Supplementary Information

Supplementary Table 1. Projected additional clinical malaria cases between 1 May 2020 and 30 April 2021 for different COVID-19 scenarios in malaria endemic countries in sub-Saharan Africa. Different combinations of malaria interventions are considered on each row, with the colour denoting whether they were halted for the period of health system interruption (red), reduced to 50% of the normal coverage level (light green) or continued as normal (dark green). LLINs = distribution of long-lasting insecticide treated nets in countries due for mass campaigns in 2020, SMC = seasonal malaria chemoprevention with amodiaquine plus sulfadoxine-pyrimethamine covering 70% of children 3–59 months of age (under 10 years in Senegal), in SMC target areas in the Sahel and, Treatment = treatment of clinical cases. The proportion of clinical cases treated varies geographically (see Methods). LLINs are only disrupted in regions where they were previously planned. Care should be taken when directly comparing the relative impact of different malaria interventions as they vary in their period of disruption (other than in the suppression scenario). Values are shown as the point estimate and 95% uncertainty interval (95% UI) rounded to the nearest million.

				COVID-19 scenario			
				Unmitigated	Mitigation	Suppression	Suppression lift
Malaria scenario				**Additional clinical malaria cases ('000,000) (95% UI)** (compared to a baseline estimate of 258.6 million (95% UI 195.5–321.7 million) cases in this period without malaria service interruption)			
No.	LLINs	SMC	Treatment				
1				154 (122–187)	206 (157–254)	239 (182–295)	206 (158–255)
2				151 (120–181)	184 (147–222)	214 (173–256)	184 (147–222)
3				8 (5–10)	33 (19–46)	61 (41–82)	33 (20–47)
4				10 (7–14)	46 (25–68)	79 (46–112)	47 (25–69)
5				14 (10–17)	39 (25–53)	58 (39–77)	39 (25–53)
6				147 (116–178)	197 (151–244)	250 (190–309)	198 (151–245)
7				5 (2–7)	39 (19–60)	78 (44–111)	40 (19–61)
8				16 (11–21)	54 (30–77)	87 (52–121)	54 (31–78)
9				151 (118–184)	220 (160–281)	292 (209–376)	222 (161–283)
10				143 (112–175)	211 (153–269)	283 (202–364)	212 (153–271)
11				155 (121–188)	224 (163–286)	289 (207–371)	226 (164–288)

Supplementary Table 2. Projected COVID-19 and additional malaria life-years lost between 1 May 2020 and 30 April 2021 for different COVID-19 scenarios in malaria endemic countries in sub-Saharan Africa. Different combinations of malaria interventions are considered on each row, with the colour denoting whether they were halted for the period of health system interruption (red), reduced to 50% of the normal coverage level (light green) or continued as normal (dark green). *LLINs* = distribution of long-lasting insecticide treated nets in countries due for mass campaigns in 2020, SMC = seasonal malaria chemoprevention in SMC target areas in the Sahel and, *Treatment* = treatment of clinical cases. LLINs are only disrupted in regions where they were previously planned. Care should be taken when directly comparing the relative impact of different malaria interventions as they vary in their period of disruption (other than in the suppression scenario). The point estimate of deaths due to COVID-19 is from the assumption of an R_0 of 3.0, with ranges in brackets for an R_0 of 2.5 and 3.5. Values are shown as the point estimate and 95% uncertainty interval (95% UI) rounded to the nearest million.

				COVID-19 scenario			
				Unmitigated	Mitigation	Suppression	Suppression lift
COVID-19 life-years lost (‘000,000)				123 (99–140)	93 (88–120)	10 (9–12)	123 (99–140)
Malaria scenario				**Additional malaria life-years lost (‘000,000) (95% UI)** (compared to a baseline estimate of 20.4 million (95% UI 11.6–29.2 million) life-years lost in this period without malaria service interruption)			
No.	LLINs	SMC	Treatment				
1				12 (7–16)	19 (11–26)	23 (14–31)	19 (11–26)
2				11 (7–15)	14 (9–19)	16 (10–22)	14 (9–19)
3				1 (0.8–2)	5 (3–8)	10 (6–14)	5 (3–8)
4				2 (1–3)	9 (5–13)	15 (9–22)	9 (5–13)
5				2 (1–3)	6 (4–9)	9 (6–13)	6 (4–9)
6				11 (7–15)	18 (11–24)	24 (15–34)	18 (11–24)
7				1 (0.7–2)	8 (4–11)	15 (9–21)	8 (4–11)
8				3 (2–4)	10 (6–14)	16 (10–23)	10 (6–14)
9				12 (7–16)	22 (14–31)	34 (21–47)	23 (14–32)
10				11 (6–15)	21 (13–30)	33 (20–45)	21 (13–30)
11				12 (8–17)	24 (14–33)	34 (21–47)	24 (14–33)

