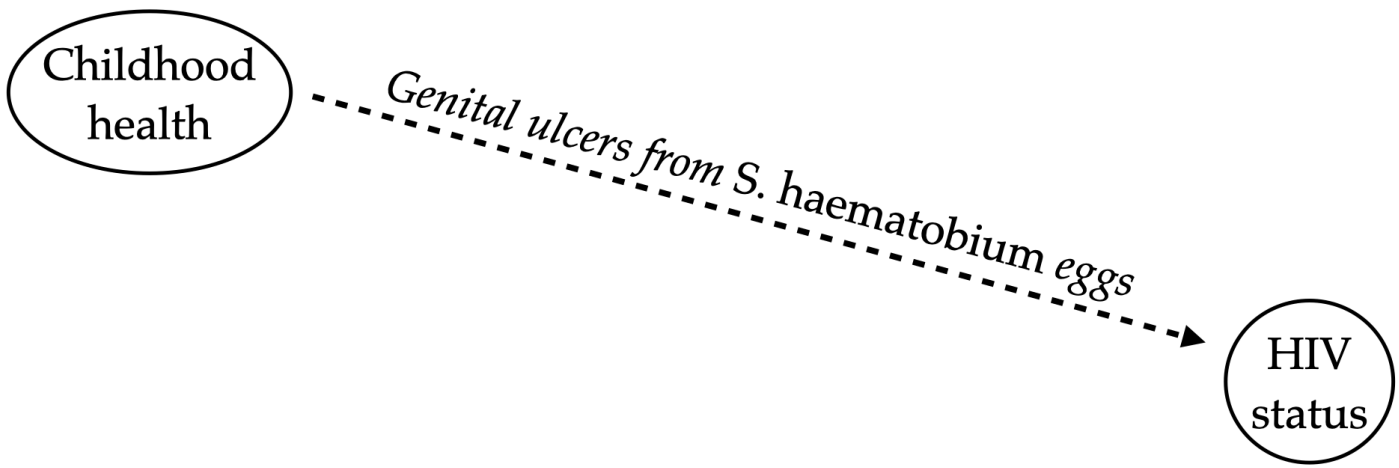

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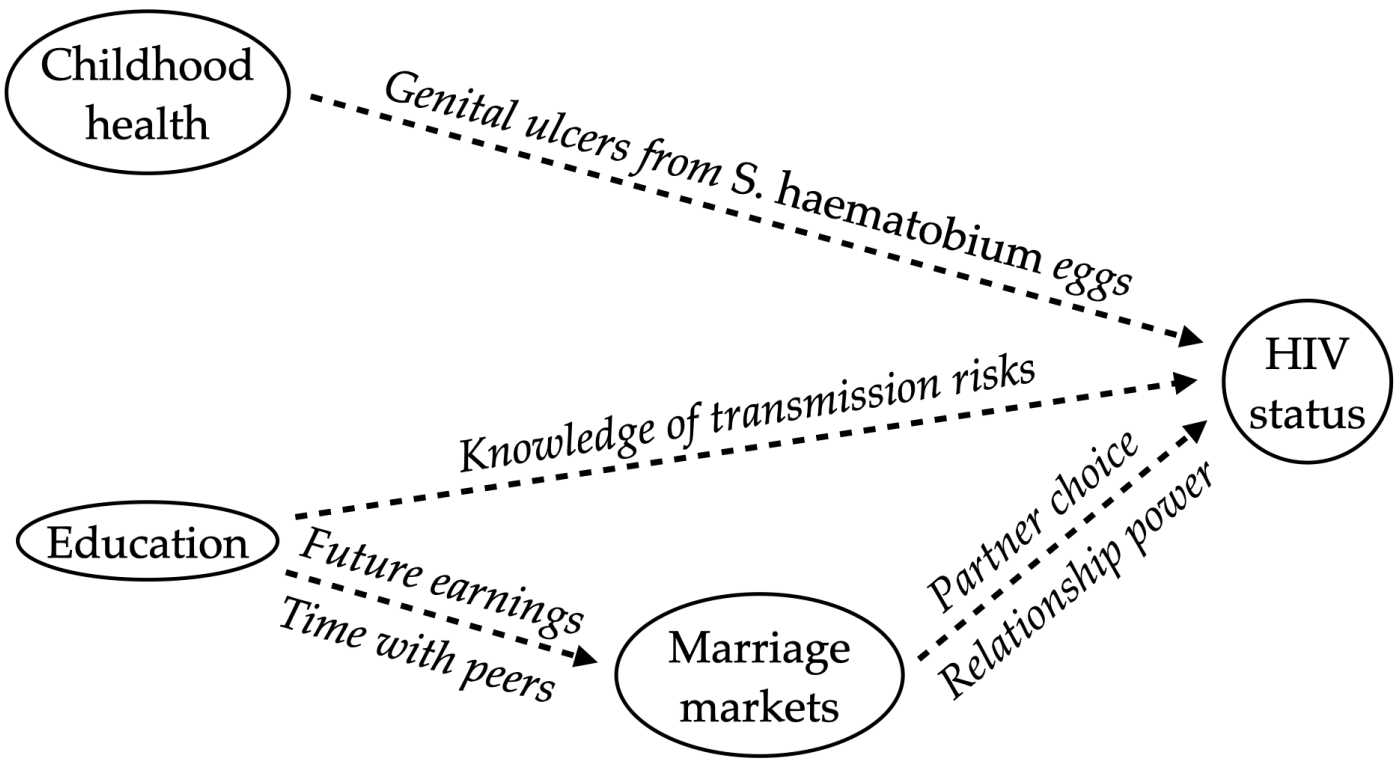

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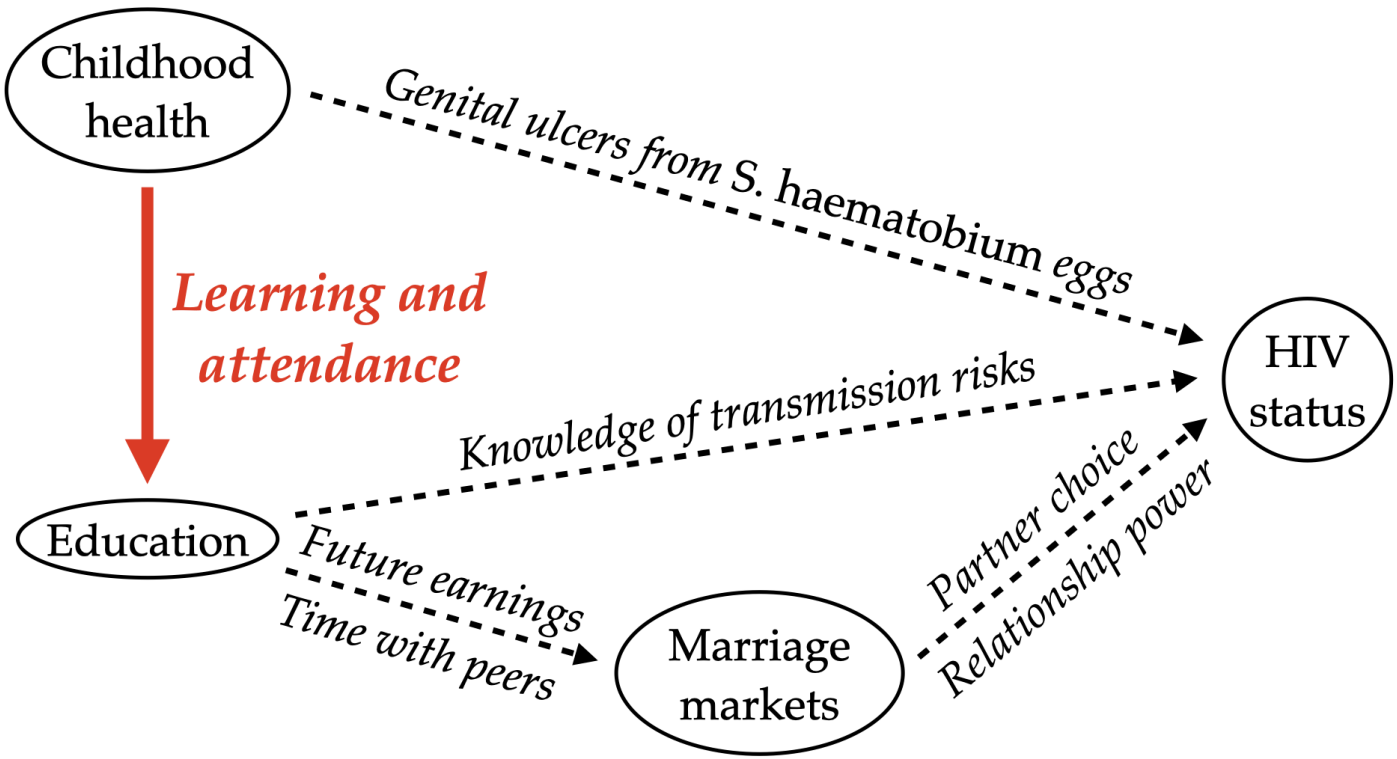
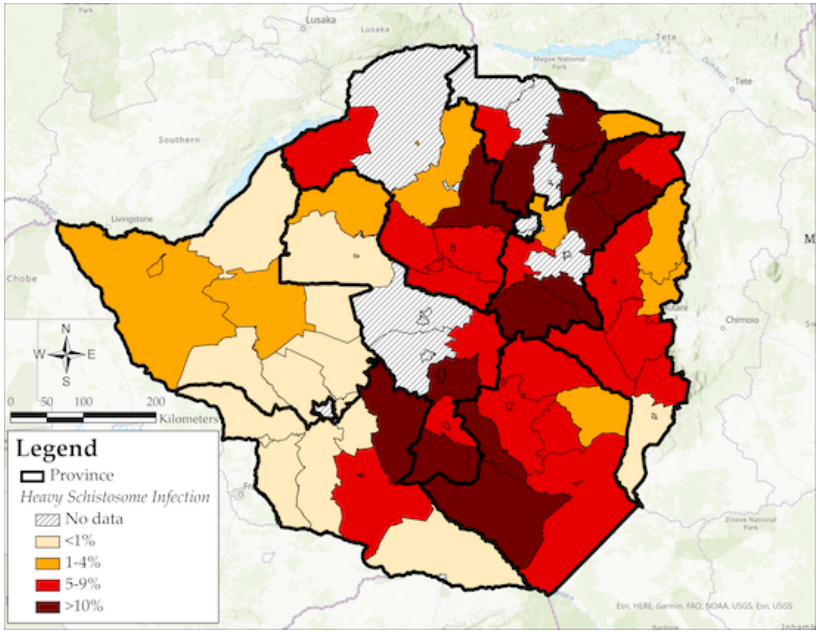
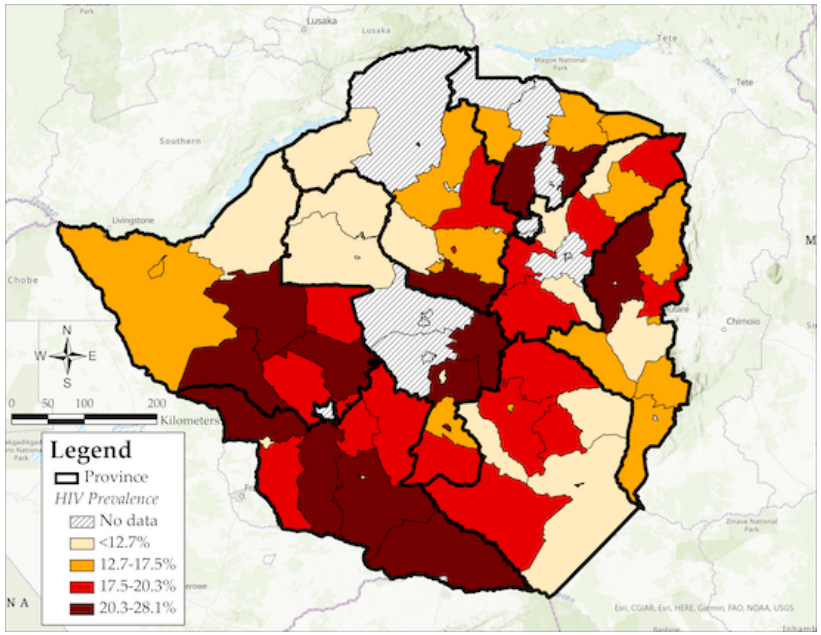


