

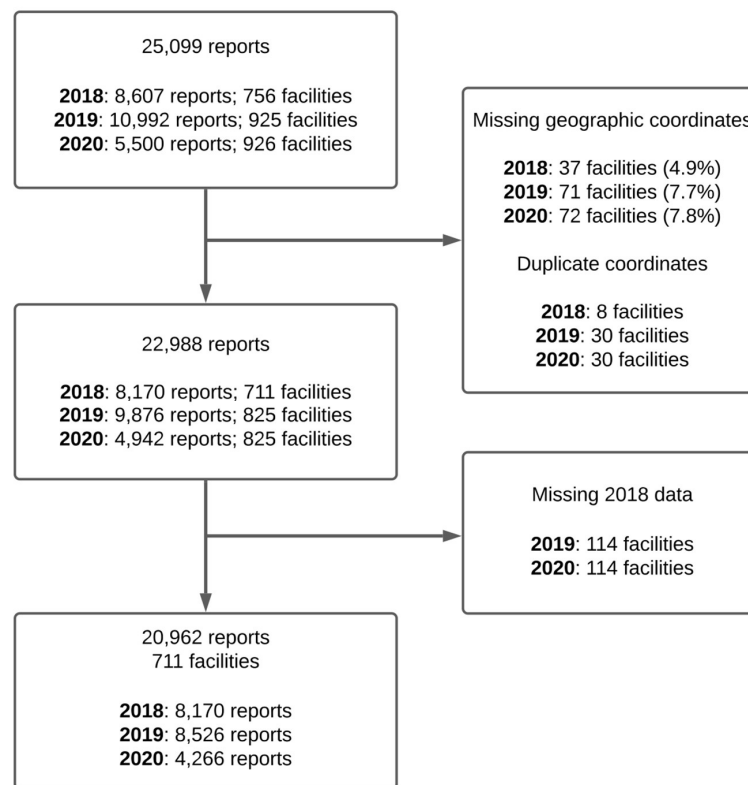
SUPPLEMENTARY MATERIAL

Effectiveness of a National Mass Distribution Campaign of Long-Lasting Insecticide-Treated Nets on Clinical Malaria in Malawi, 2018-2020

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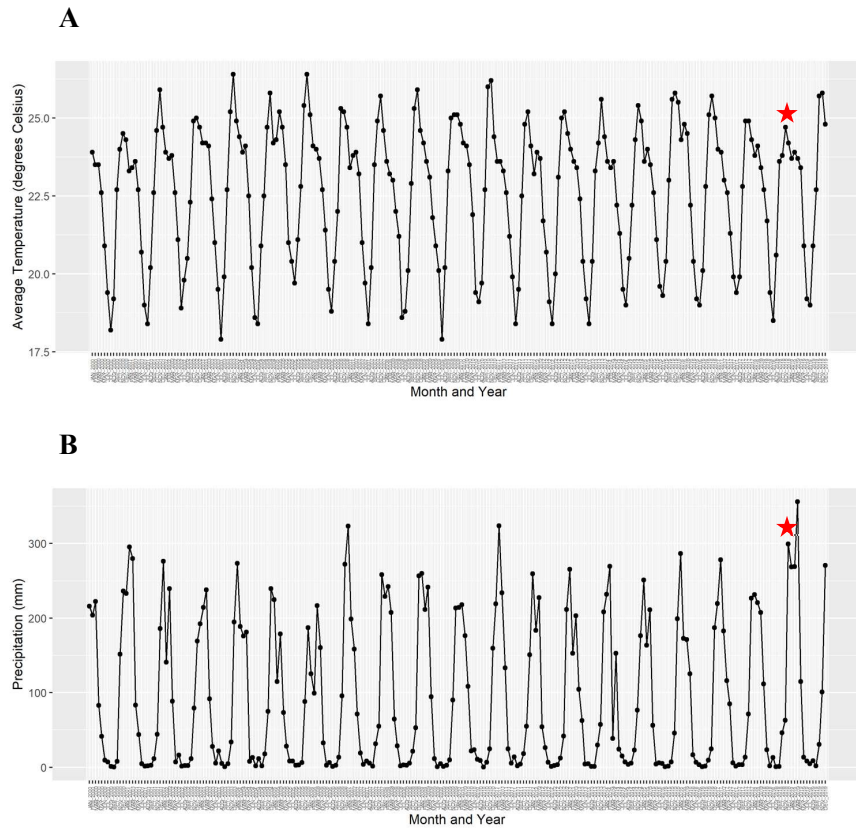


Supplementary Figure 1. Health facilities and facility reports from Malawi's District Health Information Software 2 which were included in the analysis, January 2018 to June 2020.