Supplementary Table 3. Projected additional deaths due to malaria in Nigeria between May 2020 and April 2021 for different COVID-19 scenarios. Different combinations of malaria interventions are considered on each row, with the colour denoting whether they were halted for the period of health system interruption (red), reduced to 50% of the normal coverage level (light green) or continued as normal (dark green). LLINs = distribution of long-lasting insecticide treated nets in countries due for mass campaigns in 2020, SMC = seasonal malaria chemoprevention in SMC target areas in Northern Nigeria. Treatment = treatment of clinical cases. LLINs and SMC campaigns are only disrupted in states where they were previously planned. Disruptions to malaria interventions last for different time periods depending on the COVID-19 scenarios as noted in Figure 1. Values are shown as the point estimate and 95% uncertainty interval (95% UI) based on 20 parameter draws, rounded to the nearest thousand.

				COVID-19 scenario			
				Unmitigated	Mitigation	Suppression	Suppression lift
Malaria scenario				**Additional malaria deaths in Nigeria ('000) (95% UI)** (compared to a baseline estimate of 117 (95% UI 60–174) thousand deaths in Nigeria in this period without malaria service interruption)			
No.	LLINs	SMC	Treatment				
1				48 (26–70)	81 (44–119)	95 (51–138)	82 (45–120)
2				40 (22–58)	40 (22–58)	40 (22–58)	40 (22–58)
3				9 (5–13)	34 (18–50)	42 (22–62)	34 (18–50)
4				17 (9–25)	71 (36–106)	89 (46–132)	72 (37–107)
5				11 (6–17)	37 (19–54)	45 (24–67)	37 (19–55)
6				45 (24–66)	77 (41–112)	90 (49–131)	77 (42–113)
7				15 (8–22)	67 (34–100)	84 (44–125)	68 (35–100)
8				19 (10–29)	76 (39–113)	93 (48–139)	76 (39–113)
9				54 (29–79)	125 (66–183)	153 (82–223)	126 (67–184)
10				51 (27–74)	118 (63–174)	146 (78–214)	120 (64–175)
11				57 (31–83)	131 (70–192)	159 (86–233)	132 (71–193)

Supplementary Table 4. Projected case fatality ratio of malaria and the percentage of clinical cases receiving treatment between 1 May 2020 and 30 April 2021 for different COVID-19 scenarios in malaria endemic countries in sub-Saharan Africa. Values in brackets indicate % of clinical cases treated over the year. There is a negative association between percentage of cases treated and case fatality ratios (deaths per clinical case of malaria) showing the importance of case management to death rate. Different combinations of malaria interventions are considered on each row, with the colour denoting whether they were halted for the period of health system interruption (red), reduced to 50% of the normal coverage level (light green) or continued as normal (dark green). LLINs = distribution of long-lasting insecticide treated nets in countries due for mass campaigns in 2020, SMC = seasonal malaria chemoprevention with amodiaquine plus sulfadoxine-pyrimethamine covering 70% of children 3–59 months of age (under 10 years in Senegal), in SMC target areas in the Sahel and, Treatment = treatment of clinical cases. Care should be taken when directly comparing the relative impact of different malaria interventions as they vary in their period of disruption (other than in the suppression scenario).

				COVID-19 scenario			
				Unmitigated	Mitigation	Suppression	Suppression lift
Malaria scenario				**Case fatality ratio (deaths per clinical case, %)** (value in brackets indicates the % of clinical cases receiving treatment over the year)			
No.	LLINs	SMC	Treatment				
1				0.16 (44)	0.17 (34)	0.18 (24)	0.17 (34)
2				0.16 (47)	0.16 (46)	0.16 (47)	0.16 (46)
3				0.17 (44)	0.18 (33)	0.19 (24)	0.18 (33)
4				0.17 (42)	0.20 (20)	0.22 (0)	0.20 (19)
5				0.17 (44)	0.19 (33)	0.19 (24)	0.19 (33)
6				0.16 (45)	0.17 (34)	0.18 (24)	0.17 (34)
7				0.17 (42)	0.20 (21)	0.22 (0)	0.20 (20)
8				0.17 (41)	0.20 (20)	0.22 (0)	0.20 (19)
9				0.16 (42)	0.18 (22)	0.20 (0)	0.18 (21)
10				0.16 (42)	0.18 (23)	0.20 (0)	0.18 (21)
11				0.16 (42)	0.19 (21)	0.20 (0)	0.19 (20)