Novel: Linking childhood health to HIV via learning / attendance

Evidence: Urogenital Schistosomiasis → HIV (I)



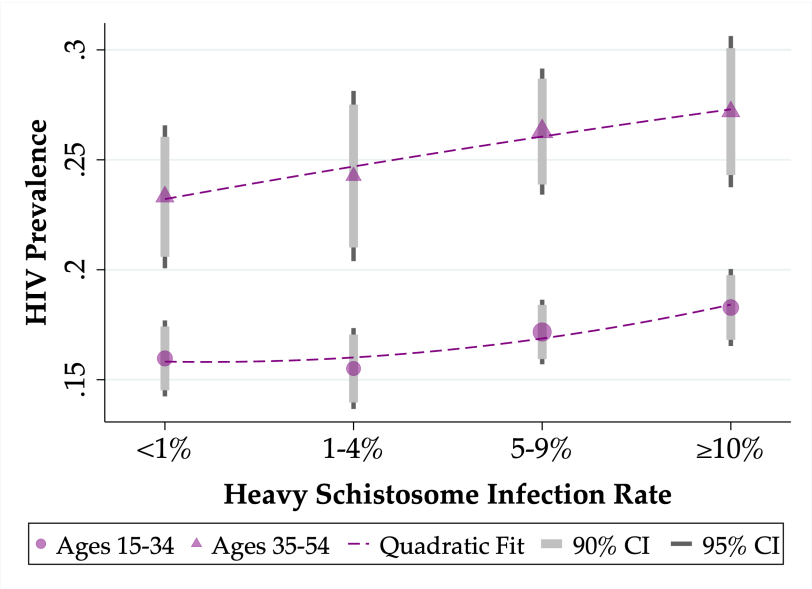
Heavy *S. haematobium* Infection:
Students, 2010
Source: Midzi et al. (2014)



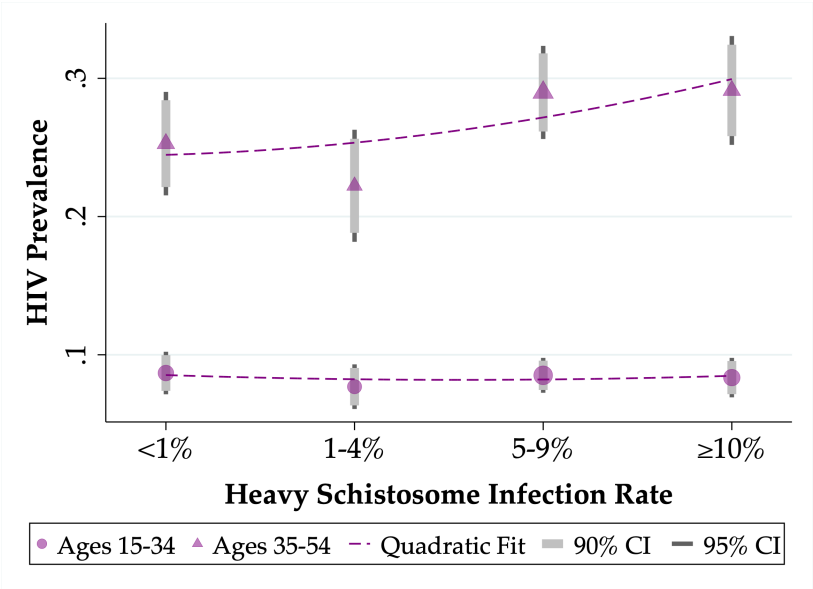
HIV Prevalence:
Ages 15-49, 2005 and 2010
Source: DHS data

Comparison: Clear visual correlation

Evidence: Urogenital Schistosomiasis → HIV (II)



Women



Men

Notes: Plots show HIV prevalence within heavy schistosome infection ranges by sex in 2005 and 2010 for ages 15 to 34 (circles) and 35 to 54 (triangles). Ranges are taken from Midzi et al. (2014). Dashed lines denote fitted quadratic trends, bars denote confidence intervals, and shape sizes reflect the number of respondents in each group.

✓ **Pattern:** These data are consistent with schisto exacerbating HIV transmission cycle driven by age-disparate relationships ▸ Explanation

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Nationwide School-Based Deworming Program

Source: WHO (2012)

Wedza, 17 Sept. 2012 – In line with the new global momentum towards the control, elimination and eradication of neglected tropical diseases (NTDs) , Zimbabwe launched a mass drug administration against schistosomiasis (bilharzia) and soil transmitted helminthes (intestinal worms) at a function held at Wedza High School.

The mass drug administration is the final phase of a process which started with a national prevalence survey in 2010, and the development of the master plan that began in 2011 and completed in 2012.

The National Prevalence Survey of 2010 showed that Mashonaland East Province, under which Wedza district falls was one of the highly affected. The mass drug administration will therefore target people, mainly under the age of 15, and will be delivered through the country ' s network of schools and health facilities in the high burden districts. The mass drug administration was made possible by WHO which donated to the Ministry of Health and Child Welfare Praziquantel (PZQ) used in the treatment of bilharzia, and Albendazole (ALB) for intestinal worms. A total of 2 583 000 PZQ tablets (600mg) , and 2 450 200 ALB tablets (400mg) were donated. These drugs are expected to cover 3 794 638 people mainly under the age of 15 in the high burden districts.

End of 2012 school year: Mass deworming began in schools

$\rightarrow$ Targeted high-burden districts, "mainly under the age of 15"

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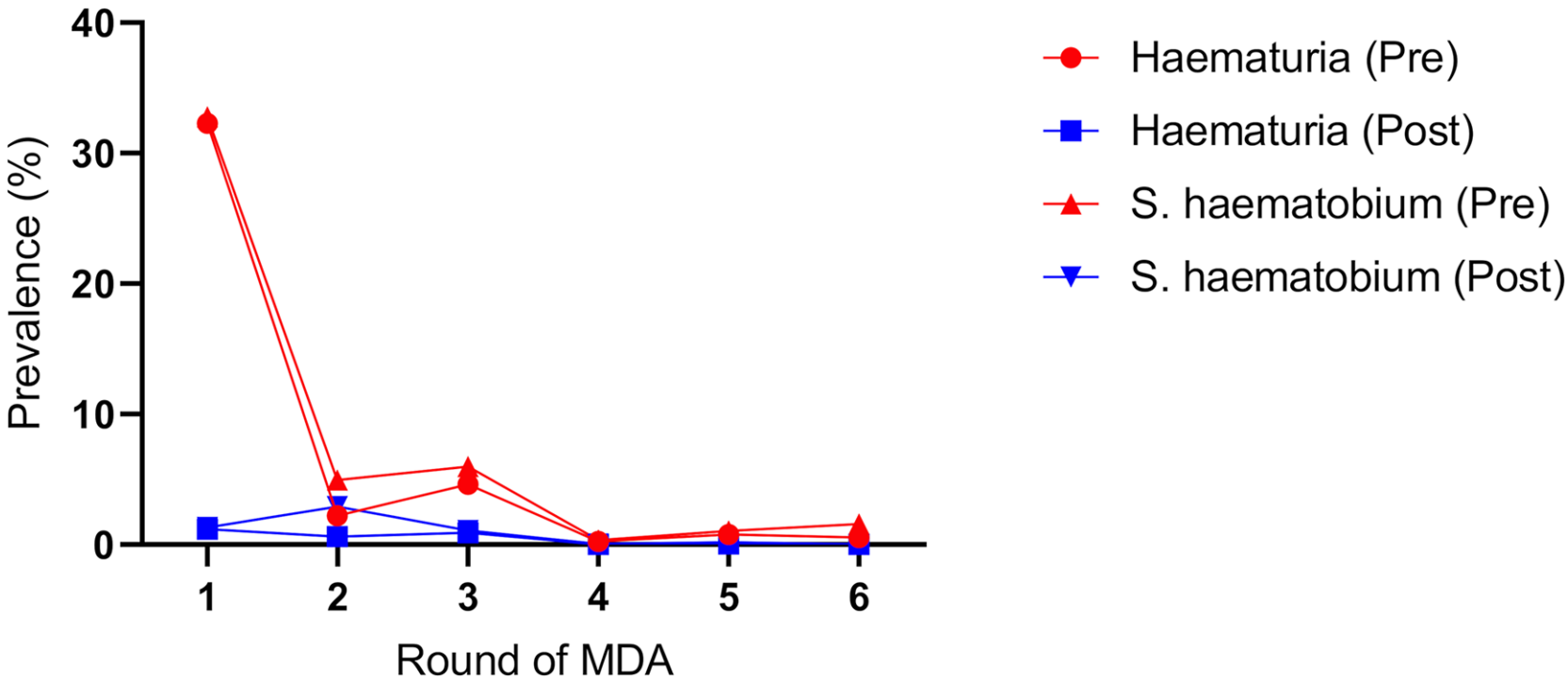
$\rightarrow$ Planned to treat 3.8 million students (est. 5.2 million under age 15)