Supplementary Table 1. Proportion of health facilities, health facility reports, and confirmed malaria cases included in the study analysis and in DHIS2, by year.

Year	Health facilities			Health facility reports			Confirmed malaria cases		
	included in study	DHIS2	%	included in study	DHIS2	%	included in study	DHIS2	%
2018: Jan-Dec	711	756	94.0	8,170	8,607	94.9	6,833,895	6,997,921	97.7
2019: Jan-Dec	711	925	76.9	8,526	10,992	77.6	5,074,442	5,229,573	97.0
2020: Jan-Jun	711	926	76.8	4,266	5,500	77.6	4,664,899	4,839,038	96.4
TOTAL	711	926	76.8	20,962	25,099	83.5	16,573,236	17,066,532	97.1

DHIS2 = District Health Information Software 2



Supplementary Figure 2. A) average monthly temperature and B) total monthly precipitation, Malawi, 2000 to 2019. Stars indicate peaks in November and December 2018, respectively, immediately before the start of the 2019 high malaria transmission season.

Supplementary Table 2. Bed net coverage by district, calculated using 2018 Malawi census population counts and bed net distribution counts for all health facilities included in the analysis (n=711). Nkhotakota did not distribute bed nets, but sprayed 112,264 structures in 2018, resulting in a coverage rate of 94.9% (PMI Malawi Malaria Operational Plan FY 2020).