Supplementary Table 5. Projected additional malaria deaths between 1 May 2020 and 30 April 2021 for different COVID-19 scenarios in malaria endemic administrative units in sub-Saharan Africa that received seasonal malaria chemoprevention (SMC) in 2019. Different combinations of malaria interventions are considered on each row, with the colour denoting whether they were halted for the period of health system interruption (red), reduced to 50% of the normal coverage level (light green) or continued as normal (dark green). LLINs = distribution of long-lasting insecticide treated nets in countries due for mass campaigns in 2020, SMC = seasonal malaria chemoprevention in SMC target areas in the Sahel and, Treatment = treatment of clinical cases. LLINs are only disrupted in regions where they were previously planned. Care should be taken when directly comparing the relative impact of different malaria interventions as they vary in their period of disruption (other than in the suppression scenario). Values are shown as the point estimate and 95% uncertainty interval (95% UI), rounded to the nearest thousand.

				COVID-19 scenario			
				Unmitigated	Mitigation	Suppression	Suppression lift
Malaria scenario				**Additional malaria deaths ('000) within SMC regions (95% UI)** (compared to a baseline estimate of 87 (95% UI 46–127) deaths in this period without malaria service interruption)			
No.	LLINs	SMC	Treatment				
1				71 (42–100)	95 (56–135)	65 (39–91)	96 (56–135)
2				64 (38–91)	65 (39–92)	65 (40–91)	65 (39–92)
3				19 (10–27)	34 (19–50)	52 (30–74)	34 (19–50)
4				23 (13–34)	57 (30–83)	64 (36–92)	57 (30–84)
5				33 (19–47)	51 (28–74)	41 (23–58)	51 (28–74)
6				52 (31–74)	73 (42–104)	95 (57–134)	73 (42–104)
7				9 (5–13)	37 (19–54)	60 (33–86)	37 (20–54)
8				39 (22–56)	78 (42–114)	86 (48–123)	78 (42–114)
9				59 (34–83)	103 (59–148)	134 (80–189)	104 (59–148)
10				40 (23–56)	77 (44–110)	106 (63–150)	77 (44–110)
11				77 (45–109)	130 (74–185)	140 (83–197)	130 (75–185)

Supplementary Table 6. Projected additional malaria deaths in Nigeria between May 2020 and April 2021 for two periods of mitigated disruption: 6 months and 9 months (corresponding to a basic reproduction number for COVID-19 of 3 or 2.5, respectively). Illustrations of the different COVID-19 epidemics simulated are provided in Supplementary Figure 3. Different combinations of malaria interventions are considered on each row, with the colour denoting whether they were halted for the period of health system interruption (red), reduced to 50% of the normal coverage level (light green) or continued as normal (dark green). LLINs = distribution of long-lasting insecticide treated nets in countries due for mass campaigns in 2020, SMC = seasonal malaria chemoprevention in SMC target areas in the Sahel and, Treatment = treatment of clinical cases. LLINs are only disrupted in regions where they were previously planned. Care should be taken when directly comparing the relative impact of different malaria interventions as they vary in their period of disruption (other than in the suppression scenario). Values are shown as the point estimate and 95% uncertainty interval (95% UI) based on 20 parameter draws, rounded to the nearest hundred.