Rapid Reductions in Schisto Morbidity



Source: Mduluza et al. (2020)

2012-17: 6 years of mass drug administration (MDA) in schools

Tracked prevalence in sentinel sites (mostly high-schisto areas)

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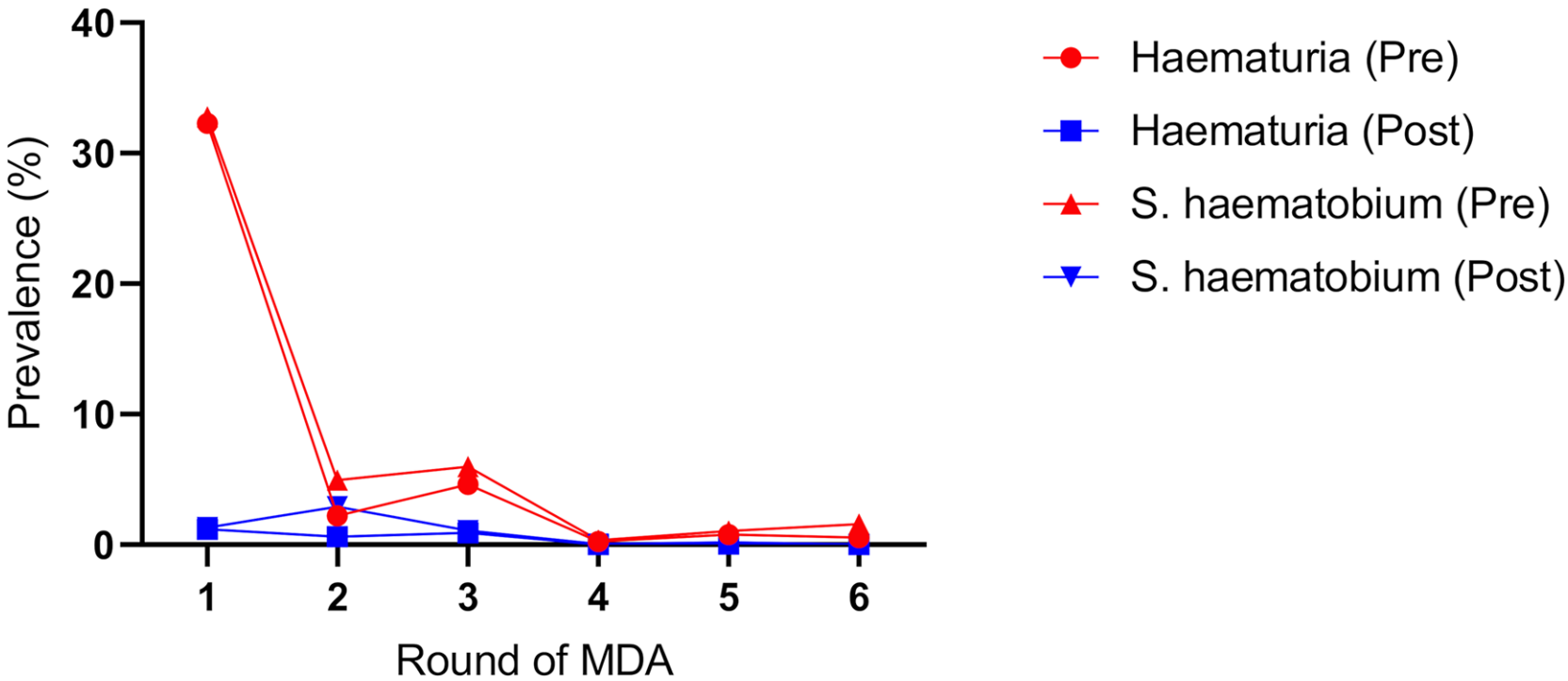

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2012-17: 6 years of mass drug administration (MDA) in schools

→ Almost all of morbidity reduction occurred in first round (2012)

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Quick Detour into Econometrics (No Math! Just Graphs)

Ideal setup for determining causality: Randomized control trial

- Randomization: Groups are balanced on all dimensions $\rightarrow$ control group is ideal counterfactual for treatment group
- Real world: Rare to have policy implemented randomly

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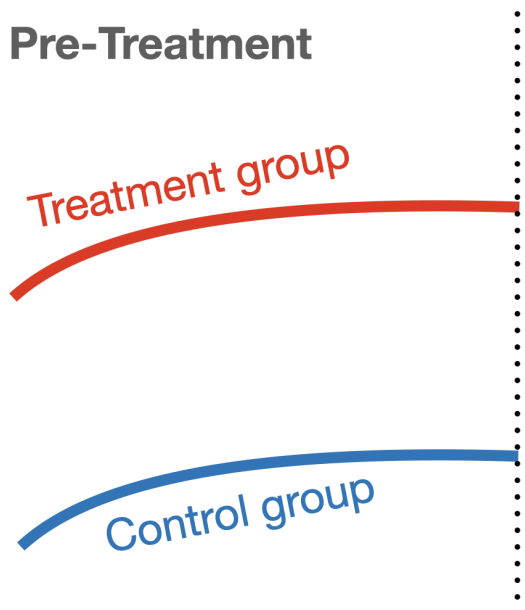

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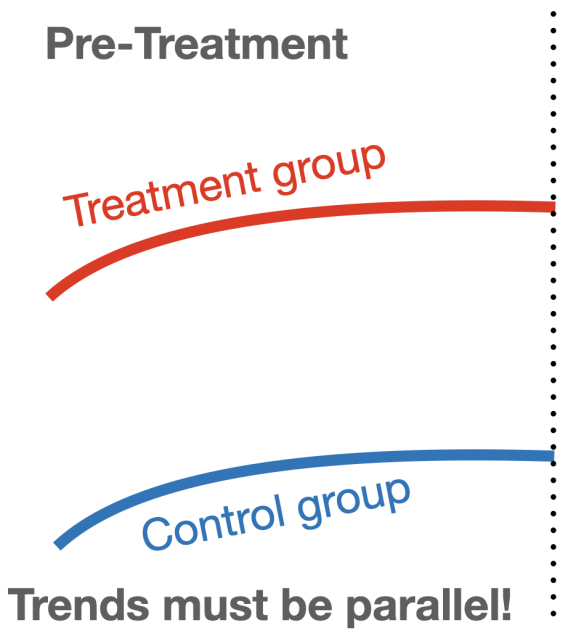

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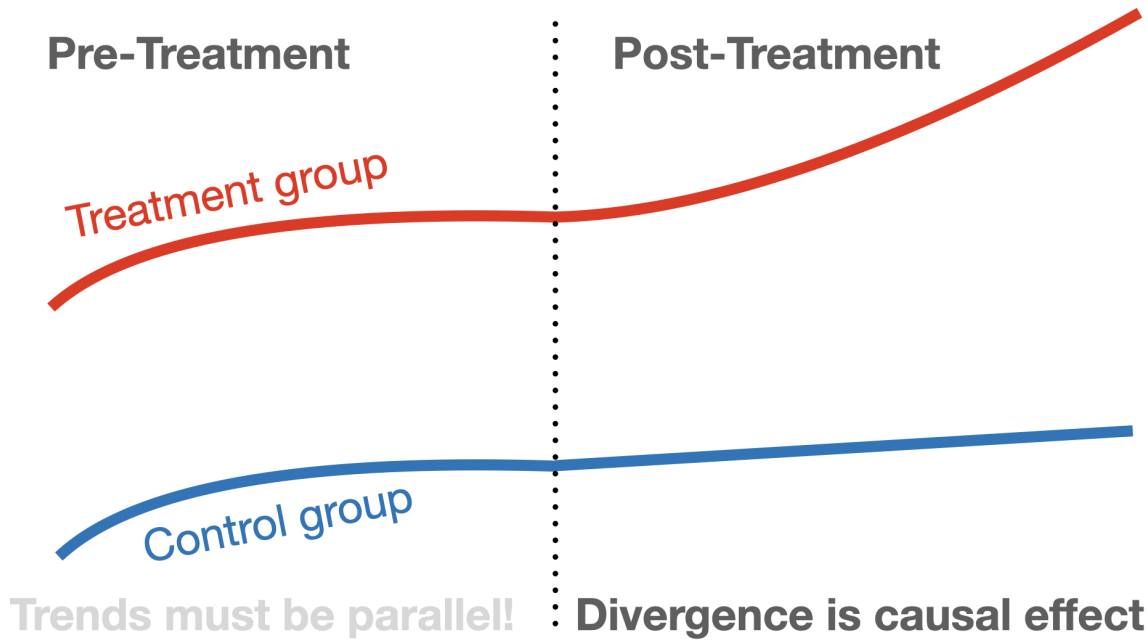