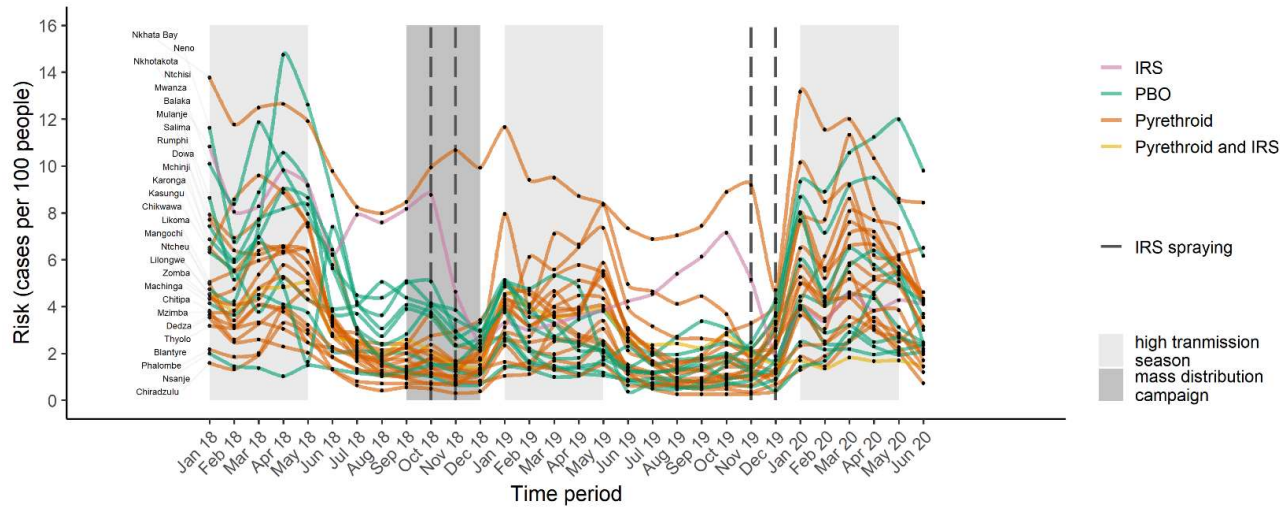
District	Intervention	Population size (2018)	Number of bed nets distributed	Coverage (nets per 100 people)	Number of people per net
Balaka	Pyrethroid	448,706	301,033	67.1	1.5
Blantyre	Pyrethroid	1,251,484	692,646	55.3	1.8
Chikwawa	Pyrethroid	534,779	396,272	74.1	1.3
Chiradzulu	Pyrethroid	356,875	238,011	66.7	1.5
Chitipa	Pyrethroid	234,927	129,579	55.2	1.8
Dedza	Pyrethroid	830,512	518,538	62.4	1.6
Dowa	Pyrethroid	772,569	461,366	59.7	1.7
Karonga	PBO	365,028	253,486	69.4	1.4
Kasungu	Pyrethroid	842,953	513,735	60.9	1.6
Likoma	PBO	14,527	8,535	58.8	1.7
Lilongwe	Pyrethroid	2,626,901	1,441,780	54.9	1.8
Machinga	PBO	735,438	518,742	70.5	1.4
Mangochi	Pyrethroid / IRS	1,148,611	784,210	68.3	1.5
Mchinji	Pyrethroid / PBO	602,305	413,605	68.7	1.5
Mulanje	Pyrethroid	684,107	466,162	68.1	1.5
Mwanza	PBO	130,949	84,698	64.7	1.5
Mzimba	Pyrethroid	1,161,456	672,652	57.9	1.7
Neno	PBO	167,409	81,198	48.5	2.1
Nkhata Bay	Pyrethroid	284,681	179,657	63.1	1.6
Nkhotakota	IRS	393,077
Nsanje	PBO	503,412	230,374	45.8	2.2
Ntcheu	Pyrethroid	659,608	392,781	59.5	1.7
Ntchisi	PBO	317,069	190,242	60.0	1.7
Phalombe	Pyrethroid	398,666	285,977	71.7	1.4
Rumphi	PBO	229,161	140,902	61.5	1.6
Salima	PBO	478,346	327,771	68.5	1.5
Thyolo	Pyrethroid	721,456	481,419	66.7	1.5
Zomba	Pyrethroid	860,604	583,576	67.8	1.5
TOTAL	..	17,755,616	10,788,947	68.8	1.6

IRS = indoor residual spraying, PBO = piperonyl butoxide