				COVID-19 scenario	
				Mitigation: 6 months	Mitigation: 9 months
Malaria scenario				**Additional malaria deaths in Nigeria (95% UI)** (compared to a baseline estimate of 116,800 (95% UI 59,600–174,000) deaths in Nigeria in this period without malaria service interruption)	
No.	LLINs	SMC	Treatment		
1				81,400 (44,400–118,500)	91,700 (49,900–133,500)
2				40,100 (21,800–58,400)	39,900 (21,700–58,100)
3				33,800 (17,700–49,900)	39,900 (20,900–58,900)
4				71,300 (36,500–106,100)	85,100 (43,600–126,600)
5				36,900 (19,300–54,500)	43,200 (22,600–63,800)
6				76,900 (41,500–112,300)	86,800 (46,900–126,700)
7				67,100 (34,500–99,800)	80,000 (41,100–118,900)
8				75,700 (38,800–112,600)	89,600 (45,900–133,300)
9				124,600 (66,500–182,600)	147,000 (78,500–215,500)
10				118,400 (63,200–173,700)	140,800 (75,200–206,400)
11				130,900 (70,200–191,600)	153,900 (82,500–225,300)

Supplementary Table 7. Modelled impact of extending the age range of children targeted in seasonal malaria chemoprevention (SMC) campaigns on additional malaria deaths due to COVID-19 in regions that received SMC in 2019. Values give the number of deaths between 1 May 2020 and 30 April 2021 and only COVID-19 mitigation and suppression scenarios are presented. Different combinations of malaria interventions are considered on each row, with the colour denoting whether they were halted for the period of health system interruption (red), continued as normal (dark green) or whether a new strategy is considered (gold). LLINs = distribution of long-lasting insecticide treated nets in countries due for mass campaigns in 2020, Treatment = treatment of clinical cases, SMC = seasonal malaria chemoprevention in SMC target areas in the Sahel. SMC campaigns are either targeted to children younger than five years (U5, except Senegal where the baseline is under 10 years) under 10 (U10) and under 15 (U15) years of age. All campaigns are for the normal duration and are adopted with 70% coverage. LLINs are only disrupted in regions where they were previously planned. Values are shown as the point estimate and 95% uncertainty interval (95% UI), rounded to the nearest hundred.

				COVID-19 scenario	
				Mitigation	Suppression
Malaria scenario				**Additional malaria deaths within SMC regions (95% UI)** (compared to a baseline estimate of 86,900 (95% UI 46,400–127,400) deaths in this period without malaria service interruption)	
No.	LLINs	SMC (70% coverage)	Treatment		
1		U5		76,900 (43,700–110,000)	106,500 (63,200–149,800)
2		U10		63,400 (36,100–90,800)	100,200 (59,500–141,000)
3		U15		54,400 (31,000–77,900)	94,600 (56,200–133,100)
4		U5		36,700 (19,400–54,100)	59,700 (33,500–86,000)
5		U10		26,500 (14,000–39,100)	54,400 (30,500–78,300)
6		U15		19,100 (10,100–28,100)	49,500 (27,700–71,300)

Supplementary Table 8. Modelled impact of extending the age range of children targeted in seasonal malaria chemoprevention (SMC) campaigns on additional malaria deaths due to COVID-19 in States of Nigeria where SMC has been implemented previously. Values give the number of deaths between 1 May 2020 and 30 April 2021 and only COVID-19 mitigation and suppression scenarios are presented. Different combinations of malaria interventions are considered on each row, with the colour denoting whether they were halted for the period of health system interruption (red), continued as normal (dark green) or whether a new strategy is considered (gold). LLINs = distribution of long-lasting insecticide treated nets in countries due for mass campaigns in 2020, Treatment = treatment of clinical cases. SMC campaigns are either targeted to children younger than five years (U5) under 10 (U10) and under 15 (U15) years of age. All campaigns are for the normal duration and are adopted with 70% coverage. LLINs are only disrupted in regions where they were previously planned. The variable impact across states is depicted in Supplementary Figure 5. Values are shown as the point estimate and 95% uncertainty interval (95% UI) based on 20 parameter draws, rounded to the nearest hundred.

				COVID-19 scenario	
				Mitigation	Suppression
Malaria scenario				**Additional malaria deaths in Nigeria within SMC regions (95% UI)** (compared to a baseline estimate of 34,300 (95% UI 17,500–51,100) deaths in Nigeria in this period without malaria service interruption)	
No.	LLINs	SMC (70% coverage)	Treatment		
1		U5		38,000 (20,300–55,700)	42,400 (22,800–62,100)
2		U10		35,000 (18,700–51,300)	39,400 (21,100–57,600)
3		U15		32,900 (17,500–48,200)	37,100 (19,900–54,200)
4		U5		21,800 (11,200–32,300)	25,000 (13,000–36,900)
5		U10		19,800 (10,200–29,500)	22,800 (11,900–33,800)
6		U15		17,900 (9,200–26,600)	20,800 (10,800–30,800)