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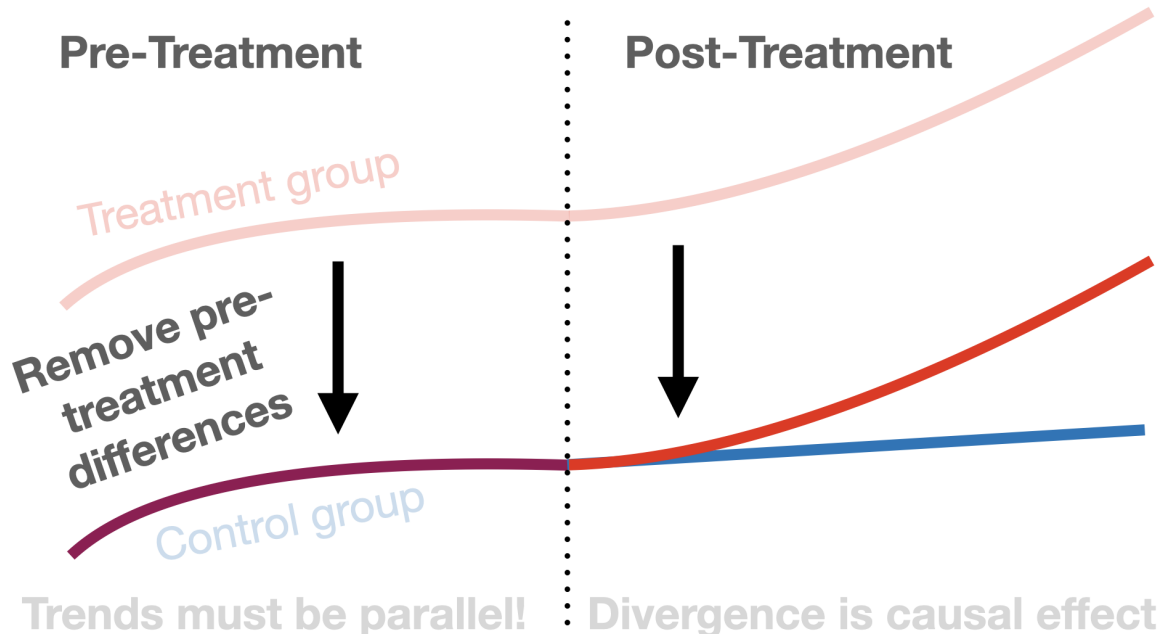

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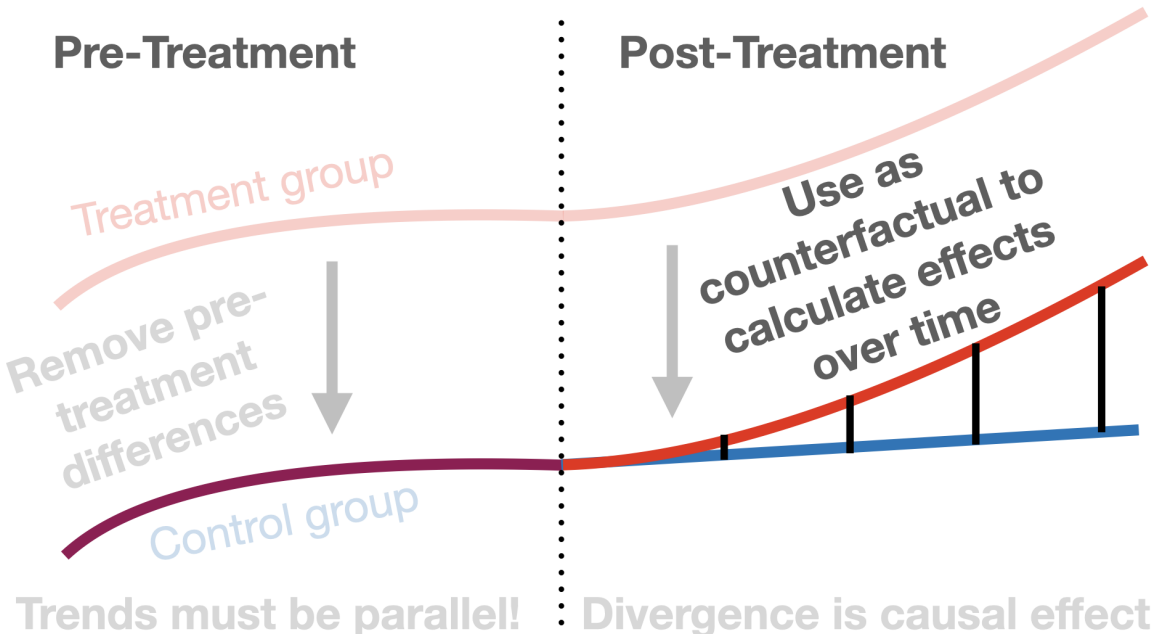

Defining "Treatment" and "Control" Groups

Prevalence category	Districts (IUs)	Comments and intervention strategies
≥10%	Murehwa, Shamva, Mwenezi, Shurugwi, Chikomba, Mutoko, UMP, Hwedza, Mazowe, Mt. Darwin, Zvimba, Chivi, Insiza, Mberengwa (n = 14)	Morbidity is highest, highest transmitting districts. Highest priority requiring uninterrupted intensified PCT with annual geographic coverage of 100% per district. Complementary strategies urgently required. The goal is to control morbidity (reduce prevalence of heavy infection by any schistosome to <5%) in the first 5 years and prevent transmission.
≥5% but <10%	Buhera, Chimanimani, Makoni, Mutare, Mudzi, Seke, Guruve, Muzarabani, Chegutu, Kariba, Kadoma, Chiredzi, Gutu, Masvingo, Zaka, Gwanda, Chirumhanzu, Zvishavane (n = 18)	Morbidity is high. High transmitting districts requiring MDA regularly according to WHO strategies with geographic coverage of 75–100% per district. Complementary strategies are required. The goal is to control morbidity by reducing the prevalence of heavy infection by any schistosome species in the first 5 years to <5% and prevent transmission.
≥1% but <5%	Mutasa, Nyanga, Goromonzi, Marondera, Rushinga, Makonde, Karoyi, Bikita, Hwange, Lupane, Gokwe North, Glenview/Mufakose, Highfields/Glen Norah, Marlbereign/Warren Park, Mabvuku/Tafara, Chitungwiza-Zengeza, Mbare/Hatfield, Khami (n = 17)	Morbidity is moderate though unjustifiable. Moderate transmitting districts. Regular MDA according to WHO guidelines based on prevalence. In addition, identification of transmission foci for intensified PCT is recommended. Complementary strategies are required. The goal is to eliminate schistosomiasis as a public health problem.
<1%	Chipinge, Binga, Beitbridge, Chitungwiza-Seke (n = 4)	Morbidity is low. Low transmitting districts. PCT to be implemented according to WHO guidelines. In addition, monitoring and surveillance of schistosomaisis transmitting foci for intensified PCT is recommended. Complementary strategies are required. The goal is to interrupt transmission.
0%	Bubi, Nkayi, Tsholotsho, Umguza, Bulilima, Matobo, Magwe, Umzingwane, Gokwe South, Reigate, Imbizo, Mzilikazi, Sizinda, North Central (n = 15)	Detailed surveillance should be done to identify any transmitting foci for intensified PCT. Complementary strategies are required. The goal is to interrupt schistosomiasis.

Source: Midzi et al. (2014)

All districts treated simultaneously: "High schisto" vs "low schisto"

→ Treatment guidelines based on heavy infection rates

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≥1% but <5%	Mutasa, Nyanga, Goromonzi, Marondera, Rushinga, Makonde, Karoyi, Bikita, Hwange, Lupane, Gokwe North, Glenview/Mufakose, Highfields/Glen Norah, Marlbereign/Warren Park, Mabvuku/Tafara, Chitungwiza-Zengeza, Mbare/Hatfield, Khami (n = 17)	Morbidity is moderate though unjustifiable. Moderate transmitting districts. Regular MDA according to WHO guidelines based on prevalence. In addition, identification of transmission foci for intensified PCT is recommended. Complementary strategies are required. The goal is to eliminate schistosomiasis as a public health problem.
<1%	Chipinge, Binga, Beitbridge, Chitungwiza-Seke (n = 4)	Morbidity is low. Low transmitting districts. PCT to be implemented according to WHO guidelines. In addition, monitoring and surveillance of schistosomaisis transmitting foci for intensified PCT is recommended. Complementary strategies are required. The goal is to interrupt transmission.
0%	Bubi, Nkayi, Tsholotsho, Umguza, Bulilima, Matobo, Magwe, Umzingwane, Gokwe South, Reigate, Imbizo, Mzilikazi, Sizinda, North Central (n = 15)	Detailed surveillance should be done to identify any transmitting foci for intensified PCT. Complementary strategies are required. The goal is to interrupt schistosomiasis.

