Natural resource management and nutrition outcomes:

a quasi-experimental evaluation of fisheries decentralisation in Laos

Credit: https://www.mekongfishnetwork.org/community-fishing-day-laos/

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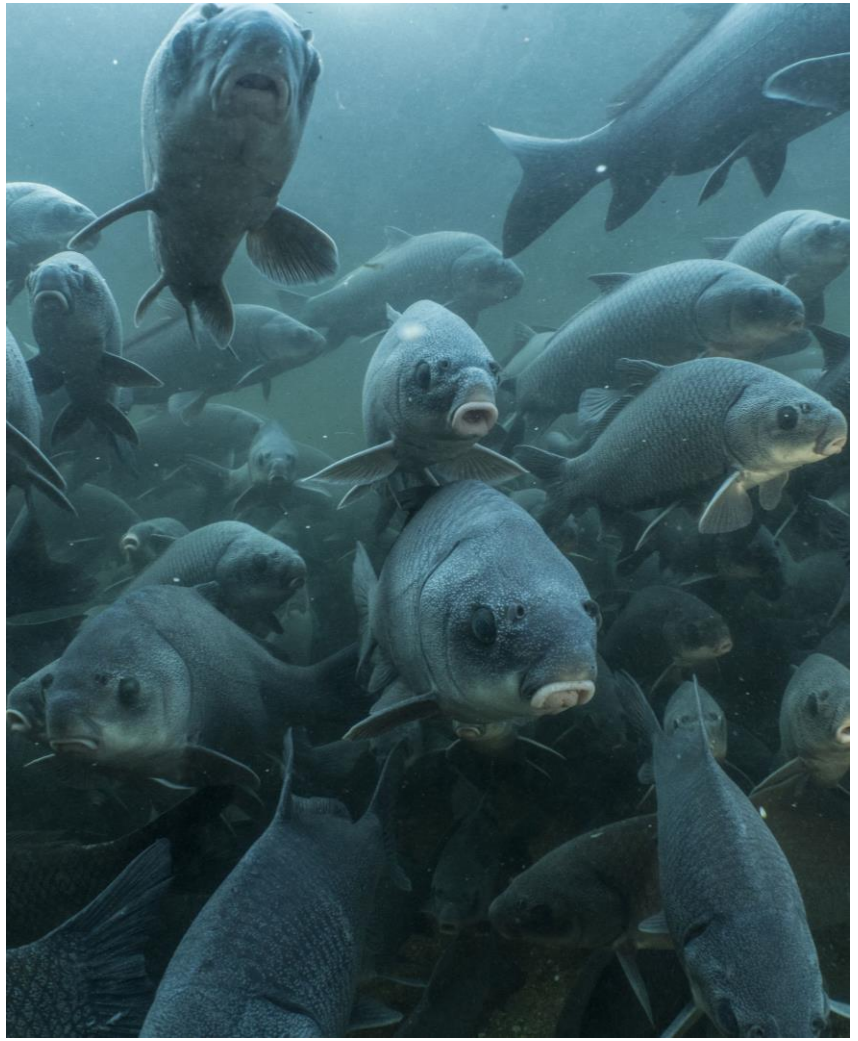
Why is this question is important?

- Over 1 billion people in developing countries rely on fish as an essential source of protein and micronutrients

- Critical to rural communities where alternate sources of low-cost protein and employment are scarce

- Global migratory freshwater fish stocks have declined by 76%, unmanaged fishing zones decreasing at the fastest rate
  - ➢ habitat modification and destruction, environmental pollution, climate change and overfishing



Credit: https://wwfint.awsassets.panda.org/downloads/world_s_forgotten_fishes__report_final__1.pdf

Motivation for decentralised natural resource management

Credit: https://panorama.solutions/en/solution/fisheries-co-management-fisherfolk-part-solution

- Weak property rights can lead to over-exploitation of natural resources, as described by Hardin's (1968) 'tragedy of the commons'
  - ➢ Policy prescriptions: Government regulation or privatisation

- Ostrom (1990) argues decentralised natural resource management (also known as community based natural resource management) can be more effective than traditional prescriptions.
  - ➢ Lower enforcement and administrative costs
  - ➢ Tailored policy tapping into extensive experience and knowledge

Laos 2009 Fisheries Law

- In 2009, the government of Lao PDR approved a new Fisheries Law
  - Formalised the decentralisation of fisheries management at the village level

- Local communities responsible for identification and management of conservation zones and the regulation of fishing gear and methods

- Law was nationally implemented Lao PDR, a landlocked country that relies on the Mekong River as an essential source of ecosystem services, including fish provision

Lao People's Democratic Republic
Peace Independence Democracy Unity Prosperity

National Assembly — No. 03/NA
Vientiane Capital, 09 July 2009

(UNOFFICIAL TRANSLATION)

Fisheries Law

Part I
General Provisions

Article 1. Purpose

The Fisheries Law specifies principles, regulations and measures governing the organization, implementation, management, and inspection of the work of fisheries, the promotion of aquaculture, conservation, protection, development and the sustainable exploitation of aquatic fauna, aiming to ensure the provision of fish and other aquatic fauna as a food source for all Lao people, the protection of the environment, contributing to the economic development of the nation.

• • •

Article 52. Rights and duties of Committees for the Management of Fisheries in Bodies of Water

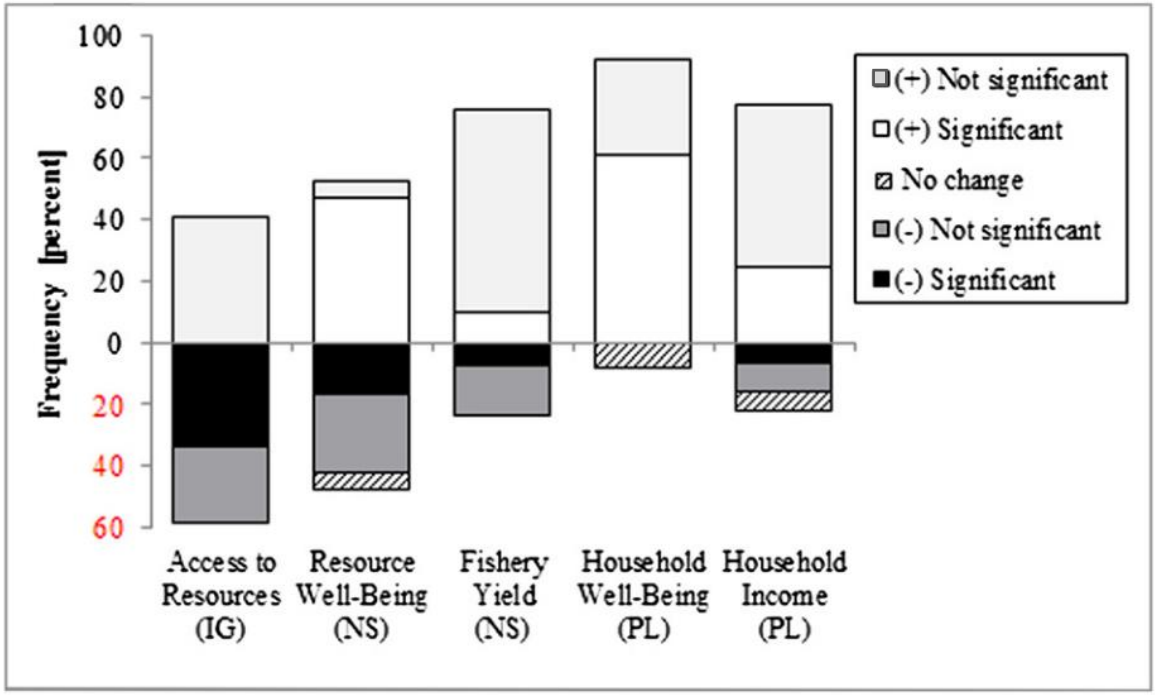
The rights and duties of the Committees for the Management of Fisheries shall be as follow:

1. To prepare plans for the management and development of fisheries within their own water resource areas, namely: identified fisheries areas, conservation zones, protected areas, fish spawning grounds, areas for the expansion of fish species, fish release areas and others;
2. To propose plans and regulations for the management of fisheries including the use of fishing gear and methods, seasons and prohibitions related to the catching or trapping of certain protected aquatic animals and submit these to the municipal, district administration authorities for their consideration, approval and adoption;
3. To disseminate and publicize the fisheries management plans and regulations by means of posters and announcement in the mass media;
4. To protect the rights and benefits of the fishermen including the settlement of disputes arising in the management of the water resources areas under their control;
5. To guide, follow up, and inspect the implementation of fisheries management regulations in the areas under their control;
6. To seek funding for the support to fisheries management and development in the water resources areas under their control;
7. To collect annual statistics related to fisheries, including the production, details of the fishermen, fish conservation zones and summaries and reports and submit these to the local authorities and the relevant sectors;
8. To exercise other rights and duties as assigned by the relevant sectors.

Note. Reprinted from *Fisheries Law 2009* (Laos). Retrieved from https://laotradeportal.gov.la/kcfinder/upload/files/Fisheries%20Law%20No.03%20(2009)_English.pdf

What do we already know?

- Meta-analysis of the impact of fisheries co-management on human wellbeing in developing countries (Evans et al., 2011)
  - ➢ None of the studies conducted a rigorous impact assessment
  - ➢ Only local case studies



Note. Reprinted from Evans, L., Cherrett, N., & Pemsl, D. (2011). Assessing the impact of fisheries co-management interventions in developing countries: A meta-analysis. *Journal of Environmental Management*, *92*(8), 1938–1949. https://doi.org/10.1016/j.jenvman.2011.03.010

- Quasi-experimental evaluations of decentralised fisheries:
  - ➢ Khan, Alam & Islam 2012
    - Bangladesh community-based fisheries management increases income and household expenditure
  - ➢ Haque & Dey 2016
    - Bangladesh community-based fish culture management increases household expenditure

- Impact of environmental programs (Ferraro & Hanauer, 2014)
  - ➢ “We have no shortage of good ideas to solve environmental problems, but we do have a glaring shortage of evidence to support these ideas.”