Supplementary Table 9. Modelled impact of supplemental mass drug administration (MDA) malaria campaigns to alleviate additional malaria deaths due to COVID-19, in regions that did not receive seasonal malaria chemoprevention (SMC) in 2019. Impact is shown as additional to the modelled deaths predicted for the same time period (May 2020–April 2021) in the absence of COVID-19 and only COVID-19 mitigation and suppression scenarios are presented. Different combinations of malaria interventions are considered on each row, with the colour denoting whether they were halted for the period of health system interruption (red), continued as normal (dark green) or whether a new strategy is considered (gold). LLINs = distribution of long-lasting insecticide treated nets in countries due for mass campaigns in 2020, Treatment = treatment of clinical cases, MDA = mass drug administration with amodiaquine plus sulfadoxine-pyrimethamine (AQ-SP). MDA campaigns are a single round either targeted to children younger than five years (U5) or people of all ages (All ages) and distributes the drug AQ-SP to 70% of the population. MDA is simulated to be implemented at the optimal time, prior to the transmission peak for each administration unit. LLINs are only disrupted in regions where they were previously planned. Values are shown as the point estimate and 95% uncertainty interval (95% UI) based on 20 parameter draws, rounded to the nearest hundred.

				COVID-19 scenario	
				Mitigation	Suppression
Malaria scenario				**Additional malaria deaths outside SMC regions (95% UI)** (compared to a baseline estimate of 335,100 (95% UI 178,900–491,300) deaths in this period without malaria service interruption)	
No.	LLINs	Treatment	MDA (70% coverage)		
1				351,800 (202,100–501,400)	555,600 (330,100–781,100)
2			U5	324,700 (186,600–462,800)	524,800 (311,800–737,800)
3			All ages	162,400 (93,300–231,500)	319,800 (190,000–449,600)
4				127,200 (68,300–186,100)	250,600 (140,500–360,700)
5			U5	101,900 (54,800–149,100)	223,000 (125,100–321,000)
6			All ages	–22,400 (–12,000—32,700)–	61,800 (34,700–89,000)

Supplementary Table 10. Modelled impact of supplemental mass drug administration (MDA) malaria campaigns to alleviate additional malaria deaths due to COVID-19, in regions that did not receive seasonal malaria chemoprevention (SMC) in 2019, in Nigeria, in States where SMC is not implemented. . Impact is shown as additional to the modelled deaths predicted for the same time period (May 2020–April 2021) in the absence of COVID-19 and only COVID-19 mitigation and suppression scenarios are presented. Different combinations of malaria interventions are considered on each row, with the colour denoting whether they were halted for the period of health system interruption (red), continued as normal (dark green) or whether a new strategy is considered (gold). LLINs = distribution of long-lasting insecticide treated nets in countries due for mass campaigns in 2020, Treatment = treatment of clinical cases, MDA = mass drug administration with amodiaquine plus sulfadoxine-pyrimethamine (AQ-SP). MDA campaigns are a single round either targeted to children younger than five years (U5) or people of all ages (All ages) and distributes the drug AQ-SP to 70% of the population. MDA is simulated to be implemented at the optimal time, prior to the transmission peak for each administration unit. LLINs are only disrupted in regions where they were previously planned. Values are shown as the point estimate and 95% uncertainty interval (95% UI) based on 20 parameter draws, rounded to the nearest hundred. The variable impact across States is depicted in Supplementary Figure 5.