Source: Midzi et al. (2014)

All districts treated simultaneously: "High schisto" vs "low schisto"

→ Treatment guidelines based on heavy infection rates

Defining "Treatment" and "Control" Groups

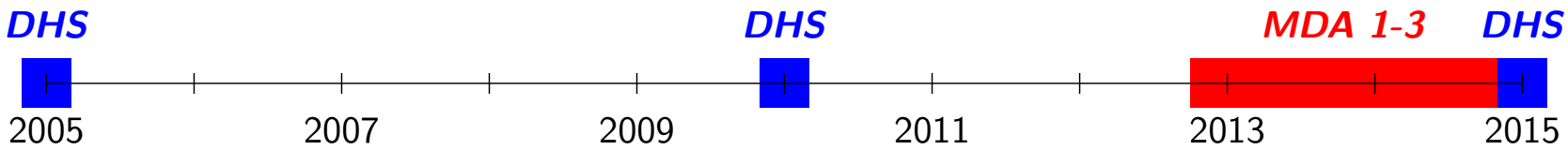
Prevalence category	Districts (IUs)	Comments and intervention strategies
≥10%	Murehwa, Shamva, Mwenezi, Shurugwi, Chikomba, Mutoko, UMP, Hwedza, Mazowe, Mt. Darwin, Zvimba, Chivi, Insiza, Mberengwa (n = 14)	Morbidity is highest, highest transmitting districts. Highest priority requiring uninterrupted intensified PCT with annual geographic coverage of 100% per district. Complementary strategies urgently required. The goal is to control morbidity (reduce prevalence of heavy infection by any schistosome to <5%) in the first 5 years and prevent transmission.
≥5% but <10%	Buhera, Chimanimani, Makoni, Mutare, Mudzi, Seke, Guruve, Muzarabani, Chegutu, Kariba, Kadoma, Chiredzi, Gutu, Masvingo, Zaka, Gwanda, Chirumhanzu, Zvishavane (n = 18)	Morbidity is high. High transmitting districts requiring MDA regularly according to WHO strategies with geographic coverage of 75–100% per district. Complementary strategies are required. The goal is to control morbidity by reducing the prevalence of heavy infection by any schistosome species in the first 5 years to <5% and prevent transmission.
≥1% but <5%	Mutasa, Nyanga, Goromonzi, Marondera, Rushinga, Makonde, Karoyi, Bikita, Hwange, Lupane, Gokwe North, Glenview/Mufakose, Highfields/Glen Norah, Marlbereign/Warren Park, Mabvuku/Tafara, Chitungwiza-Zengeza, Mbare/Hatfield, Khami (n = 17)	Morbidity is moderate though unjustifiable. Moderate transmitting districts. Regular MDA according to WHO guidelines based on prevalence. In addition, identification of transmission foci for intensified PCT is recommended. Complementary strategies are required. The goal is to eliminate schistosomiasis as a public health problem.
<1%	Chipinge, Binga, Beitbridge, Chitungwiza-Seke (n = 4)	Morbidity is low. Low transmitting districts. PCT to be implemented according to WHO guidelines. In addition, monitoring and surveillance of schistosomaisis transmitting foci for intensified PCT is recommended. Complementary strategies are required. The goal is to interrupt transmission.
0%	Bubi, Nkayi, Tsholotsho, Umguza, Bulilima, Matobo, Magwe, Umzingwane, Gokwe South, Reigate, Imbizo, Mzilikazi, Sizinda, North Central (n = 15)	Detailed surveillance should be done to identify any transmitting foci for intensified PCT. Complementary strategies are required. The goal is to interrupt schistosomiasis.

Source: Midzi et al. (2014)

All districts treated simultaneously: "High schisto" vs "low schisto"

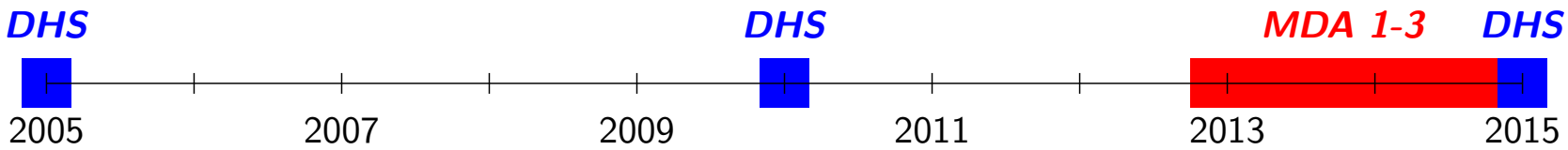
$\rightarrow$ "High" $\geq$ 5% heavy infection (N = 43), "low" $<$ 5% (N = 28)

Empirical Strategy: Diff-in-Diff



Compare: High- vs low-schisto areas, before vs after deworming

Empirical Strategy: Diff-in-Diff

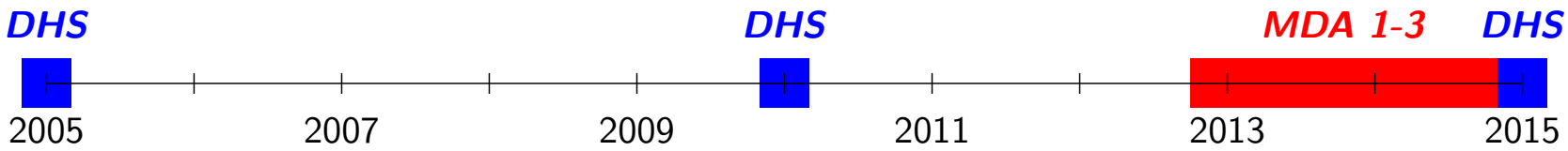


Compare: High- vs low-schisto areas, before vs after deworming

Age-specific focus: Ages 12-17 in 2012 $\rightarrow$ ages 15-20 in 2015

- 17 is last age at which most boys and girls were in school

Empirical Strategy: Diff-in-Diff



Compare: High- vs low-schisto areas, before vs after deworming

Age-specific focus: Ages 12-17 in 2012 $\rightarrow$ ages 15-20 in 2015

- 17 is last age at which most boys and girls were in school

Robustness and credibility

- Upper end of age range may have migrated, schisto more prevalent in rural areas $\rightarrow$ check for same effects among rural women ages 15-18
- Ages 18-21 in 2012 (ages 21-24 in 2015) similar but "mostly unexposed" to deworming $\rightarrow$ use women ages 21-24 as placebo test

Effect of Deworming on Young Adults' HIV Prevalence

	Positive HIV Blood Test					
	Ages 15-20		Women 15-18		Ages 21-24	
	Women	Men	All	Rural	Women	Men
	(1)	(2)	(3)	(4)	(5)	(6)
2005 × High	-0.001	0.037	0.007	-0.007	-0.045	0.007
	(0.019)	(0.022)	(0.022)	(0.022)	(0.027)	(0.034)
2015 × High	-0.029	0.041	-0.036	-0.040	-0.009	0.005
	(0.017)	(0.031)	(0.020)	(0.027)	(0.037)	(0.035)
Observations	4,309	4,126	3,011	2,499	2,435	1,559
Districts	71	71	71	54	71	70
Pre-Deworming Mean (High=1)	0.064	0.027	0.050	0.041	0.151	0.066

Notes: Estimates and bootstrapped standard errors (in parentheses) are obtained using the procedure developed by de Chaisemartin and D'Haultfœuille (2020). Observations are clustered by district. High equals 1 if a district had high or the highest pre-deworming rates of heavy schistosome infection, and 0 otherwise. Regressions control for age, age squared, altitude, and a quadratic in latitude and longitude.

Column 1: Young women's HIV ↓ 45% (2.9 p.p.) more

Effect of Deworming on Young Adults' HIV Prevalence

	Positive HIV Blood Test					
	Ages 15-20		Women 15-18		Ages 21-24	
	Women	Men	All	Rural	Women	Men
	(1)	(2)	(3)	(4)	(5)	(6)
2005 × High	-0.001	0.037	0.007	-0.007	-0.045	0.007
	(0.019)	(0.022)	(0.022)	(0.022)	(0.027)	(0.034)
2015 × High	-0.029	0.041	-0.036	-0.040	-0.009	0.005
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Column 2: No evidence of HIV effect for young men

Effect of Deworming on Young Adults' HIV Prevalence

	Positive HIV Blood Test					
	Ages 15-20		Women 15-18		Ages 21-24	
	Women	Men	All	Rural	Women	Men
	(1)	(2)	(3)	(4)	(5)	(6)
2005 × High	-0.001	0.037	0.007	-0.007	-0.045	0.007
	(0.019)	(0.022)	(0.022)	(0.022)	(0.027)	(0.034)
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Notes: Estimates and bootstrapped standard errors (in parentheses) are obtained using the procedure developed by de Chaisemartin and D'Haultfœuille (2020). Observations are clustered by district. High equals 1 if a district had high or the highest pre-deworming rates of heavy schistosome infection, and 0 otherwise. Regressions control for age, age squared, altitude, and a quadratic in latitude and longitude.

Columns 3-4: Robust to women 15-18, rural restrictions

Effect of Deworming on Young Adults' HIV Prevalence

	Positive HIV Blood Test					
	Ages 15-20		Women 15-18		Ages 21-24	
	Women	Men	All	Rural	Women	Men
	(1)	(2)	(3)	(4)	(5)	(6)
2005 × High	-0.001	0.037	0.007	-0.007	-0.045	0.007
	(0.019)	(0.022)	(0.022)	(0.022)	(0.027)	(0.034)
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Notes: Estimates and bootstrapped standard errors (in parentheses) are obtained using the procedure developed by de Chaisemartin and D'Haultfœuille (2020). Observations are clustered by district. High equals 1 if a district had high or the highest pre-deworming rates of heavy schistosome infection, and 0 otherwise. Regressions control for age, age squared, altitude, and a quadratic in latitude and longitude.

Columns 5-6: No effects detected in placebo tests

Effect of Deworming on Components of Human Capital

	Anemic		Attending School			
					Rural Women	
	Women 15-20	Men 15-20	Women 13-18	Men 13-18	13-18	15-18
	(1)	(2)	(3)	(4)	(5)	(6)
2005 × High	-0.013	0.007	-0.020	-0.004	-0.025	-0.022
	(0.041)	(0.032)	(0.037)	(0.030)	(0.041)	(0.059)
2015 × High	0.022	-0.035	0.068	0.004	0.072	0.074
	(0.049)	(0.035)	(0.038)	(0.037)	(0.044)	(0.063)
Observations	4,521	4,368	6,261	6,606	5,310	3,060
Districts	71	71	71	71	54	54
Pre-Deworming Mean (High=1)	0.290	0.102	0.669	0.718	0.679	0.514

Notes: Estimates and bootstrapped standard errors (in parentheses) are obtained using the procedure developed by de Chaisemartin and D'Haultfœuille (2020). Observations are clustered by district. High equals 1 if a district had high or the highest pre-deworming rates of heavy schistosome infection, and 0 otherwise. Regressions control for age, age squared, altitude, and a quadratic in latitude and longitude.