Methodology: Propensity score approach

Probability of establishing FMC

List of covariates that influence FMC establishment and nutrition outcome measure.

$$\overbrace{e(\boldsymbol{X}_v)} = Pr(D = 1|\overbrace{\boldsymbol{X}_v}) \quad (1)$$

- Assumptions:
  - Overlap: Common support and trimming
  - Unconfoundedness: Suite of variables from a rich dataset

$$\text{ATE} = E[\underbrace{H_{iv}}|D = 1, e(\boldsymbol{X}_v)] - E[H_{iv}|D = 0, e(\boldsymbol{X}_v)] \quad (2)$$

Height-for-age z-score

- Problem: unlikely to account for differences in child demographics and their environment
  - Unconfoundedness not likely to hold

Methodology: Propensity score weighted OLS regression

Child level drivers of nutrition

$$H_{iv} = D_v + \overbrace{Z_{\mathrm{iv}}} + \underbrace{\varepsilon_{iv}} \tag{3}$$

Clustered standard error at village level

$$Weight_v = \begin{cases} 1 & if\ D_v = 1 \\ \dfrac{e(\boldsymbol{X_v})}{(1 - e(\boldsymbol{X_v}))} & if\ D_v = 0 \end{cases} \tag{4}$$

- Allows controlling for selection bias and child level heterogeneity
  - ➢ Causal interpretation of the treatment effect

What data is used?

2005 Census

Pre-treatment village level variables
- Used to estimate propensity scores

2011 Agricultural Census

Treatment variable
- Fisheries management committees (0 no; 1 yes)

2011-2012 Social Indicator Survey

Outcome variable
- Height-for-age z score

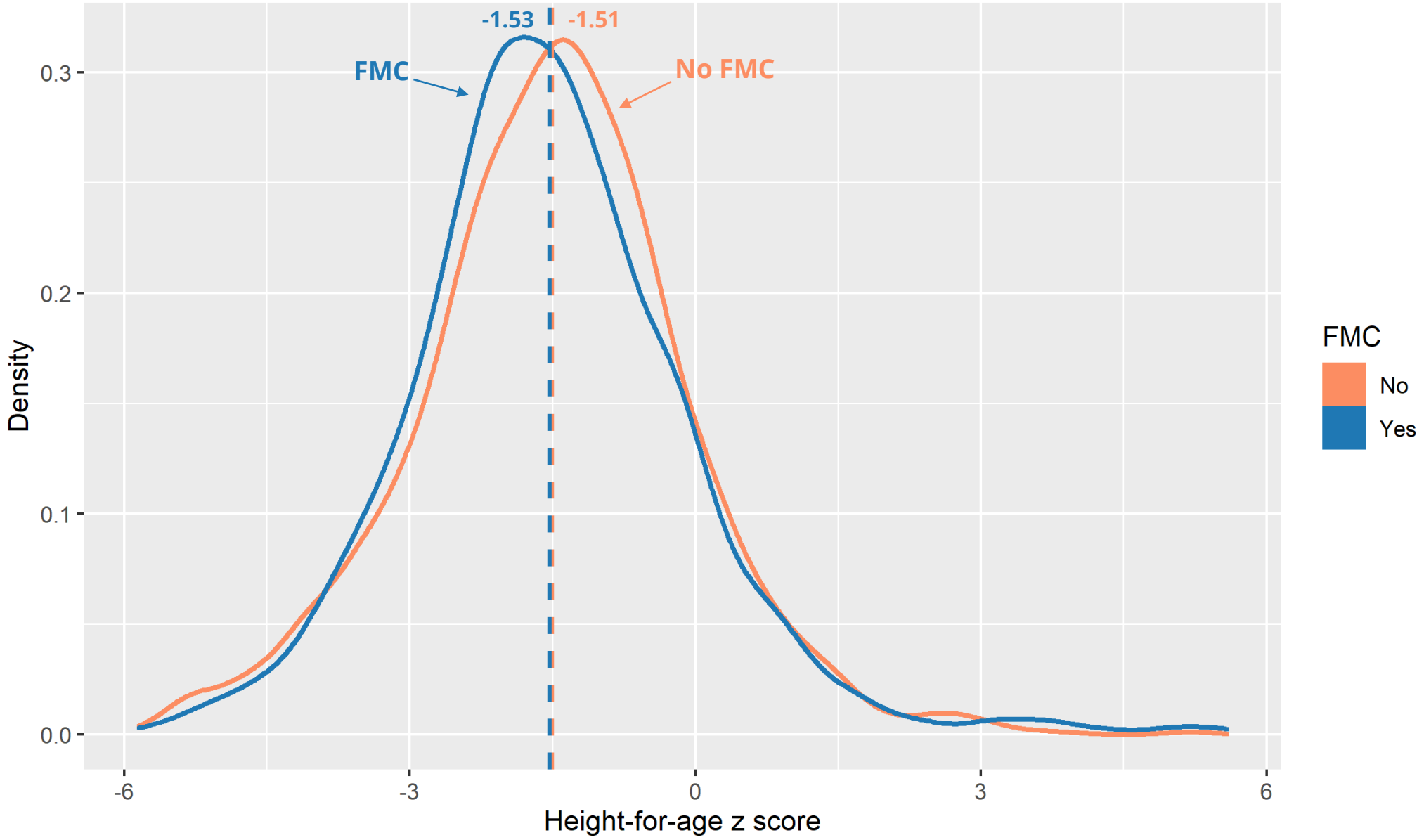
Child and household level variables

2012-2013 Expenditure and Consumption Survey

Analysis of mechanism variables
- Fish consumption, time spent fishing and fishing equipment ownership

Note. Reprinted from Phouthavong, K. (2015). Adapting fisheries-based livelihoods to hydrological changes in the Lower Mekong River Basin : a case study of Lao PDR. Retrieved from https://www.semanticscholar.org/paper/Adapting-fisheries-based-livelihoods-to-changes-in-Phouthavong/17b3ea7a8f462edf675cb1952646fdb6c06fc113#references

Descriptive statistics



Descriptive statistics

Table 1

Balance on village characteristics across FMC groups

Variable	Village without FMC	Village with FMC	Difference in means
HAZ	-1.510	-1.534	0.024
	(0.029)	(0.044)	
N	2466	1111	
Distance (meters) from nearest river or tributary	679.423	480.697	198.726***
	(12.184)	(15.128)	
Mean travel time (min) to province capital	121.771	168.881	-47.110***
	(3.414)	(5.556)	
Mean travel time (min) to district capital	63.341	89.750	-26.410***
	(2.776)	(4.578)	
Village population	658.081	530.549	127.533***
	(11.006)	(12.338)	
Dependency ratio	78.703	84.317	-5.615***
	(0.507)	(0.637)	
% of literate population	71.276	67.679	3.597***
	(0.518)	(0.706)	
Village with hospital (0 no; 1 yes)	0.086	0.109	-0.023**
	(0.006)	(0.010)	
Average age of women at first delivery	20.878	20.527	0.351***
	(0.029)	(0.039)	
% of population living below the poverty line	34.563	40.097	-5.535***
	(0.423)	(0.598)	
% of population of ethno-linguistic category Lao	43.263	31.532	11.731***
	(1.006)	(1.349)	
Ethnicity concentration index	0.875	0.859	0.016**
	(0.004)	(0.006)	
% of households with farmland	71.796	80.176	-8.380***
	(0.628)	(1.520)	
Population with main activity unemployed	6.225	2.321	3.904***
	(0.389)	(0.230)	
% of population with main activity non-farm sector	20.541	11.165	9.376***
	(0.664)	(0.554)	
Village with electricity (0 no; 1 yes)	0.518	0.339	0.179***
	(0.011)	(0.015)	
Village with water supply (0 no; 1 yes)	0.150	0.045	0.105***
	(0.008)	(0.007)	
N:	2079	1006	