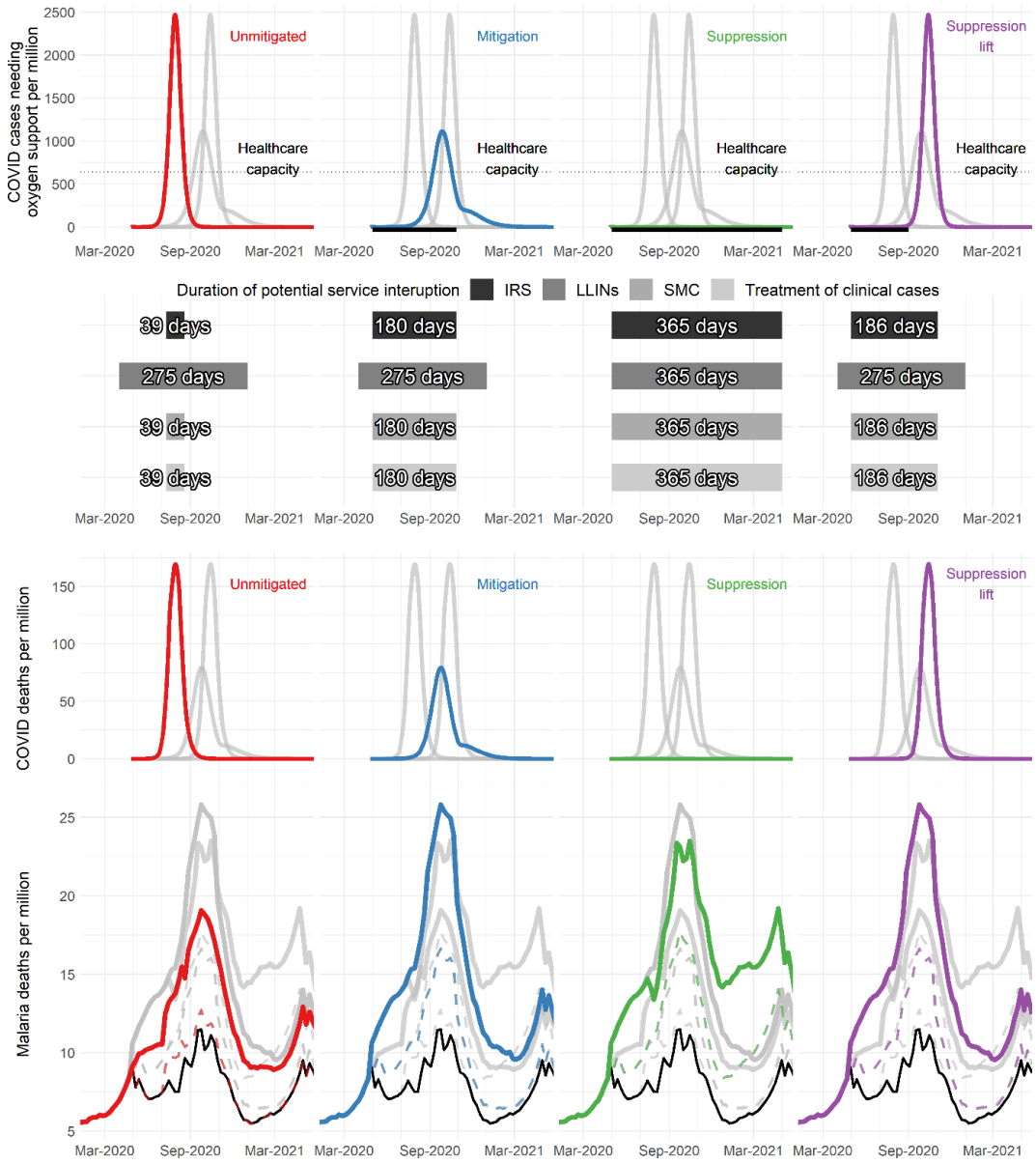
				COVID-19 scenario	
				Mitigation	Suppression
Malaria scenario				**Additional malaria deaths in Nigeria outside SMC regions (95% UI)** (compared to a baseline estimate of 82,400 (95% UI 122,800–42,000) deaths in this period without malaria service interruption)	
No.	LLINs	Treatment	MDA (70% coverage)		
1				80,500 (43,200–117,800)	103,800 (55,900–151,700)
2			U5	70,700 (37,900–103,600)	94,800 (51,100–138,600)
3			All ages	50,400 (27,000–73,700)	74,300 (40,000–108,600)
4				45,400 (23,200–67,500)	59,500 (30,800–88,200)
5			U5	38,000 (19,500–56,600)	52,800 (27,300–78,200)
6			All ages	23,100 (11,800–34,400)	37,300 (19,300–55,400)

Supplementary Table 11. The COVID-19 transmission model parameters and ranges used in the univariate and multivariate sensitivity analyses. In the univariate sensitivity analysis we take point estimates for all parameters and vary R_0. In the multivariate sensitivity analysis we varied R_0, social distancing, duration of hospitalisation parameters and all severity parameters. Uncertainty in the probability of requiring hospitalization, and probability of requiring critical care given hospitalization, and how these change with age were generated as in [1] using samples from the joint posterior distribution of the infection fatality ratio by age in the presence of good access to care. Results of the uncertainty analysis are presented in Table 1 and Supplementary Figure 3.