Columns 1-2: Some evidence of an anemia effect for men

Effect of Deworming on Components of Human Capital

	Anemic		Attending School			
					Rural Women	
	Women 15-20	Men 15-20	Women 13-18	Men 13-18	13-18	15-18
	(1)	(2)	(3)	(4)	(5)	(6)
2005 × High	-0.013	0.007	-0.020	-0.004	-0.025	-0.022
	(0.041)	(0.032)	(0.037)	(0.030)	(0.041)	(0.059)
2015 × High	0.022	-0.035	0.068	0.004	0.072	0.074
	(0.049)	(0.035)	(0.038)	(0.037)	(0.044)	(0.063)
Observations	4,521	4,368	6,261	6,606	5,310	3,060
Districts	71	71	71	71	54	54
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Notes: Estimates and bootstrapped standard errors (in parentheses) are obtained using the procedure developed by de Chaisemartin and D'Haultfœuille (2020). Observations are clustered by district. High equals 1 if a district had high or the highest pre-deworming rates of heavy schistosome infection, and 0 otherwise. Regressions control for age, age squared, altitude, and a quadratic in latitude and longitude.

Column 3: Young women's attendance ↑ 10% (6.8 p.p.) more

Effect of Deworming on Components of Human Capital

	Anemic		Attending School			
					Rural Women	
	Women 15-20	Men 15-20	Women 13-18	Men 13-18	13-18	15-18
	(1)	(2)	(3)	(4)	(5)	(6)
2005 × High	-0.013	0.007	-0.020	-0.004	-0.025	-0.022
	(0.041)	(0.032)	(0.037)	(0.030)	(0.041)	(0.059)
2015 × High	0.022	-0.035	0.068	0.004	0.072	0.074
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Column 4: No school effect for young men (as in Baird et al., 2016)

Effect of Deworming on Components of Human Capital

	Anemic		Attending School			
					Rural Women	
	Women 15-20	Men 15-20	Women 13-18	Men 13-18	13-18	15-18
	(1)	(2)	(3)	(4)	(5)	(6)
2005 × High	-0.013	0.007	-0.020	-0.004	-0.025	-0.022
	(0.041)	(0.032)	(0.037)	(0.030)	(0.041)	(0.059)
2015 × High	0.022	-0.035	0.068	0.004	0.072	0.074
	(0.049)	(0.035)	(0.038)	(0.037)	(0.044)	(0.063)
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Columns 5-6: Robust to women 15-18, rural restrictions

Effect of Deworming on HIV Risks (Women 15-20)

	Know Reduces Risk		Partner Age Gap		≥2 Sex Partners	Condom Last Sex
	1 Partner	Condom	≥9 Years	5-8 Years		
	(1)	(2)	(3)	(4)	(5)	(6)
2005 × High	-0.031	0.004	-0.061	-0.002	-0.008	-0.012
	(0.035)	(0.052)	(0.098)	(0.092)	(0.021)	(0.047)
2015 × High	0.011	0.090	-0.221	0.194	-0.027	-0.042
	(0.042)	(0.041)	(0.083)	(0.113)	(0.024)	(0.044)
Observations	4,679	4,677	1,308	1,308	4,861	1,778
Districts	71	71	70	70	71	70
Pre-Deworming Mean (High=1)	0.814	0.717	0.265	0.400	0.077	0.091

Notes: Estimates and bootstrapped standard errors (in parentheses) are obtained using the procedure developed by de Chaisemartin and D'Haultfœuille (2020). Observations are clustered by district. High equals 1 if a district had high or the highest pre-deworming rates of heavy schistosome infection, and 0 otherwise. Regressions control for age, age squared, altitude, and a quadratic in latitude and longitude.

Column 1: No effect on knowing monogamy reduces risk

Effect of Deworming on HIV Risks (Women 15-20)

	Know Reduces Risk		Partner Age Gap		≥2 Sex Partners	Condom Last Sex
	1 Partner	Condom	≥9 Years	5-8 Years		
	(1)	(2)	(3)	(4)	(5)	(6)
2005 × High	-0.031	0.004	-0.061	-0.002	-0.008	-0.012
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Column 2: Knowing condoms reduce risk ↑ 13% (9.0 p.p.) more

Effect of Deworming on HIV Risks (Women 15-20)

	Know Reduces Risk		Partner Age Gap		≥2 Sex Partners	Condom Last Sex
	1 Partner	Condom	≥9 Years	5-8 Years		
	(1)	(2)	(3)	(4)	(5)	(6)
2005 × High	-0.031	0.004	-0.061	-0.002	-0.008	-0.012
	(0.035)	(0.052)	(0.098)	(0.092)	(0.021)	(0.047)
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Column 3: Age gap above 75 pctile ↓ 84% (22.1 p.p.) more

Effect of Deworming on HIV Risks (Women 15-20)

	Know Reduces Risk		Partner Age Gap		≥2 Sex Partners	Condom Last Sex
	1 Partner	Condom	≥9 Years	5-8 Years		
	(1)	(2)	(3)	(4)	(5)	(6)
2005 × High	-0.031	0.004	-0.061	-0.002	-0.008	-0.012
	(0.035)	(0.052)	(0.098)	(0.092)	(0.021)	(0.047)
2015 × High	0.011	0.090	-0.221	0.194	-0.027	-0.042
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Notes: Estimates and bootstrapped standard errors (in parentheses) are obtained using the procedure developed by de Chaisemartin and D'Haultfœuille (2020). Observations are clustered by district. High equals 1 if a district had high or the highest pre-deworming rates of heavy schistosome infection, and 0 otherwise. Regressions control for age, age squared, altitude, and a quadratic in latitude and longitude.

Column 4: Age gap in 50-75 pctile ↑ 49% (19.4 p.p.) more

Effect of Deworming on HIV Risks (Women 15-20)

	Know Reduces Risk		Partner Age Gap		≥2 Sex Partners	Condom Last Sex
	1 Partner	Condom	≥9 Years	5-8 Years		
	(1)	(2)	(3)	(4)	(5)	(6)
2005 × High	-0.031	0.004	-0.061	-0.002	-0.008	-0.012
	(0.035)	(0.052)	(0.098)	(0.092)	(0.021)	(0.047)
2015 × High	0.011	0.090	-0.221	0.194	-0.027	-0.042
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Notes: Estimates and bootstrapped standard errors (in parentheses) are obtained using the procedure developed by de Chaisemartin and D'Haultfœuille (2020). Observations are clustered by district. High equals 1 if a district had high or the highest pre-deworming rates of heavy schistosome infection, and 0 otherwise. Regressions control for age, age squared, altitude, and a quadratic in latitude and longitude.

Column 5: Having 2+ partners in lifetime ↓ 25% (2.7 p.p.) more

Effect of Deworming on HIV Risks (Women 15-20)

	Know Reduces Risk		Partner Age Gap		≥2 Sex Partners	Condom Last Sex
	1 Partner	Condom	≥9 Years	5-8 Years		
	(1)	(2)	(3)	(4)	(5)	(6)
2005 × High	-0.031	0.004	-0.061	-0.002	-0.008	-0.012
	(0.035)	(0.052)	(0.098)	(0.092)	(0.021)	(0.047)
2015 × High	0.011	0.090	-0.221	0.194	-0.027	-0.042
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Districts	71	71	70	70	71	70
Pre-Deworming Mean (High=1)	0.814	0.717	0.265	0.400	0.077	0.091

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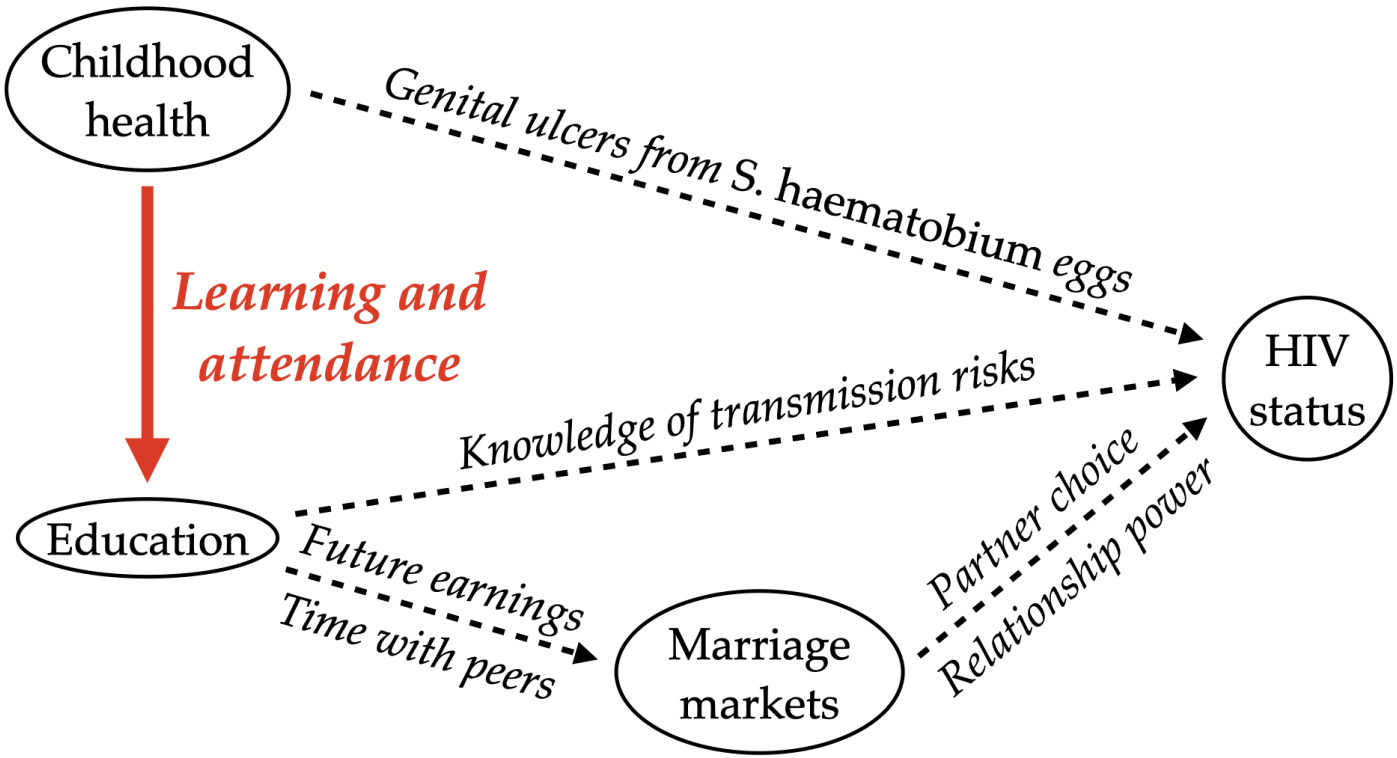
Column 6: Surprise! Condom use ↓ more, but not significant