Results: Average treatment effect

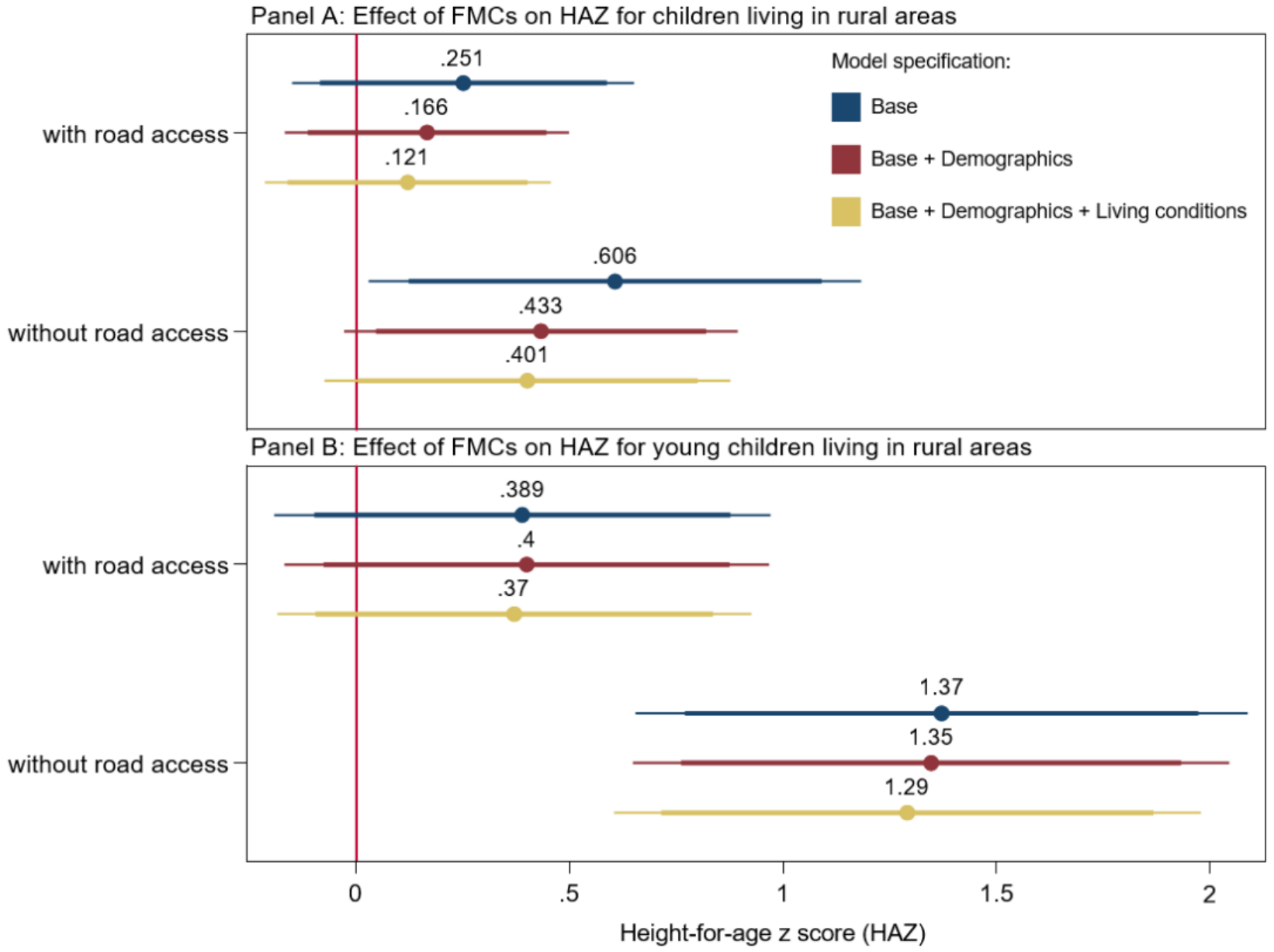
Table 2
Effect of FMC on HAZ

Dependant variable:	HAZ (1)	HAZ (2)	HAZ (3)
Village with FMC (0 no; 1 yes)	0.125	0.0795	0.0804
	(0.0774)	(0.0652)	(0.0633)
Sex (0 female; 1 male)	-0.160***	-0.165***	-0.171***
	(0.0570)	(0.0557)	(0.0564)
Child measured standing (0 no; 1 yes)	0.476***	0.476***	0.485***
	(0.120)	(0.115)	(0.114)
Age (months)	-0.0352***	-0.0334***	-0.0338***
	(0.00358)	(0.00347)	(0.00345)
% of households with farmland	0.00458**	0.00445***	0.00432***
	(0.00179)	(0.00135)	(0.00150)
Population with main activity unemployed	0.00748**	0.00488	0.00393
	(0.00365)	(0.00333)	(0.00340)
% of population with main activity non-farm sector	0.00785***	0.00369*	0.00236
	(0.00278)	(0.00197)	(0.00213)
Village with water supply (0 no; 1 yes)	-0.156	-0.108	-0.0891
	(0.236)	(0.174)	(0.175)
Demographic controls	No	Yes	Yes
Living conditions controls	No	No	Yes
N	3,007	3,007	3,007

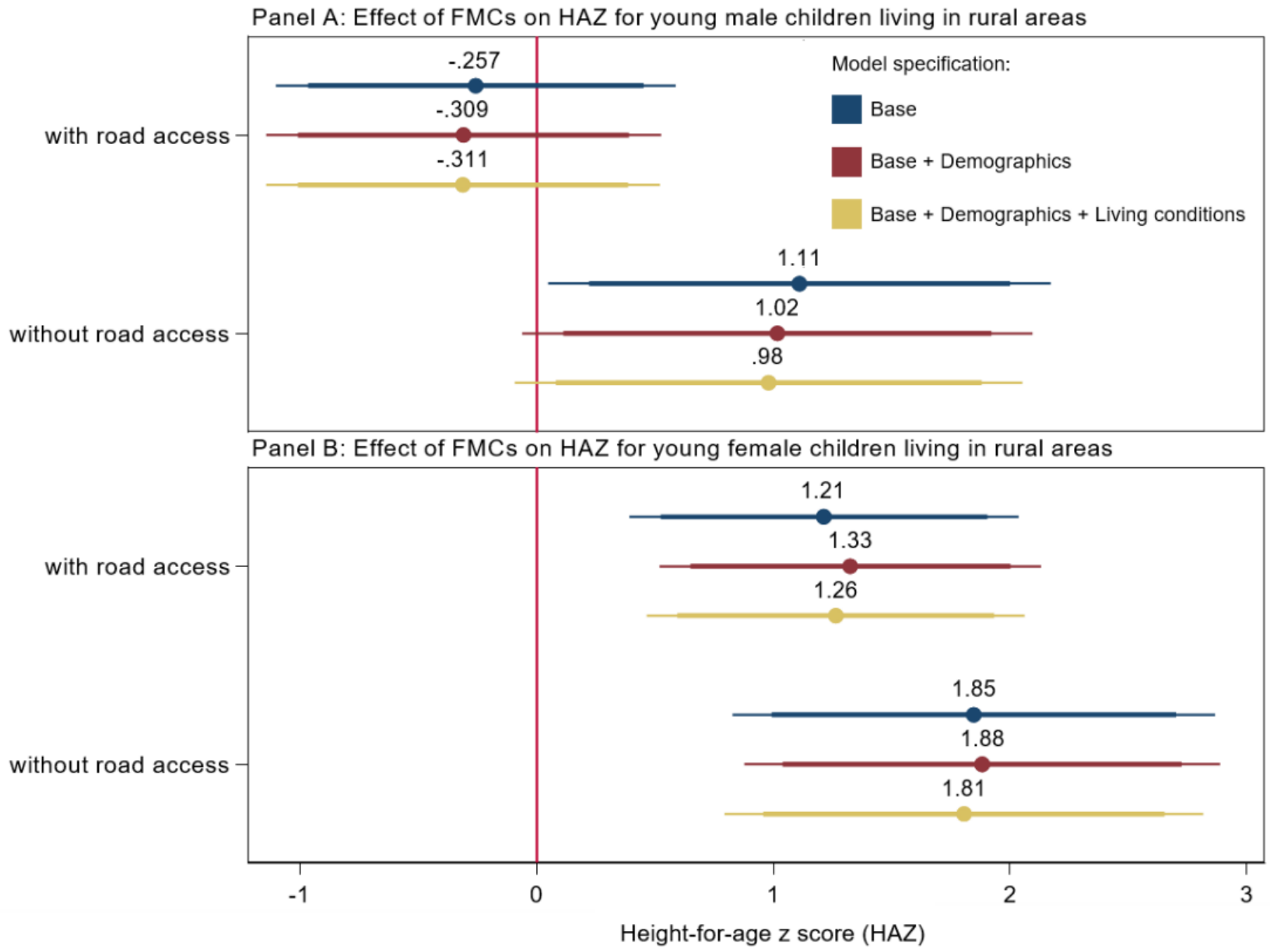
Note: Weighted OLS estimates. Robust standard errors clustered at the village level in parentheses. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively. Sample truncated to villages with distance to river less than 2km, absolute value of HAZ less 6 and propensity score within the 1-99 percentiles of its distribution. Data on child nutritional status from the LSIS 2011/12. Data on village FMC treatment status from 2011 Laos Agricultural Census. Data on other village characteristics from 2005 Laos Population Census.

- Result is unsurprising for two reasons:
  - Heterogeneity in economic conditions and therefore dependence of fisheries
  - Heterogeneity in age exposed to FMCs

Results: Heterogeneity analysis



Results: Heterogeneity analysis



Results: Placebo test

Dependant variable:	Child received any vaccination (0 no; 1 yes)		
	(1)	(2)	(3)
Village with FMC (0 no; 1 yes)	-0.0266	-0.0219	-0.0414
	(0.0764)	(0.0797)	(0.0785)
Village in rural area with road (0 no; 1 yes)	-0.0384	-0.0416	-0.0601
	(0.0616)	(0.0621)	(0.0654)
Village in rural area with no road (0 no; 1 yes)	0.0121	0.00819	-0.0388
	(0.0853)	(0.0852)	(0.0907)
Child under the age of 2 (0 no; 1 yes)	-0.0920	-0.0901	-0.0852
	(0.0566)	(0.0577)	(0.0566)
Village in rural area with road and FMC (0 no; 1 yes)	0.0272	0.0232	0.0426
	(0.0941)	(0.0968)	(0.0960)
Village in rural area with no road and FMC (0 no; 1 yes)	-0.0335	-0.0414	-0.0358
	(0.143)	(0.146)	(0.147)
Village with FMC and child under the age of 2 (0 no; 1 yes)	0.139	0.142	0.143
	(0.0900)	(0.0935)	(0.0898)
Village in rural area, road, child under the age of 2 (0 no; 1 yes)	0.0169	0.0181	0.0184
	(0.0571)	(0.0581)	(0.0575)
Village in rural area, no road, child under the age of 2 (0 no; 1 yes)	-0.0813	-0.0773	-0.0832
	(0.0774)	(0.0781)	(0.0762)
Village with FMC, rural area, road, child under the age of 2 (0 no; 1 yes)	-0.102	-0.102	-0.102
	(0.106)	(0.110)	(0.107)
Village with FMC, rural area, no road, child under the age of 2 (0 no; 1 yes)	0.112	0.109	0.126
	(0.136)	(0.137)	(0.136)
Sex (0 female; 1 male)	0.00432	0.00851	0.0100
	(0.0209)	(0.0204)	(0.0202)
Age (months)	0.00559***	0.00559***	0.00580***
	(0.00113)	(0.00110)	(0.00110)
% of households with farmland	0.000855	0.000865	0.000770
	(0.000943)	(0.000919)	(0.000845)
Population with main activity unemployed	-0.00296**	-0.00249*	-0.00245
	(0.00149)	(0.00148)	(0.00149)
% of population with main activity non-farm sector	-0.000777	-0.000588	-0.000320
	(0.00111)	(0.00111)	(0.00111)
Village with water supply (0 no; 1 yes)	0.0545	0.0555	0.0673
	(0.0752)	(0.0745)	(0.0791)
Demographic controls	No	Yes	Yes
Living conditions controls	No	No	Yes
N	3,007	3,007	3,007