Supplementary Table 3. One-month risk of malaria (cases per 100 people) by month from January 2018 to June 2020, stratified by age group and intervention type. 'No data' refers to health facilities which did not have any bed net distribution or IRS information.

	Age group risk (cases per 100 people)			Insecticide type risk (cases per 100 people)				
	<5 years	≥5 years	All ages	IRS	Pyrethroid	PBO	Pyrethroid / IRS	No data
Jan-18	14.9	3.4	5.0	10.8	5.0	6.1	4.5	1.4
Feb-18	13.5	3.0	4.5	8.0	4.7	5.0	3.8	1.2
Mar-18	16.5	3.5	5.4	8.3	5.6	6.0	4.8	1.7
Apr-18	16.4	3.8	5.7	9.8	6.0	6.0	4.8	1.9
May-18	15.6	3.4	5.2	9.2	5.4	5.5	5.0	1.8
Jun-18	9.7	2.2	3.3	6.2	3.2	4.3	2.7	1.3
Jul-18	7.6	1.4	2.3	7.9	2.3	3.0	2.5	0.5
Aug-18	6.2	1.1	1.8	7.6	1.7	2.7	2.0	0.4
Sep-18	6.7	1.2	2.0	8.2	1.7	2.9	2.6	0.4
Oct-18	6.8	1.3	2.1	8.8	2.0	2.9	2.1	0.4
Nov-18	5.5	1.0	1.7	4.6	1.7	2.1	1.5	0.4
Dec-18	5.8	1.0	1.7	2.4	1.9	1.9	1.5	0.4
Jan-19	9.7	2.4	3.5	3.3	3.9	3.4	4.5	0.8
Feb-19	8.5	2.1	3.0	3.0	3.5	2.3	4.0	0.9
Mar-19	9.2	2.4	3.4	3.3	4.3	1.9	3.5	0.9
Apr-19	9.4	2.3	3.3	3.6	4.2	1.8	3.7	0.9
May-19	9.6	2.5	3.5	3.9	4.5	1.8	3.9	0.9
Jun-19	6.4	1.3	2.1	4.2	2.5	1.2	2.5	0.6
Jul-19	5.6	1.0	1.6	4.5	1.9	1.1	2.4	0.5
Aug-19	4.8	0.8	1.4	5.4	1.4	1.1	2.4	0.4
Sep-19	5.0	0.9	1.5	6.1	1.5	1.4	2.2	0.4
Oct-19	5.7	1.1	1.7	7.1	1.7	1.5	2.8	0.5
Nov-19	5.0	1.1	1.6	5.1	1.8	1.4	1.9	0.5
Dec-19	5.9	1.3	2.0	1.9	2.3	2.0	1.5	0.6
Jan-20	12.9	3.6	5.0	3.9	6.1	5.0	1.7	1.4
Feb-20	10.6	3.0	4.1	3.4	5.1	3.8	1.3	1.1
Mar-20	13.1	4.1	5.4	4.6	6.8	4.8	1.8	1.4
Apr-20	11.8	3.4	4.6	3.8	5.7	4.5	1.7	1.3
May-20	11.3	2.9	4.1	4.3	5.0	4.3	1.7	1.1
Jun-20	9.1	2.0	3.0	4.1	3.5	3.4	1.5	0.8