Summary: Revisiting Hypotheses



Novel: Linking childhood health to HIV via learning / attendance and its effects on marriage market matching

Conclusion

1. **Childhood health:** Improving it for girls lowers their chances of contracting HIV as young women, most likely by increasing their human capital, which changes their marriage market matches

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Conclusion

1. **Childhood health:** Improving it for girls lowers their chances of contracting HIV as young women, most likely by increasing their human capital, which changes their marriage market matches

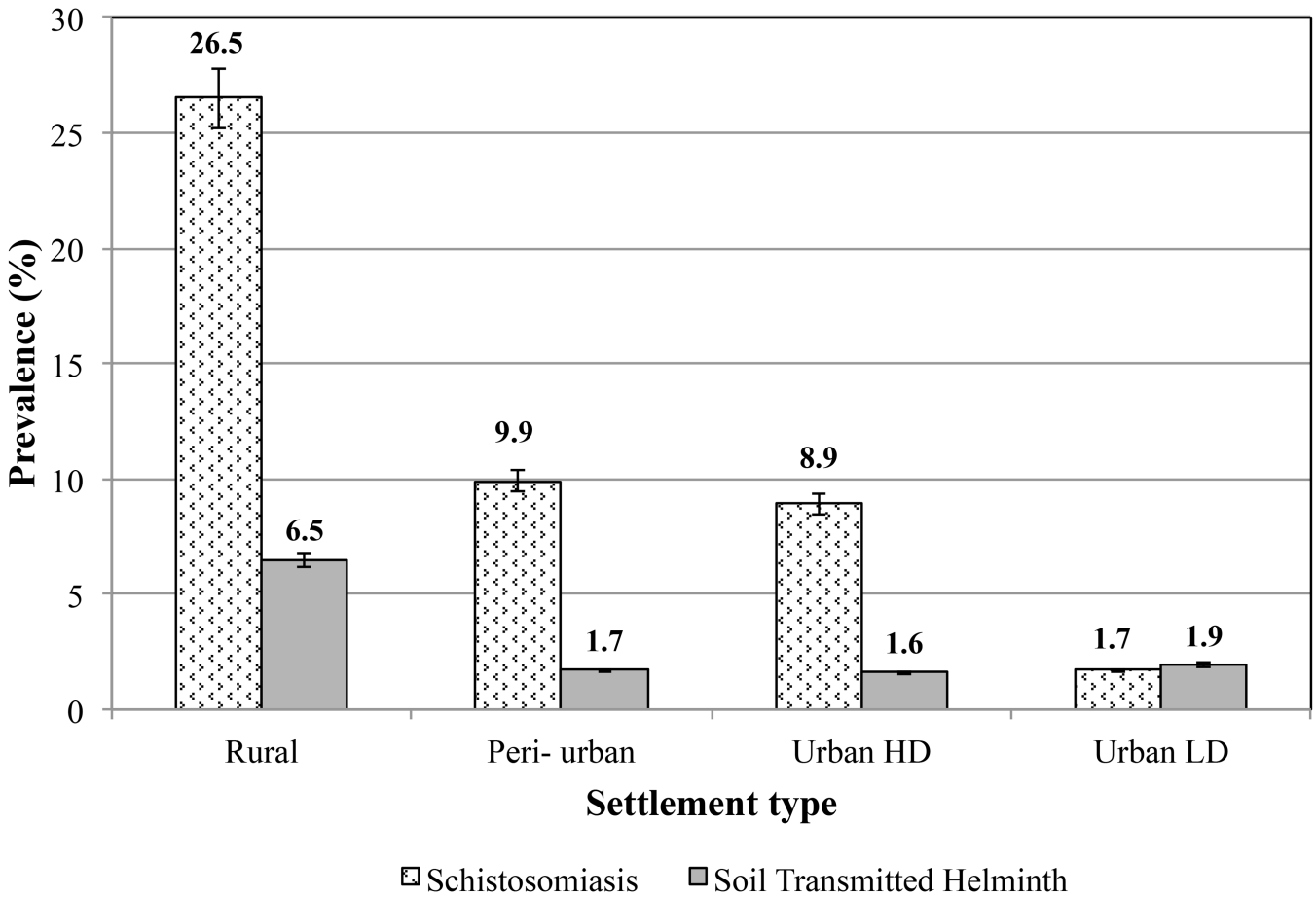
2. **Cost-effectiveness:** Very cheap to improve childhood health $\rightarrow$ potentially very cheap to avert (very expensive) HIV infections for high-risk group

3. **Marriage markets:** Helps us understand role of childhood health (as part of human capital), especially in non-Western context

Roadmap

4. **Appendix Slides**

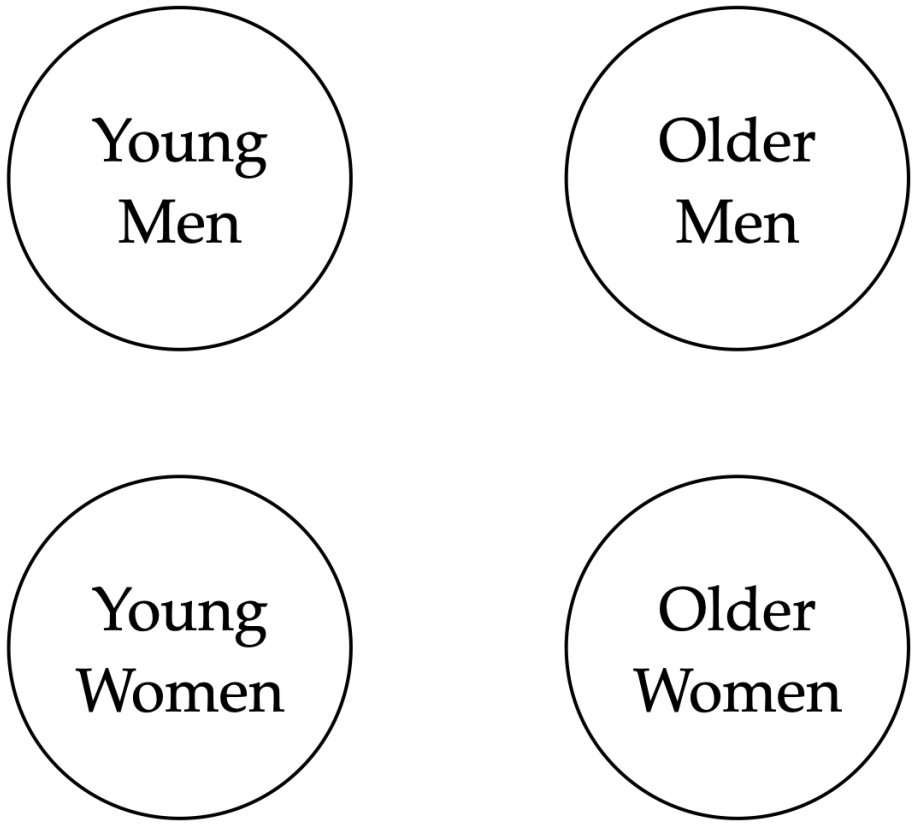
Appendix: Helminths More Common in Rural Areas



Source: Midzi et al. (2014)

◂ Back

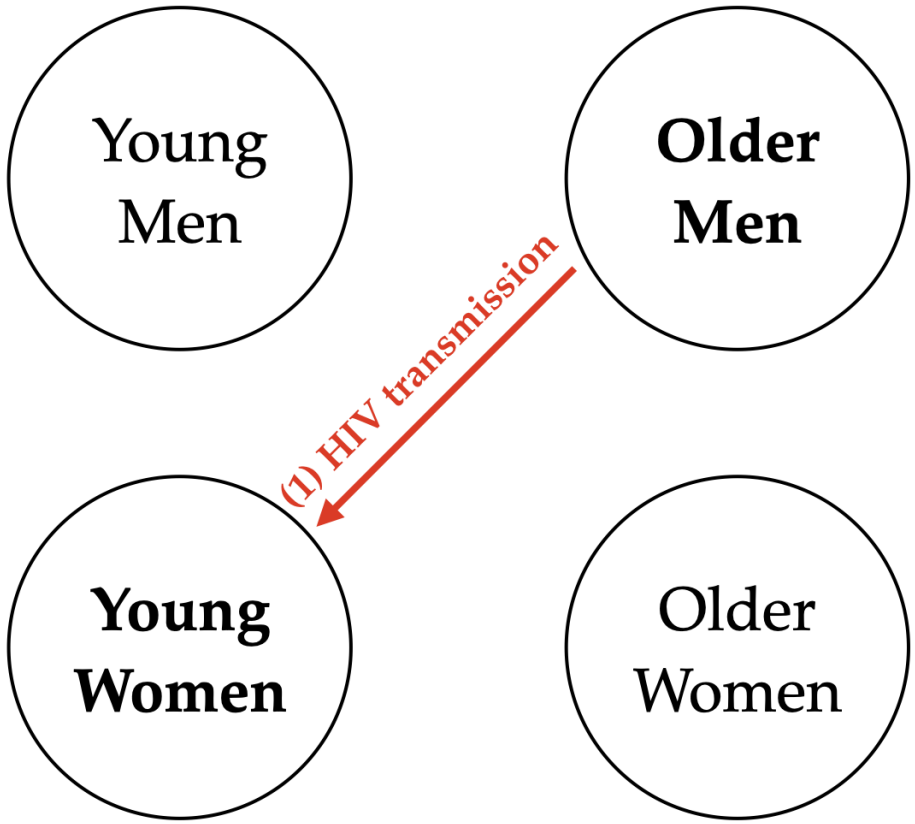
Appendix: Age-Disparate Relationships and HIV



Notes: Based on de Oliveira et al. (2017).