Results: Mechanism analysis

Table 3

Effect of FMC on fish consumption

Dependant variable:	Fish consumed by household in past month		
	(1)	(2)	(3)
Village with FMC (0 no; 1 yes)	-27,423	-26,443	-24,975
	(29,395)	(29,734)	(29,216)
Village in rural area with road (0 no; 1 yes)	-27,761	-24,942	-28,043
	(17,519)	(17,569)	(17,857)
Village in rural area with no road (0 no; 1 yes)	-92,671**	-87,807**	-94,439**
	(35,629)	(35,283)	(36,137)
Village with FMC, rural area and road (0 no; 1 yes)	69,183**	69,374*	67,706*
	(34,818)	(35,342)	(35,141)
Village with FMC, rural area and no road (0 no; 1 yes)	147,523*	146,099*	148,630**
	(74,665)	(74,996)	(72,135)
Dependency ratio		-45,781*	-44,804*
		(24,371)	(23,867)
Household head sex (0 female; 1 male)		-43,959**	-44,127**
		(19,339)	(19,313)
Productive assets index		1,638	1,443
		(4,716)	(4,812)
Agricultural land area owned by household (Hectares)		2,172	2,069
		(4,246)	(4,142)
Survey in the wet season (0 no; 1 yes)			-16,074
			(17,655)
Constant	223,342***	277,527***	288,248***
	(13,204)	(25,873)	(29,090)
Observations:	1187	1187	1187

Note: Weighted OLS estimates. Robust standard errors clustered at the village level in parentheses. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively. Sample truncated to villages with distance to river less than 2km and propensity score within the 1-99 percentiles. Fish consumption measured in Laotian Kip (9,583.36 LAK ≈ 1 USD). Data on village FMC treatment status from 2011 Laos Agricultural Census. Fish consumption data and household level controls from the 2012-2013 LECS.

Results: Mechanism analysis

Table 4

Effect of FMC on fishing inputs

Dependant variable:	Time fishing by household in past 24 hours			Household owns fishing net (0 no; 1 yes)			Household owns boat (0 no; 1 yes)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Village with FMC (0 no; 1 yes)	0.186	0.204	0.192	0.0131	0.00652	0.0228	-0.0755	-0.0686	-0.0686
	(0.375)	(0.374)	(0.372)	(0.0989)	(0.0986)	(0.102)	(0.0891)	(0.0915)	(0.0912)
Village in rural area with road (0 no; 1 yes)	0.0787	0.0984	0.120	0.0680	0.0761	0.0470	0.0938	0.104	0.104
	(0.277)	(0.276)	(0.279)	(0.0737)	(0.0733)	(0.0676)	(0.0799)	(0.0803)	(0.0816)
Village in rural area with no road (0 no; 1 yes)	0.151	0.203	0.251	0.202*	0.204*	0.138	0.0978	0.118	0.118
	(0.744)	(0.728)	(0.740)	(0.113)	(0.107)	(0.0847)	(0.182)	(0.181)	(0.182)
Village in rural area with road and FMC	0.157	0.142	0.154	0.0963	0.105	0.0860	0.105	0.0996	0.0996
	(0.440)	(0.442)	(0.441)	(0.121)	(0.120)	(0.123)	(0.115)	(0.117)	(0.117)
Village in rural area with no road and FMC	0.859	0.812	0.795	0.102	0.116	0.137	0.272	0.257	0.257
	(0.744)	(0.728)	(0.740)	(0.165)	(0.162)	(0.137)	(0.247)	(0.246)	(0.246)
Dependency ratio		-0.348	-0.356		-0.0685	-0.0591		-0.170**	-0.170**
		(0.298)	(0.298)		(0.0742)	(0.0712)		(0.0770)	(0.0770)
Household head sex (0 female; 1 male)		-0.0487	-0.0448		-0.267***	-0.271***		-0.0103	-0.0103
		(0.254)	(0.254)		(0.0629)	(0.0625)		(0.0667)	(0.0663)
Productive assets index		-0.0411	-0.0430						
		(0.0766)	(0.0771)						
Agricultural land area owned by household (Hectares)		0.0148	0.0155		-0.000591	-0.00159		0.00525*	0.00524*
		(0.0201)	(0.0198)		(0.00337)	(0.00338)		(0.00292)	(0.00296)
Survey in the wet season (0 no; 1 yes)			0.116			-0.162***			-0.000262
			(0.204)			(0.0564)			(0.0623)
Constant	0.898***	1.015**	0.936**	0.487***	0.784***	0.894***	0.181***	0.227**	0.227**
	(0.254)	(0.399)	(0.412)	(0.0590)	(0.0882)	(0.0901)	(0.0637)	(0.0957)	(0.0997)
Observations	1224	1224	1224	1224	1224	1224	1224	1224	1224

Note: Weighted OLS estimates. Robust standard errors clustered at the village level in parentheses. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively. Sample truncated to villages with distance to river less than 2km and propensity score within the 1-99 percentiles. Data on village FMC treatment status from 2011 Laos Agricultural Census. Dependant variables and household level controls from the 2012-2013 LECS.

Conclusion

- Over 1 billion people in developing countries rely on fish as an essential source of nutrition and micronutrients
  - ➢ Regulation is required to prevent over-exploitation

- Decentralised fisheries management decreases child malnutrition
  - ➢ Effects are heterogeneous, driven by isolated villages with limited alternate sources of nutrition and employment
  - ➢ Girls seem to benefit more than boys

- Effects are likely due to increased fishery productivity, as the presence of FMCs increase fish consumption but do not increase fishing inputs

Source: https://www.fishforward.eu/wp-content/uploads/2015/06/kids_mekong_wwfcanon_hogan.jpg

 Questions?

Appendix:

Table A.1

Propensity score estimation

Dependent variable:	Village with FMC (0 no; 1 yes)	
	Coef.	Std.Err.
Distance (meters) from nearest river or tributary	-0.000460***	(6.19e-05)
Mean travel time (min) to province capital	0.00107***	(0.000334)
Mean travel time (min) to district capital	-0.000902**	(0.000389)
Village population	-3.54e-05	(7.43e-05)
Dependency ratio	-0.00143	(0.00160)
% of literate population	0.00879***	(0.00168)
Village with hospital (0 no; 1 yes)	0.191**	(0.0844)
Average age of women at first delivery	-0.0327	(0.0221)
% of population living below the poverty line	0.00741***	(0.00215)
% of population of ethno-linguistic category Lao	-0.00285***	(0.000901)
Ethnicity concentration index	0.596	(1.159)
% of households with farmland	0.00119	(0.000824)
Population with main activity unemployed	-0.00110	(0.00285)
% of population with main activity non-farm sector	-0.00455**	(0.00178)
Village with electricity (0 no; 1 yes)	-0.220***	(0.0656)
Village with water supply (0 no; 1 yes)	-0.209	(0.127)
Distance to river Lao ethnicity interaction	2.52e-06**	(1.05e-06)
Ethnicity concentration index squared	-1.434	(1.883)
Constant	0.593	(0.931)
N	3085	

Note: Data on village FMC treatment status from 2011 Laos Agricultural Census. Data on other village characteristics from 2005 Laos Population Census. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively. Sample truncated to villages with distance to river less than 2km.

Appendix:

Table A.2
Balance on village characteristics across FMC groups with propensity score weight

Variable	Village without FMC	Village with FMC	Difference in means
Distance (meters) from nearest river or tributary	479.484	480.697	-1.213
	(10.489)	(15.128)	
Mean travel time (min) to province capital	170.315	168.881	1.434
	(5.719)	(5.556)	
Mean travel time (min) to district capital	90.336	89.750	0.585
	(4.414)	(4.578)	
Village population	527.057	530.549	-3.491
	(8.581)	(12.338)	
Dependency ratio	84.600	84.317	0.282
	(0.524)	(0.637)	
% of literate population	67.388	67.679	-0.291
	(0.558)	(0.706)	
Village with hospital (0 no; 1 yes)	0.109	0.109	-0.000
	(0.009)	(0.010)	
Average age of women at first delivery	20.519	20.527	-0.008
	(0.030)	(0.039)	
% of population living below the poverty line	40.469	40.097	0.371
	(0.512)	(0.598)	
% of population of ethno-linguistic category Lao	31.181	31.532	-0.351
	(1.021)	(1.349)	
Ethnicity concentration index	0.866	0.859	0.007
	(0.005)	(0.006)	
% of households with farmland	80.102	80.176	-0.074
	(0.637)	(1.520)	
Population with main activity unemployed	1.974	2.321	-0.347
	(0.113)	(0.230)	
% of population with main activity non-farm sector	10.215	11.165	-0.950
	(0.341)	(0.554)	
Village with electricity (0 no; 1 yes)	0.336	0.339	-0.003
	(0.011)	(0.015)	
Village with water supply (0 no; 1 yes)	0.039	0.045	-0.006
	(0.003)	(0.007)	
N:	2024	1006	

Note: The value displayed for t-tests are the propensity score weighted differences in the means across the groups. Data on village FMC treatment status from 2011 Laos Agricultural Census. Data on other village characteristics from 2005 Laos Population Census. Standard errors shown in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Sample truncated to villages with distance to river less than 2km.