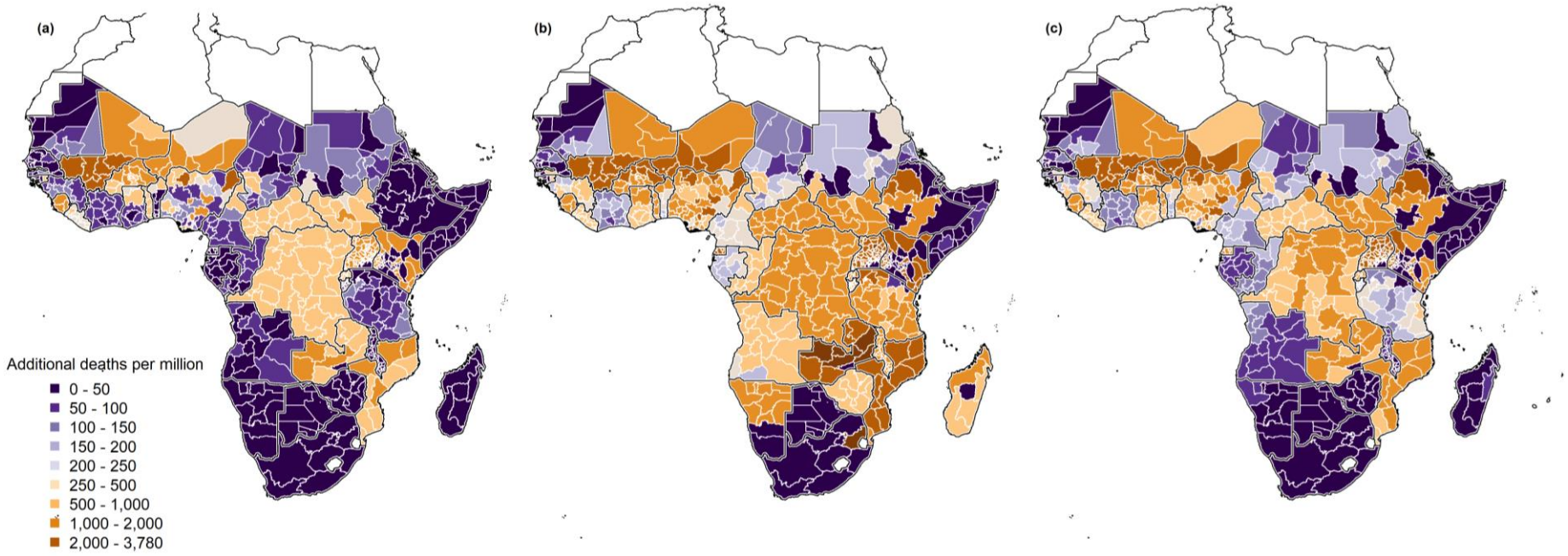
Parameter varied	Point Estimate	Range	Reference
R_0	3	2.0–3.5	[1–5]
Probability of death if critical care required but not received	90.5%	85–95%	[6]
Probability of death if hospitalised with oxygen available	25%	20–30%	[6]
Probability of death if requiring hospitalisation with oxygen but not available	60%	50–70%	[6]
Probability of death if but without an available hospital bed	60%	50–70%	[6]
Mean Duration of Hospitalisation for non-critical cases if survive	9.5 days	66–150% of point estimate	[6]
Mean Duration of Hospitalisation for non-critical cases if die	7.6 days	66–150% of point estimate	[6]
Mean Duration in ICU if survive	11.3 days	66–150% of point estimate	[6]
Mean Duration in ICU if die	10.1 days	66–150% of point estimate	[6]
Mean Duration in Recovery after ICU	3.4 days	66–150% of point estimate	[6]
Reduction in contact rate following arrival of COVID-19 (and default value returned lifting of mitigation/suppression measures	20%	10-30%	Assumed
Effectiveness of social distancing measures during the mitigation/suppression period (% reduction in contact rate)	0% (unmitigated) 45% (mitigation) 75% (suppression) 75% (suppression lift)	0% (unmitigated) 30–60% (mitigation) 60-90% (suppression) 60-90% (suppression lift)	Assumed
Period with which social distancing measures were in place (days)	0 (unmitigated) 180 (mitigated) 365 (suppression) 60 (suppression lift)	0 (unmitigated) 180-365 (mitigated) 365 (suppression) 60 (suppression lift)	Assumed