◂ Back

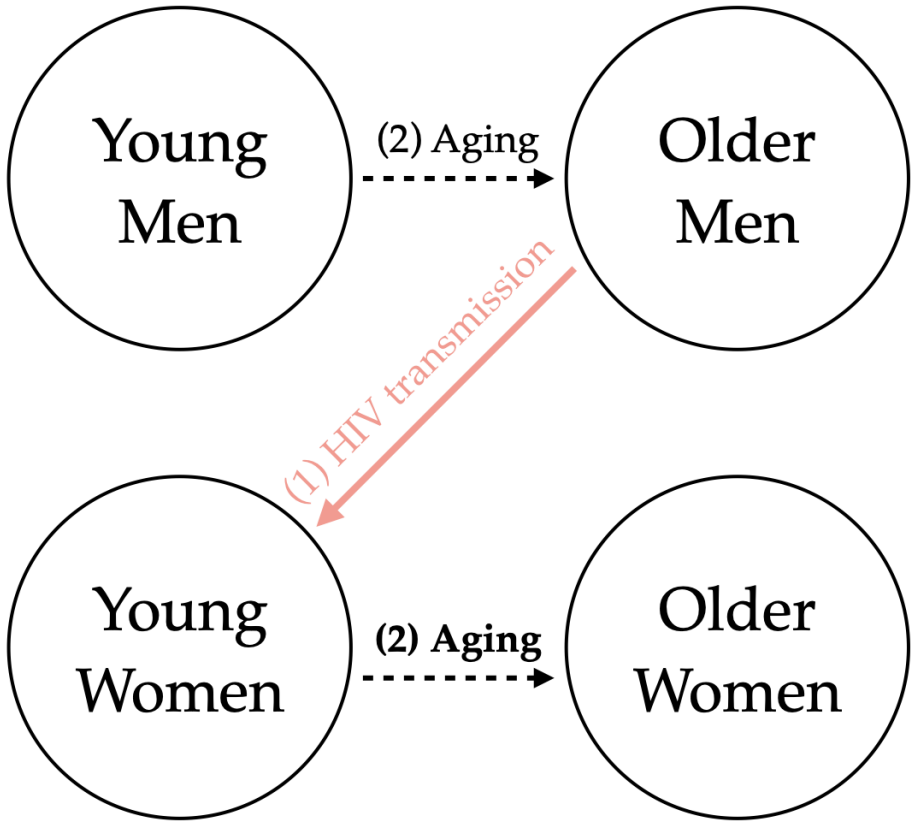
Appendix: Age-Disparate Relationships and HIV



Notes: Based on de Oliveira et al. (2017).

◂ Back

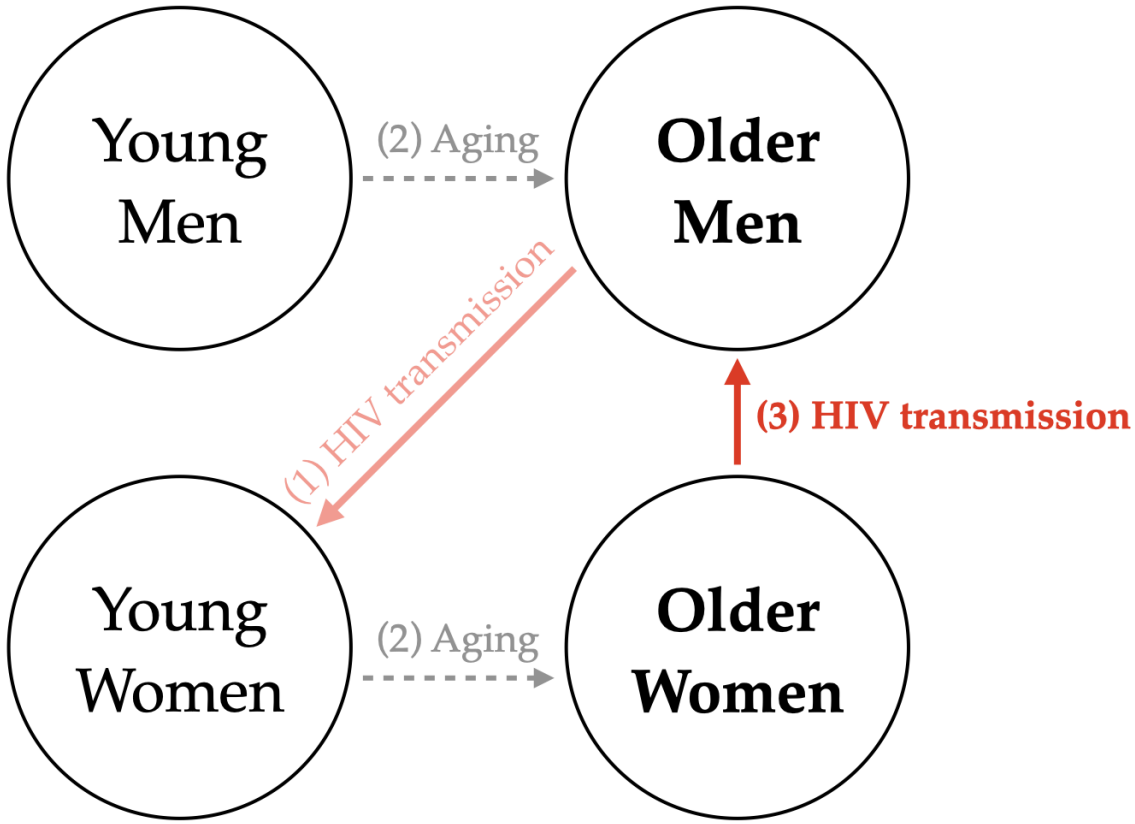
Appendix: Age-Disparate Relationships and HIV



Notes: Based on de Oliveira et al. (2017).

◂ Back

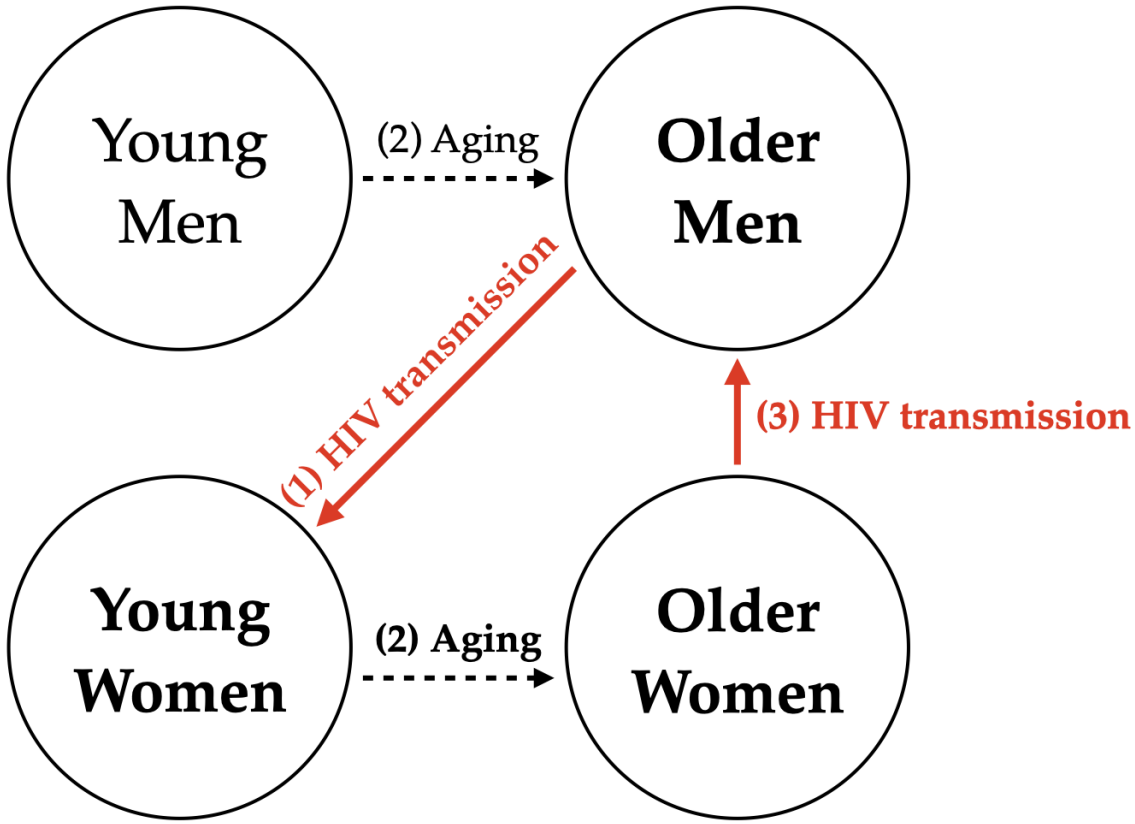
Appendix: Age-Disparate Relationships and HIV



Notes: Based on de Oliveira et al. (2017).

◂ Back

Appendix: Age-Disparate Relationships and HIV



Notes: Based on de Oliveira et al. (2017).

◂ Back