Appendix:

Table A.3
Balance on village characteristics across FMC groups with propensity score weight after trimming

Variable	Village without FMC	Village with FMC	Difference in means
Distance (meters) from nearest river or tributary	487.512	486.483	1.029
	(10.518)	(15.464)	
Mean travel time (min) to province capital	161.149	158.687	2.461
	(5.172)	(5.279)	
Mean travel time (min) to district capital	89.023	86.579	2.444
	(4.520)	(4.572)	
Village population	522.491	524.253	-1.762
	(8.781)	(12.103)	
Dependency ratio	84.663	84.030	0.633
	(0.530)	(0.657)	
% of literate population	66.935	67.430	-0.495
	(0.570)	(0.736)	
Village with hospital (0 no; 1 yes)	0.107	0.098	0.009
	(0.009)	(0.010)	
Average age of women at first delivery	20.509	20.554	-0.045
	(0.031)	(0.040)	
% of population living below the poverty line	40.091	39.453	0.638
	(0.499)	(0.604)	
% of population of ethno-linguistic category Lao	31.217	32.644	-1.428
	(1.048)	(1.406)	
Ethnicity concentration index	0.867	0.868	-0.001
	(0.005)	(0.006)	
% of households with farmland	80.618	78.639	1.979*
	(0.639)	(0.816)	
Population with main activity unemployed	1.565	2.166	-0.601***
	(0.103)	(0.208)	
% of population with main activity non-farm sector	9.081	10.927	-1.846***
	(0.329)	(0.552)	
Village with electricity (0 no; 1 yes)	0.337	0.349	-0.012
	(0.011)	(0.016)	
Village with water supply (0 no; 1 yes)	0.024	0.039	-0.015**
	(0.003)	(0.006)	
Observations	1810	946	Total: 2756

Note: The value displayed for t-tests are the propensity score weighted differences in the means across the groups. Data on village FMC treatment status from 2011 Laos Agricultural Census. Data on other village characteristics from 2005 Laos Population Census. Standard errors shown in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Sample truncated to villages with distance to river less than 2km and propensity score within the 1-99 percentiles of its distribution

Appendix

Table A.4
Effect of FMC on HAZ

Dependant variable:	HAZ (1)	HAZ (2)	HAZ (3)
Village with FMC (0 no; 1 yes)	0.125	0.0795	0.0804
	(0.0774)	(0.0652)	(0.0633)
Sex (0 female; 1 male)	-0.160***	-0.165***	-0.171***
	(0.0570)	(0.0557)	(0.0564)
Child measured standing (0 no; 1 yes)	0.476***	0.476***	0.485***
	(0.120)	(0.115)	(0.114)
Age (months)	-0.0352***	-0.0334***	-0.0338***
	(0.00358)	(0.00347)	(0.00345)
% of households with farmland	0.00458**	0.00445***	0.00432***
	(0.00179)	(0.00135)	(0.00150)
Population with main activity unemployed	0.00748**	0.00488	0.00393
	(0.00365)	(0.00333)	(0.00340)
% of population with main activity non-farm sector	0.00785***	0.00369*	0.00236
	(0.00278)	(0.00197)	(0.00213)
Village with water supply (0 no; 1 yes)	-0.156	-0.108	-0.0891
	(0.236)	(0.174)	(0.175)
Mother's education: primary (0 no; 1 yes)		0.236***	0.176**
		(0.0878)	(0.0873)
Mother's education: secondary (0 no; 1 yes)		0.369***	0.266***
		(0.0953)	(0.0966)
Mother's education: higher (0 no; 1 yes)		0.335**	0.226
		(0.152)	(0.156)
Dependence ratio		0.0126	0.127
		(0.255)	(0.256)
Mother aged <20 at birth (0 no; 1 yes)		-0.447***	-0.401***
		(0.134)	(0.136)
Mother aged 20-34 at birth (0 no; 1 yes)		-0.200*	-0.197*
		(0.111)	(0.112)
Ethnicity of household head Lao (0 no; 1 yes)		0.466***	0.419***
		(0.0715)	(0.0726)
Ethnicity of household head Khmu (0 no; 1 yes)		0.0179	0.0149
		(0.106)	(0.107)
Ethnicity of household head Hmong (0 no; 1 yes)		0.0992	0.0650
		(0.106)	(0.103)
Birth order		-0.133***	-0.114***
		(0.0419)	(0.0424)
Household head sex (0 female; 1 male)		0.167	0.173
		(0.110)	(0.110)
Household is owned by household member (0 no; 1 yes)			-0.300
			(0.293)
Household has electricity (0 no; 1 yes)			0.205***
			(0.0777)
Household with piped water source (0 no; 1 yes)			-0.0390
			(0.0930)
Household with improved sanitation (0 no; 1 yes)			0.117*
			(0.0707)
Positive salt iodization test (0 no; 1 yes)			0.0288
			(0.0918)
Constant	-1.294***	-1.311***	-1.232***
	(0.171)	(0.249)	(0.379)
N	3,007	3,007	3,007

Note: Weighted OLS estimates. Robust standard errors clustered at the village level in parentheses. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively. Sample truncated to villages with distance to river less than 2km, absolute value of HAZ less 6 and propensity score within the 1-99 percentiles of its distribution. Data on child nutritional status from the LSIS 2011/12. Data on village FMC treatment status from 2011 Laos Agricultural Census. Data on other village characteristics from 2005 Laos Population Census.

Appendix:

Table A.5
Effect of FMC on HAZ for children in rural areas

Dependant variable:	HAZ (1)	HAZ (2)	HAZ (3)
Village with FMC (0 no; 1 yes)	-0.125	-0.0947	-0.0661
	(0.176)	(0.151)	(0.152)
Village in rural area with road (0 no; 1 yes)	-0.209*	-0.121	-0.0560
	(0.114)	(0.113)	(0.112)
Village in rural area with no road (0 no; 1 yes)	-0.435**	-0.228	-0.101
	(0.192)	(0.172)	(0.191)
Village in rural area with road and FMC (0 no; 1 yes)	0.251	0.166	0.121
	(0.204)	(0.169)	(0.170)
Village in rural area with no road and FMC (0 no; 1 yes)	0.606**	0.433*	0.401*
	(0.293)	(0.234)	(0.241)
Sex (0 female; 1 male)	-0.164***	-0.165***	-0.168***
	(0.0564)	(0.0554)	(0.0562)
Child measured standing (0 no; 1 yes)	0.462***	0.467***	0.479***
	(0.121)	(0.116)	(0.115)
Age (months)	-0.0347***	-0.0331***	-0.0335***
	(0.00358)	(0.00349)	(0.00348)
% of households with farmland	0.00464***	0.00439***	0.00416***
	(0.00170)	(0.00132)	(0.00151)
Population with main activity unemployed	0.00650*	0.00444	0.00378
	(0.00354)	(0.00335)	(0.00337)
% of population with main activity non-farm sector	0.00710**	0.00354	0.00262
	(0.00294)	(0.00229)	(0.00242)
Village with water supply (0 no; 1 yes)	-0.134	-0.0982	-0.0831
	(0.229)	(0.169)	(0.170)
Mother's education: primary (0 no; 1 yes)		0.235***	0.175**
		(0.0876)	(0.0884)
Mother's education: secondary (0 no; 1 yes)		0.369***	0.266***
		(0.0941)	(0.0968)
Mother's education: higher (0 no; 1 yes)		0.343**	0.236
		(0.150)	(0.155)
Dependence ratio		0.00909	0.129
		(0.256)	(0.256)
Mother aged <20 at birth (0 no; 1 yes)		-0.447***	-0.402***
		(0.135)	(0.138)
Mother aged 20-34 at birth (0 no; 1 yes)		-0.204*	-0.204*
		(0.113)	(0.114)
Ethnicity of household head Lao (0 no; 1 yes)		0.457***	0.407***
		(0.0703)	(0.0715)
Ethnicity of household head Khmu (0 no; 1 yes)		0.0254	0.0126
		(0.108)	(0.108)
Ethnicity of household head Hmong (0 no; 1 yes)		0.103	0.0777
		(0.107)	(0.105)
Birth order		-0.132***	-0.116***
		(0.0420)	(0.0423)
Household head sex (0 female; 1 male)		0.164	0.169
		(0.111)	(0.112)
Household is owned by household member (0 no; 1 yes)			-0.301
			(0.290)
Household has electricity (0 no; 1 yes)			0.213***
			(0.0789)
Household with piped water source (0 no; 1 yes)			-0.0426
			(0.0959)
Household with improved sanitation (0 no; 1 yes)			0.128*
			(0.0732)
Positive salt iodization test (0 no; 1 yes)			0.0277
			(0.0923)
Constant	-1.096***	-1.189***	-1.168***
	(0.181)	(0.261)	(0.383)
N	3,007	3,007	3,007

Note: Weighted OLS estimates. Robust standard errors clustered at the village level in parentheses. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively. Sample truncated to villages with distance to river less than 2km, absolute value of HAZ less 6 and propensity score within the 1-99 percentiles of its distribution. Data on child nutritional status from the LSIS 2011/12. Data on village FMC treatment status from 2011 Laos Agricultural Census. Data on other village characteristics from 2005 Laos Population Census.