IRS = indoor residual spraying, PBO = piperonyl butoxide



Supplementary Figure 3. One-month risk of malaria from January 2018 to June 2020, stratified by district, all ages. Line colors represent the type of invention which households in each district received. Dark gray color blocks represent months where the mass distribution campaign occurred (September to December 2018) and light gray blocks represent months which fall during the yearly high malaria transmission season (January to May). Risk was measured monthly and curves are smoothed using X-splines. Note: IRS = indoor residual spraying, PBO = piperonyl butoxide.

Supplementary Table 4. Changes in malaria risk (cases per 100 people) by district from January 2018 to June 2020, stratified by age group and high and low malaria transmission seasons.

HIGH TRANSMISSION* risk (cases per 100 people)

DISTRICT	Insecticide	<5 years					≥5 years					All ages				
		2018	2019	2020	RD 19 vs. 18	RD 20 vs. 18	2018	2019	2020	RD 19 vs. 18	RD 20 vs. 18	2018	2019	2020	RD 19 vs. 18	RD 20 vs. 18
BALAKA	Pyrethroid	79.6	58.5	70.4	-21.1	-9.1	31.7	28.5	35.8	-3.3	4.0	39.0	33.0	41.0	-6.0	2.0
BLANTYRE	Pyrethroid	48.6	33.6	45.0	-15.0	-3.6	10.1	8.7	14.1	-1.4	3.9	15.1	11.9	18.0	-3.2	3.0
CHIKWAWA	Pyrethroid	60.5	70.6	70.3	10.1	9.8	13.7	22.3	23.6	8.6	10.0	20.8	29.7	30.8	8.9	10.0
CHIRADZULU	Pyrethroid	31.8	23.1	21.2	-8.8	-10.6	7.8	9.6	9.4	1.8	1.6	11.0	11.4	11.0	0.5	0.0
CHITIPA	Pyrethroid	31.4	23.4	21.0	-8.0	-10.4	13.7	10.3	10.3	-3.4	-3.4	16.1	12.0	11.8	-4.0	-4.3
DEDZA	Pyrethroid	61.2	49.6	62.1	-11.6	0.8	10.2	11.2	14.9	1.0	4.8	17.6	16.8	21.8	-0.9	4.2
DOWA	Pyrethroid	103.9	60.3	99.6	-43.6	-4.3	21.3	13.6	25.9	-7.7	4.6	32.6	20.0	35.9	-12.6	3.3
KARONGA	PBO	56.9	21.5	23.3	-35.5	-33.7	20.0	6.0	8.9	-14.0	-11.1	25.1	8.1	10.9	-17.0	-14.2
KASUNGU	Pyrethroid	101.1	78.9	103.8	-22.2	2.8	16.9	15.6	20.3	-1.3	3.4	29.0	24.7	32.4	-4.3	3.3
LIKOMA	PBO	64.9	38.5	34.5	-26.4	-30.4	41.0	16.3	18.7	-24.7	-22.3	43.8	18.8	20.5	-24.9	-23.3
LILONGWE	Pyrethroid	99.9	41.7	62.8	-58.2	-37.0	14.9	7.4	13.1	-7.6	-1.8	27.2	12.2	20.1	-15.0	-7.1
MACHINGA	PBO	51.6	22.2	35.7	-29.4	-15.8	13.7	5.8	11.0	-8.0	-2.8	20.1	8.5	15.1	-11.6	-5.0
MANGOCHI	Pyrethroid / IRS	68.9	57.8	25.4	-11.1	-43.5	12.9	11.6	4.6	-1.3	-8.3	22.7	19.7	8.2	-3.0	-14.5
MCHINJI	Pyrethroid / PBO	114.8	56.6	99.0	-58.2	-15.8	28.2	14.8	29.8	-13.4	1.6	41.0	21.0	40.0	-20.0	-1.0
MULANJE	Pyrethroid	97.5	60.6	86.4	-36.9	-11.1	23.2	16.3	24.0	-6.9	0.8	33.3	22.3	32.5	-11.0	-0.8
MWANZA	PBO	114.4	60.0	149.7	-54.4	35.3	12.2	8.9	35.2	-3.3	23.0	27.2	16.4	52.0	-10.8	24.8
MZIMBA	Pyrethroid	65.2	50.6	50.6	-14.6	-14.6	18.7	14.8	18.8	-3.8	0.1	25.3	19.9	23.2	-5.4	-2.1
NENO	PBO	107.8	42.0	77.4	-65.7	-30.4	36.1	18.1	36.7	-18.0	0.5	47.0	21.8	42.9	-25.2	-4.1
NKHATA BAY	Pyrethroid	186.1	135.9	144.5	-50.2	-41.6	42.7	33.4	41.2	-9.3	-1.4	62.6	47.7	55.6	-14.9	-6.9
NKHOTAKOTA	IRS	128.2	43.5	53.5	-84.7	-74.7	30.8	12.1	13.7	-18.7	-17.0	46.1	17.0	20.0	-29.1	-26.1
NSANJE	PBO	15.4	13.3	18.2	-2.2	2.7	5.6	5.3	8.8	-0.4	3.2	7.1	6.5	10.2	-0.7	3.1
NTCHEU	Pyrethroid	75.6	62.2	74.2	-13.3	-1.4	13.3	15.2	21.3	1.9	8.0	22.3	22.0	28.9	-0.3	6.6
NTCHISI	PBO	144.3	33.8	79.0	-110.5	-65.2	31.3	5.5	21.2	-25.9	-10.2	48.1	9.7	29.8	-38.4	-18.3
PHALOMBE	Pyrethroid	29.3	16.1	23.9	-13.2	-5.4	10.3	6.5	11.7	-3.8	1.4	13.2	7.9	13.6	-5.2	0.4
RUMPHI	PBO	72.2	26.9	31.7	-45.3	-40.5	31.7	9.7	16.8	-22.0	-14.9	37.4	12.1	18.9	-25.2	-18.5
SALIMA	PBO	111.1	46.3	74.5	-64.7	-36.6	23.5	9.4	18.9	-14.1	-4.6	37.7	15.4	27.9	-22.3	-9.7
THYOLO	Pyrethroid	40.5	20.6	47.0	-20.0	6.5	7.9	4.9	12.8	-3.0	4.8	12.2	7.0	17.2	-5.3	5.0
ZOMBA	Pyrethroid	60.6	49.7	62.2	-10.9	1.6	17.4	15.2	18.4	-2.2	1.0	23.4	20.0	24.5	-3.4	1.1

* High transmission season: January to May; Low transmission season: June to December; IRS = indoor residual spraying, PBO = piperonyl butoxide, RD = risk difference