Appendix:

Table A.6
Effect of FMC on HAZ for young children in rural areas

Dependant variable:	HAZ (1)	HAZ (2)	HAZ (3)
Village with FMC (0 no; 1 yes)	0.131	0.152	0.167
	(0.233)	(0.214)	(0.210)
Village in rural area with road (0 no; 1 yes)	-0.261*	-0.162	-0.101
	(0.135)	(0.141)	(0.140)
Village in rural area with no road (0 no; 1 yes)	-0.359*	-0.141	-0.0277
	(0.212)	(0.196)	(0.217)
Child under the age of 2 (0 no; 1 yes)	-0.422*	-0.395*	-0.409*
	(0.226)	(0.231)	(0.228)
Village in rural area with road and FMC (0 no; 1 yes)	0.0342	-0.0540	-0.0838
	(0.260)	(0.234)	(0.229)
Village in rural area with no road and FMC (0 no; 1 yes)	-0.0713	-0.233	-0.237
	(0.341)	(0.287)	(0.291)
Village with FMC and child under the age of 2 (0 no; 1 yes)	-0.490*	-0.468*	-0.443*
	(0.255)	(0.248)	(0.244)
Village in rural area, road, child under the age of 2 (0 no; 1 yes)	0.132	0.103	0.109
	(0.152)	(0.151)	(0.147)
Village in rural area, no road, child under the age of 2 (0 no; 1 yes)	-0.164	-0.190	-0.165
	(0.189)	(0.182)	(0.184)
Village with FMC, rural area, road, child under the age of 2 (0 no; 1 yes)	0.389	0.400	0.370
	(0.295)	(0.288)	(0.282)
Village with FMC, rural area, no road, child under the age of 2 (0 no; 1 yes)	1.371***	1.347***	1.291***
	(0.364)	(0.355)	(0.349)
Sex (0 female; 1 male)	-0.159***	-0.160***	-0.163***
	(0.0561)	(0.0551)	(0.0560)
Child measured standing (0 no; 1 yes)	0.179	0.196	0.201
	(0.200)	(0.206)	(0.206)
Age (months)	-	-	-
	0.0367***	0.0350***	0.0355***
	(0.00377)	(0.00368)	(0.00365)
% of households with farmland	0.00459**	0.00435**	0.00409**
	*	*	*
	(0.00170)	(0.00132)	(0.00151)
Population with main activity unemployed	0.00551	0.00367	0.00301
	(0.00354)	(0.00335)	(0.00337)
% of population with main activity non-farm sector	0.00789**	0.00433**	0.00338
	*		
	(0.00281)	(0.00219)	(0.00231)
Village with water supply (0 no; 1 yes)	-0.162	-0.124	-0.107
	(0.223)	(0.163)	(0.164)
Mother's education: primary (0 no; 1 yes)		0.237***	0.179**
		(0.0871)	(0.0881)
Mother's education: secondary (0 no; 1 yes)		0.376***	0.275***
		(0.0924)	(0.0954)
Mother's education: higher (0 no; 1 yes)		0.304**	0.200
		(0.145)	(0.151)
Dependence ratio		0.0196	0.136
		(0.254)	(0.254)
Mother aged <20 at birth (0 no; 1 yes)		-0.444***	-0.399***
		(0.135)	(0.137)
Mother aged 20-34 at birth (0 no; 1 yes)		-0.198*	-0.198*
		(0.112)	(0.114)
Ethnicity of household head Lao (0 no; 1 yes)		0.448***	0.400***
		(0.0703)	(0.0713)
Ethnicity of household head Khmu (0 no; 1 yes)		0.0196	0.00628
		(0.108)	(0.108)
Ethnicity of household head Hmong (0 no; 1 yes)		0.0953	0.0713
		(0.107)	(0.105)
Birth order		-0.133***	-0.118***
		(0.0417)	(0.0420)
Household head sex (0 female; 1 male)		0.160	0.165
		(0.112)	(0.112)
Household is owned by household member (0 no; 1 yes)			-0.286
			(0.292)
Household has electricity (0 no; 1 yes)			0.204***
			(0.0783)
Household with piped water source (0 no; 1 yes)			-0.0420
			(0.0961)
Household with improved sanitation (0 no; 1 yes)			0.129*
			(0.0730)
Positive salt iodization test (0 no; 1 yes)			0.0329
			(0.0916)
Constant	-0.693**	-0.808**	-0.785*
	(0.269)	(0.333)	(0.452)
N	3,007	3,007	3,007

Note: Weighted OLS estimates. Robust standard errors clustered at the village level in parentheses. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively. Sample truncated to villages with distance to river less than 2km, absolute value of HAZ less 6 and propensity score within the 1-99 percentiles of its distribution. Data on child nutritional status from the LSIS 2011/12. Data on village FMC treatment status from 2011 Laos Agricultural Census. Data on other village characteristics from 2005 Laos Population Census.

Appendix:

Table A.7

Effect of FMC on HAZ for young female children in rural areas

Dependant variable:	HAZ (1)	HAZ (2)	HAZ (3)
Village with FMC (0 no; 1 yes)	0.423	0.569*	0.556*
	(0.368)	(0.317)	(0.316)
Village in rural area with road (0 no; 1 yes)	-0.0689	0.168	0.216
	(0.231)	(0.191)	(0.191)
Village in rural area with no road (0 no; 1 yes)	-0.315	-0.00119	0.119
	(0.314)	(0.262)	(0.298)
Child under the age of 2 (0 no; 1 yes)	-0.163	-0.0553	-0.0623
	(0.328)	(0.326)	(0.322)
Village in rural area with road and FMC (0 no; 1 yes)	-0.323	-0.624*	-0.615*
	(0.404)	(0.347)	(0.343)
Village in rural area with no road and FMC (0 no; 1 yes)	-0.250	-0.545	-0.528
	(0.494)	(0.400)	(0.412)
Village with FMC and child under the age of 2 (0 no; 1 yes)	-1.110***	-1.172***	-1.125***
	(0.347)	(0.339)	(0.338)
Village in rural area, road, child under the age of 2 (0 no; 1 yes)	-0.140	-0.196	-0.189
	(0.245)	(0.233)	(0.232)
Village in rural area, no road, child under the age of 2 (0 no; 1 yes)	-0.353	-0.331	-0.328
	(0.323)	(0.313)	(0.324)
Village with FMC, rural area, road, child under the age of 2 (0 no; 1 yes)	1.214***	1.325***	1.264***
	(0.418)	(0.410)	(0.406)
Village with FMC, rural area, no road, child under the age of 2 (0 no; 1 yes)	1.846***	1.882***	1.805***
	(0.518)	(0.511)	(0.514)
Child measured standing (0 no; 1 yes)	0.140	0.186	0.183
	(0.290)	(0.297)	(0.291)
Age (months)	-0.0365***	-0.0339***	-0.0341***
	(0.00546)	(0.00536)	(0.00529)
% of households with farmland	0.00794***	0.00694***	0.00704***
	(0.00249)	(0.00204)	(0.00223)
Population with main activity unemployed	-0.000190	-0.00257	-0.00291
	(0.00492)	(0.00386)	(0.00408)
% of population with main activity non-farm sector	0.00728*	0.00364	0.00279
	(0.00391)	(0.00314)	(0.00328)
Village with water supply (0 no; 1 yes)	0.261	0.267	0.284*
	(0.271)	(0.169)	(0.171)
Mother's education: primary (0 no; 1 yes)		0.339***	0.283**
		(0.112)	(0.115)
Mother's education: secondary (0 no; 1 yes)		0.427***	0.318**
		(0.145)	(0.154)
Mother's education: higher (0 no; 1 yes)		0.406**	0.296
		(0.200)	(0.213)
Dependence ratio		-0.0275	0.0806
		(0.376)	(0.380)
Mother aged <20 at birth (0 no; 1 yes)		-0.507**	-0.452**
		(0.198)	(0.203)
Mother aged 20-34 at birth (0 no; 1 yes)		-0.264*	-0.257*
		(0.147)	(0.151)
Ethnicity of household head Lao (0 no; 1 yes)		0.585***	0.535***
		(0.0995)	(0.104)
Ethnicity of household head Khmu (0 no; 1 yes)		0.0823	0.0767
		(0.170)	(0.170)
Ethnicity of household head Hmong (0 no; 1 yes)		0.178	0.152
		(0.184)	(0.188)
Birth order		-0.156**	-0.132**
		(0.0647)	(0.0654)
Household head sex (0 female; 1 male)		0.0214	0.0501
		(0.151)	(0.150)
Household is owned by household member (0 no; 1 yes)			-0.305
			(0.462)
Household has electricity (0 no; 1 yes)			0.238*
			(0.122)
Household with piped water source (0 no; 1 yes)			-0.0943
			(0.142)
Household with improved sanitation (0 no; 1 yes)			0.123
			(0.123)
Positive salt iodization test (0 no; 1 yes)			-0.0146
			(0.135)
Constant	-1.106***	-1.192**	-1.193*
	(0.378)	(0.486)	(0.666)
N	1,450	1,450	1,450

Note: Weighted OLS estimates. Robust standard errors clustered at the village level in parentheses. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively. Sample truncated to villages with distance to river less than 2km, absolute value of HAZ less 6, propensity score within the 1-99 percentiles of its distribution and female children. Data on child nutritional status from the LSIS 2011/12. Data on village FMC treatment status from 2011 Laos Agricultural Census. Data on other village characteristics from 2005 Laos Population Census.

Appendix:

Table A.8
Effect of FMC on HAZ for young male children in rural areas

Dependant variable:	HAZ (1)	HAZ (2)	HAZ (3)
Village with FMC (0 no; 1 yes)	-0.0478	-0.114	-0.0741
	(0.276)	(0.284)	(0.290)
Village in rural area with road (0 no; 1 yes)	-0.425*	-0.408	-0.332
	(0.225)	(0.250)	(0.261)
Village in rural area with no road (0 no; 1 yes)	-0.369	-0.233	-0.124
	(0.275)	(0.292)	(0.314)
Child under the age of 2 (0 no; 1 yes)	-0.651*	-0.651*	-0.663*
	(0.383)	(0.385)	(0.384)
Village in rural area with road and FMC (0 no; 1 yes)	0.285	0.335	0.271
	(0.304)	(0.306)	(0.313)
Village in rural area with no road and FMC (0 no; 1 yes)	-0.0140	-0.0509	-0.0704
	(0.379)	(0.370)	(0.370)
Village with FMC and child under the age of 2 (0 no; 1 yes)	-0.0586	0.0199	0.0297
	(0.388)	(0.389)	(0.388)
Village in rural area, road, child under the age of 2 (0 no; 1 yes)	0.365	0.358	0.358
	(0.255)	(0.255)	(0.258)
Village in rural area, no road, child under the age of 2 (0 no; 1 yes)	-0.0276	-0.0835	-0.0513
	(0.271)	(0.269)	(0.275)
Village with FMC, rural area, road, child under the age of 2 (0 no; 1 yes)	-0.257	-0.309	-0.311
	(0.429)	(0.424)	(0.423)
Village with FMC, rural area, no road, child under the age of 2 (0 no; 1 yes)	1.111**	1.017*	0.980*
	(0.539)	(0.548)	(0.545)
Child measured standing (0 no; 1 yes)	0.204	0.224	0.231
	(0.298)	(0.309)	(0.311)
Age (months)	-0.0369***	-0.0359***	-0.0363***
	(0.00440)	(0.00430)	(0.00426)
% of households with farmland	0.00182	0.00200	0.00123
	(0.00158)	(0.00140)	(0.00155)
Population with main activity unemployed	0.00990**	0.00808*	0.00708
	(0.00414)	(0.00472)	(0.00455)
% of population with main activity non-farm sector	0.00888***	0.00571**	0.00454
	(0.00288)	(0.00277)	(0.00288)
Village with water supply (0 no; 1 yes)	-0.510**	-0.456**	-0.443*
	(0.249)	(0.231)	(0.231)
Mother's education: primary (0 no; 1 yes)		0.158	0.0960
		(0.113)	(0.112)
Mother's education: secondary (0 no; 1 yes)		0.346***	0.252**
		(0.122)	(0.122)
Mother's education: higher (0 no; 1 yes)		0.253	0.158
		(0.196)	(0.197)
Dependence ratio		0.0636	0.173
		(0.310)	(0.310)
Mother aged <20 at birth (0 no; 1 yes)		-0.375*	-0.334*
		(0.193)	(0.193)
Mother aged 20-34 at birth (0 no; 1 yes)		-0.149	-0.151
		(0.167)	(0.166)
Ethnicity of household head Lao (0 no; 1 yes)		0.333***	0.284***
		(0.0885)	(0.0895)
Ethnicity of household head Khmu (0 no; 1 yes)		-0.0210	-0.0502
		(0.116)	(0.120)
Ethnicity of household head Hmong (0 no; 1 yes)		0.0231	-0.00433
		(0.147)	(0.145)
Birth order		-0.102*	-0.0900*
		(0.0534)	(0.0531)
Household head sex (0 female; 1 male)		0.282*	0.269*
		(0.152)	(0.154)
Household is owned by household member (0 no; 1 yes)			-0.253
			(0.225)
Household has electricity (0 no; 1 yes)			0.173**
			(0.0845)
Household with piped water source (0 no; 1 yes)			0.0104
			(0.126)
Household with improved sanitation (0 no; 1 yes)			0.135
			(0.0825)
Positive salt iodization test (0 no; 1 yes)			0.0989
			(0.0983)
Constant	-0.508	-0.731	-0.721
	(0.413)	(0.503)	(0.603)
N	1,557	1,557	1,557

Note: Weighted OLS estimates. Robust standard errors clustered at the village level in parentheses. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively. Sample truncated to villages with distance to river less than 2km, absolute value of HAZ less 6, propensity score within the 1-99 percentiles of its distribution and male children. Data on child nutritional status from the LSIS 2011/12. Data on village FMC treatment status from 2011 Laos Agricultural Census. Data on other village characteristics from 2005 Laos Population Census.

Appendix:

Table A.9

Effect of FMC on vaccination rate for young children in rural areas

Dependant variable:	Child received any vaccination (0 no; 1 yes)		
	(1)	(2)	(3)
Village with FMC (0 no; 1 yes)	-0.0266	-0.0219	-0.0414
	(0.0764)	(0.0797)	(0.0785)
Village in rural area with road (0 no; 1 yes)	-0.0384	-0.0416	-0.0601
	(0.0616)	(0.0621)	(0.0654)
Village in rural area with no road (0 no; 1 yes)	0.0121	0.00819	-0.0388
	(0.0853)	(0.0852)	(0.0907)
Child under the age of 2 (0 no; 1 yes)	-0.0920	-0.0901	-0.0852
	(0.0566)	(0.0577)	(0.0566)
Village in rural area with road and FMC (0 no; 1 yes)	0.0272	0.0232	0.0426
	(0.0941)	(0.0968)	(0.0960)
Village in rural area with no road and FMC (0 no; 1 yes)	-0.0335	-0.0414	-0.0358
	(0.143)	(0.146)	(0.147)
Village with FMC and child under the age of 2 (0 no; 1 yes)	0.139	0.142	0.143
	(0.0900)	(0.0935)	(0.0898)
Village in rural area, road, child under the age of 2 (0 no; 1 yes)	0.0169	0.0181	0.0184
	(0.0571)	(0.0581)	(0.0575)
Village in rural area, no road, child under the age of 2 (0 no; 1 yes)	-0.0813	-0.0773	-0.0832
	(0.0774)	(0.0781)	(0.0762)
Village with FMC, rural area, road, child under the age of 2 (0 no; 1 yes)	-0.102	-0.102	-0.102
	(0.106)	(0.110)	(0.107)
Village with FMC, rural area, no road, child under the age of 2 (0 no; 1 yes)	0.112	0.109	0.126
	(0.136)	(0.137)	(0.136)
Sex (0 female; 1 male)	0.00432	0.00851	0.0100
	(0.0209)	(0.0204)	(0.0202)
Age (months)	0.00559***	0.00559***	0.00580***
	(0.00113)	(0.00110)	(0.00110)
% of households with farmland	0.000855	0.000865	0.000770
	(0.000943)	(0.000919)	(0.000845)
Population with main activity unemployed	-0.00296**	-0.00249*	-0.00245
	(0.00149)	(0.00148)	(0.00149)
% of population with main activity non-farm sector	-0.000777	-0.000588	-0.000320
	(0.00111)	(0.00111)	(0.00111)
Village with water supply (0 no; 1 yes)	0.0545	0.0555	0.0673
	(0.0752)	(0.0745)	(0.0791)
Mother's education: primary (0 no; 1 yes)		-0.0188	0.0125
		(0.0329)	(0.0321)
Mother's education: secondary (0 no; 1 yes)		-0.0772**	-0.0207
		(0.0362)	(0.0362)
Mother's education: higher (0 no; 1 yes)		-0.0473	0.00337
		(0.0535)	(0.0541)
Dependence ratio		0.101	0.0374
		(0.0988)	(0.0981)
Mother aged <20 at birth (0 no; 1 yes)		-0.00841	-0.0268
		(0.0481)	(0.0478)
Mother aged 20-34 at birth (0 no; 1 yes)		-0.0519	-0.0485
		(0.0387)	(0.0391)
Ethnicity of household head Lao (0 no; 1 yes)		0.0305	0.0400
		(0.0363)	(0.0348)
Ethnicity of household head Khmu (0 no; 1 yes)		-0.0121	-0.0119
		(0.0481)	(0.0458)
Ethnicity of household head Hmong (0 no; 1 yes)		-0.0724	-0.0557
		(0.0748)	(0.0750)
Birth order		-0.0191	-0.0263
		(0.0172)	(0.0168)
Household head sex (0 female; 1 male)		-0.0191	-0.0264
		(0.0465)	(0.0482)
Household is owned by household member (0 no; 1 yes)			-0.104
			(0.0697)
Household has electricity (0 no; 1 yes)			-0.0530
			(0.0389)
Household with piped water source (0 no; 1 yes)			0.00576
			(0.0397)
Household with improved sanitation (0 no; 1 yes)			-0.105***
			(0.0285)
Positive salt iodization test (0 no; 1 yes)			0.0602*
			(0.0331)
Constant	0.271**	0.334**	0.512***
	(0.105)	(0.131)	(0.152)
N	3,007	3,007	3,007

Note: Weighted OLS estimates. Robust standard errors clustered at the village level in parentheses. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively. Sample truncated to villages with distance to river less than 2km and propensity score within the 1-99 percentiles of its distribution. Data on child nutritional status from the LSIS 2011/12. Data on village FMC treatment status from 2011 Laos Agricultural Census. Data on other village characteristics from 2005 Laos Population Census.