LOW TRANSMISSION* risk (cases per 100 people)

DISTRICT	Insecticide	<5 years			≥5 years			All ages		
		2018	2019	RD 19 vs. 18	2018	2019	RD 19 vs. 18	2018	2019	RD 19 vs. 18
BALAKA	Pyrethroid	41.5	47.8	6.3	10.5	14.7	4.2	15.2	19.7	4.5
BLANTYRE	Pyrethroid	23.5	27.3	3.8	5.1	5.7	0.6	7.5	8.5	1.0
CHIKWAWA	Pyrethroid	44.0	67.2	23.2	8.1	17.2	9.1	13.6	24.8	11.3
CHIRADZULU	Pyrethroid	12.1	9.4	-2.7	2.9	2.2	-0.6	4.1	3.2	-0.9
CHITIPA	Pyrethroid	27.4	17.0	-10.4	10.1	3.2	-6.8	12.4	5.1	-7.3
DEDZA	Pyrethroid	39.4	30.5	-8.9	5.9	5.1	-0.7	10.8	8.9	-1.9
DOWA	Pyrethroid	56.8	42.1	-14.8	8.8	7.1	-1.8	15.4	11.9	-3.5
KARONGA	PBO	72.9	16.8	-56.1	19.0	3.7	-15.3	26.4	5.5	-20.9
KASUNGU	Pyrethroid	52.6	56.1	3.6	6.3	7.1	0.9	13.0	14.2	1.3
LIKOMA	PBO	71.0	46.5	-24.5	27.6	13.7	-13.8	32.6	17.5	-15.1
LILONGWE	Pyrethroid	35.4	25.8	-9.6	4.9	3.4	-1.4	9.2	6.6	-2.6
MACHINGA	PBO	32.7	26.4	-6.2	6.5	4.6	-1.9	10.9	8.3	-2.6
MANGOCHI	Pyrethroid / IRS	45.6	52.3	6.8	7.3	8.1	0.8	14.0	15.8	1.9
MCHINJI	Pyrethroid / PBO	68.7	53.7	-15.0	13.6	11.9	-1.7	21.7	18.0	-3.7
MULANJE	Pyrethroid	58.0	52.1	-5.9	12.8	11.1	-1.7	18.9	16.6	-2.2
MWANZA	PBO	98.4	54.8	-43.5	16.4	9.1	-7.2	28.4	15.9	-12.6
MZIMBA	Pyrethroid	34.4	26.0	-8.4	6.8	5.6	-1.2	10.7	8.5	-2.2
NENO	PBO	55.5	31.8	-23.7	16.4	10.8	-5.6	22.3	14.0	-8.3
NKHATA BAY	Pyrethroid	198.0	159.9	-38.1	42.2	33.9	-8.3	63.9	51.5	-12.5
NKHOTAKOTA	IRS	121.7	96.2	-25.5	29.7	22.9	-6.8	44.2	34.4	-9.8
NSANJE	PBO	14.5	18.5	4.0	5.3	5.6	0.3	6.7	7.6	0.9
NTCHEU	Pyrethroid	46.7	42.5	-4.3	7.8	8.4	0.6	13.4	13.3	-0.1
NTCHISI	PBO	85.2	36.5	-48.7	13.1	6.4	-6.6	23.8	10.9	-12.9
PHALOMBE	Pyrethroid	22.7	14.3	-8.4	6.5	3.9	-2.6	8.9	5.5	-3.5
RUMPHI	PBO	35.0	14.5	-20.5	11.1	3.9	-7.2	14.5	5.4	-9.0
SALIMA	PBO	91.2	40.5	-50.7	15.6	5.6	-10.0	27.8	11.3	-16.5
THYOLO	Pyrethroid	24.0	27.1	3.1	3.4	4.4	1.0	6.1	7.4	1.2
ZOMBA	Pyrethroid	40.0	42.2	2.2	9.5	9.8	0.3	13.7	14.3	0.6

* High transmission season: January to May; Low transmission season: June to December; IRS = indoor residual spraying, PBO = piperonyl butoxide, RD = risk difference