Appendix: HHI Ethnicity Index

The Herfindahl–Hirschman Index (HHI) variable reflecting village ethnicity diversification was calculated using the following formula

$$HHI_i = \left(\frac{\%e_{1i}}{100}\right)^2 + \left(\frac{\%\ e_{2i}}{100}\right)^2 + \left(\frac{\%\ e_{3i}}{100}\right)^2 + \cdots \left(\frac{\%\ e_{ni}}{100}\right)^2$$

Where $\%e_i$ refers to the ethnic population percentage of each ethnic category in the 2005 Population Census in each village.

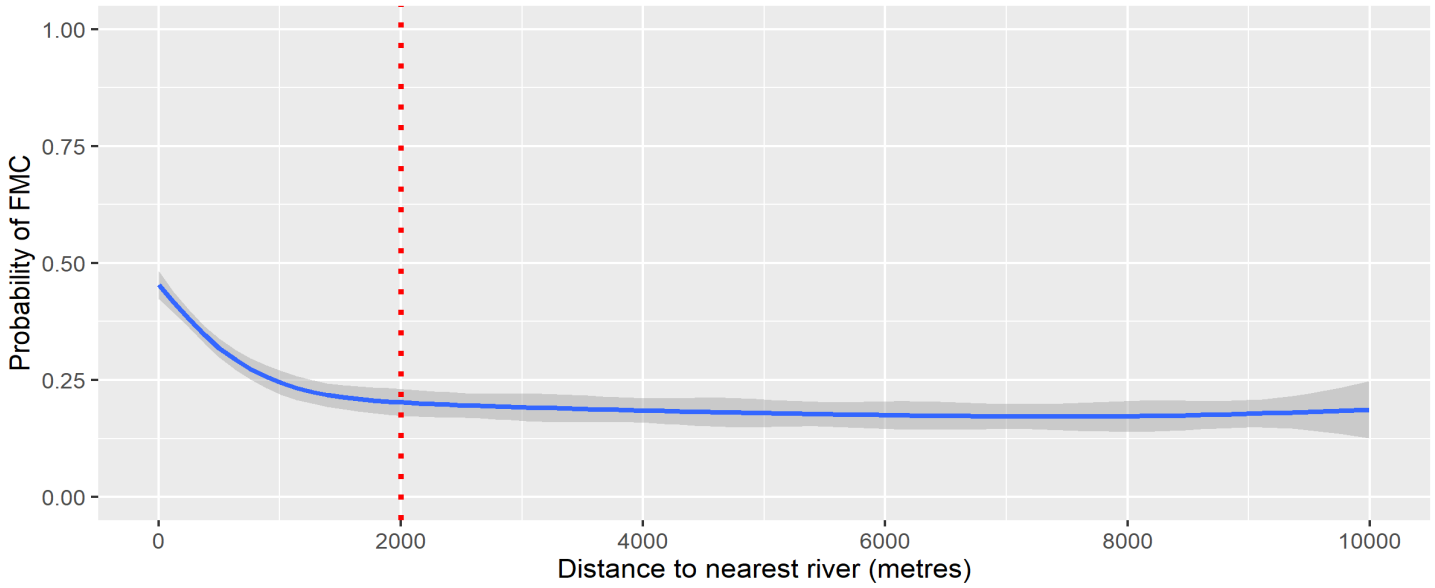
The idea is that people of similar ethnicities tend to communicate and cooperate more.

Appendix: Dependency ratio

The dependency ratio relates to the number of economically dependent (children from 0-14 years and the elderly aged 65 year and older) to the economically active group (15-64 years old).

Measures the degree to which households are burdened by dependants who cannot economically provide for the household

Appendix: Village truncation



- Fig. 2 Probability of FMC conditional on village distance to nearest river (using local polynomial regression)
  - Probability of FMC calculated as a function of distance
  - Higher likelihood of an FMC existing pre 2000 km to nearest river
  - Matches anecdotal evidence that FMC are mostly established in villages that are relatively close to rivers
  - Villages further away from rivers start to look considerably different to those closer to river, so including villages beyond this point would introduce bias, and likely additional noise as they would be de-weighted anyway.

Appendix: Propensity score and weight summary statistics

```
. summarize PROByhat
```

Variable	Obs	Mean	Std. Dev.	Min	Max
PROByhat	2,756	.3402227	.111013	.1305627	.5961537

```
. summarize weight
```

Variable	Obs	Mean	Std. Dev.	Min	Max
weight	2,756	.685942	.3139356	.1501691	1.476189

Appendix – How is the HAZ score determined?

$$\frac{Measured\ value\ -Average\ value\ in\ reference\ popualtion}{Standard\ deviation\ of\ the\ reference\ population}$$

- Interpretation:
  Number of standard deviations below or above the average height-for-age

Appendix: Why do villages without road benefit the most?

- The idea is that villages with roads may be able to use these roads to access alternative nutritional and employment options. They could catch a fish for lunch but head into town to buy beef for dinner.
- Villages without roads however likely do not have the same alternative option, or that option is much more costly in terms of travelling.
- In this case their nutritional outcomes are much more dependant on the yield provided by the fishery.
- Another way to think about it is a higher proportion of their nutrition comes from fisheries
- Therefore given an increase in fishery productivity due to FMC, these communities benefit the most.

Appendix: Why do girls benefit more than boys?

- The idea here is that each household faces a budget constraint.
- Many households in Laos are poor, and their budgets do not allow for all household members to be well fed.
- In this case, food must be allocated, and there is likely a bias towards men and male children with the intention of them conducting intense manual labour to earn for the household, which is something which requires a lot of energy and therefore food.
- The women's role is perceived to be working within the household and caring for the children (perception is especially prevalent in developing countries) which is perceived to require less energy then manual labor.
- When fisheries are introduced and increase household food supply there is no longer a need to allocate scarce food resources among household members.
- As male members are already being well fed, females experience the largest gain in food consumption, explaining why they experience the largest change in nutritional outcome

Appendix – Trimming and losing observations

- This procedure is “operationalized” (no judgement on behalf of the researcher)

- Some observations are lost for a large benefit:

“Trimming … improves the robustness properties of the estimators. The trimmed units tend to be units with high leverage whose presence makes estimators sensitive to outliers in terms of outcome values” (Imbens, 2015, p. 394)

Appendix: Interpreting triple difference estimators

Comparing the subgroup that meet the criteria with the subgroup that don't meet the criteria

So compare young children in rural areas with no roads with young children in rural areas with road, young children in urban, etc etc

Appendix – Rosenbaum bounds (used for PSM)

Steps:

1. Rematch individuals such that their propensity scores are slightly different from those used in the original matching process (reflecting the importance of a hypothetical unobserved confounder)
2. Assess the impact on the estimate for the average treatment effect.

If the estimate remains significant after sufficient deviations in propensity scores between matched observations, the estimate is not sensitive to bias caused by unobserved covariates, and therefore the violations of the conditional independence assumption are of no substantial importance.

Appendix – Sample sizes in subgroups

3007 children total (with trimming)

404 young female children in rural area with road access

107 young female children in rural area with no road access

440 young male children in rural area with road access

89 young male children in rural area with no road access

Appendix – Achieving overlap

Common support:

Drops treatment observations outside of the region of common support such that there is overlap in propensity scores between the treated and control group

Trimming:

Drops extreme values of the propensity score, further satisfying overlap and increasing the robustness of our estimates

References

Evans, L., Cherrett, N., & Pemsl, D. (2011). Assessing the impact of fisheries co-management interventions in developing countries: A meta-analysis. *Journal of Environmental Management*, *92*(8), 1938–1949. https://doi.org/10.1016/j.jenvman.2011.03.010

Ferraro, P. J., & Hanauer, M. M. (2014). Advances in measuring the environmental and social impacts of environmental programs. Annual Review of Environment and Resources, 39, 495–517. https://doi.org/10.1146/annurev-environ-101813-013230

Haque, A. B. M. M., & Dey, M. M. (2016). Impact of the Community-based Fish Culture System on Expenditure and Inequality: Evidence from Bangladesh. Journal of the World Aquaculture Society, 47(5), 646–657. https://doi.org/10.1111/jwas.12317

Hardin, G. (1968). The Tragedy of the Commons. *Science, 162*(3859), 1243-1248. doi: 10.1126/science.162.3859.1243

Holland, P. W. (1986). Statistics and causal inference. *Journal of the American Statistical Association*, *81*(396), 945–960. https://doi.org/10.1080/01621459.1986.10478354

Khan, M. A., Alam, M. F., & Islam, K. J. (2012). The impact of co-management on household income and expenditure: An empirical analysis of common property fishery resource management in Bangladesh. Ocean and Coastal Management, 65, 67–78. https://doi.org/10.1016/j.ocecoaman.2012.04.014

Oldekop, J. A., Sims, K. R. E., Karna, B. K., Whittingham, M. J., & Agrawal, A. (2019). Reductions in deforestation and poverty from decentralized forest management in Nepal. Nature Sustainability, 2(5), 421–428. https://doi.org/10.1038/s41893-019-0277-3

Ostrom, E. (1990). *Governing the Commons.* Cambridge UK: Cambridge University Press.

Pailler, S., Naidoo, R., Burgess, N. D., Freeman, O. E., & Fisher, B. (2015). Impacts of community-based natural resource management on wealth, food security and child health in Tanzania. PLoS ONE, 10(7), 1–22. https://doi.org/10.1371/journal.pone.0133252

Smith, J. A., & Todd, P. E. (2001). Reconciling Conflicting Evidence on the Performance of Propensity-Score Matching Methods. The American Economic Review, 91(2), 112-118. https://doi.org/10.1257/aer.91.2.112

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