Supplementary Table 12. Results of the analysis of sensitivity of model outcome to assumptions about timing in the distribution of long-lasting insecticide treated nets (LLINs). The point estimate is the additional deaths due to malaria, using the best available information about the timing of LLIN distributions at the country level (and at the admin-1 level for Nigeria). For the country-level distributions, where information about planned campaigns was uncertain, we ran the model assuming that net campaigns occurred either in 2019 (the lower bound), or were planned for 2020 (the upper bound), and considered the range of impact for the malaria scenarios where LLIN distributions may be interrupted. The additional deaths are for the period May 2020 to April 2021 for different COVID-19 scenarios. Different combinations of malaria interventions are considered on each row, with the colour denoting whether they were halted for the period of health system interruption (red), reduced to 50% of the normal coverage level (light green) or continued as normal (dark green). LLINs = distribution of long-lasting insecticide treated nets in countries due for mass campaigns in 2020, SMC = seasonal malaria chemoprevention in SMC target areas. Treatment = treatment of clinical cases. LLINs and SMC campaigns are only disrupted in states where they were previously planned. Disruptions to malaria interventions last for different time periods depending on the COVID-19 scenarios as noted in Figure 1. Values rounded to the nearest thousand.

				COVID-19 scenario			
				Unmitigated	Mitigation	Suppression	Suppression lift
Malaria scenario				**Additional malaria deaths ('000) (range)** (compared to a baseline estimate of 422 thousand deaths in this period without malaria service interruption)			
No.	LLINs	SMC	Treatment				
1				239 (166–498)	379 (298–709)	464 (362–824)	380 (299–712)
2				221 (145–470)	282 (184–553)	322 (208–604)	282 (184–553)
3				220 (150–471)	357 (278–677)	495 (376–862)	358 (279–680)
4				238 (172–500)	461 (403–847)	696 (577–1,165)	464 (406–853)
5				219 (156–473)	434 (378–808)	668 (551–1,125)	437 (381–814)
6				253 (189–519)	481 (428–873)	696 (590–1,164)	484 (431–878)

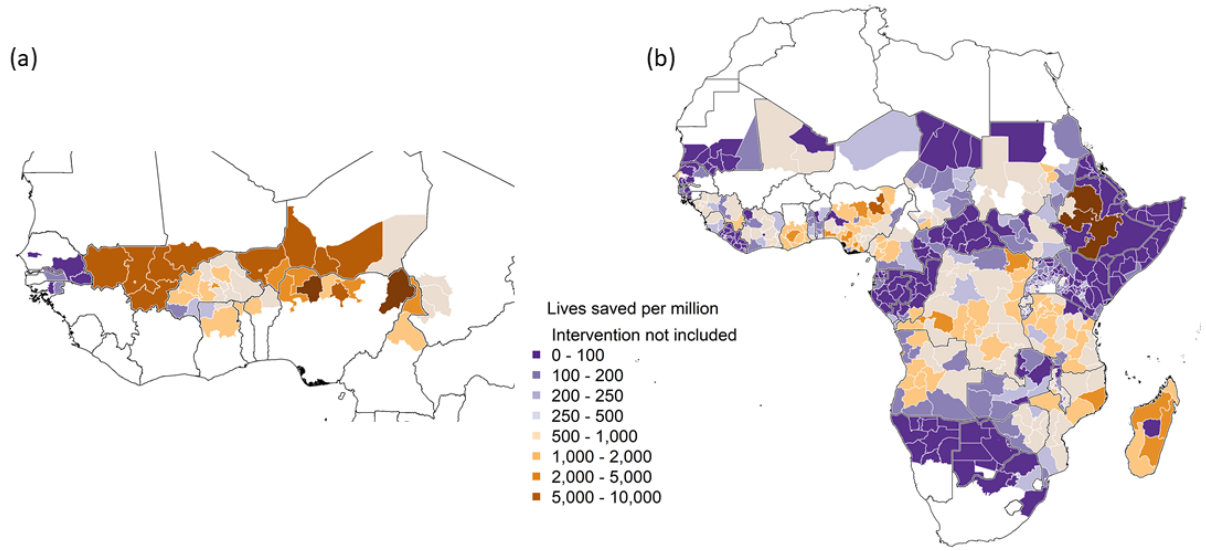


Supplementary Figure 1. Projected deaths due to COVID-19 and malaria in sub-Saharan Africa (SSA) over time for different COVID-19 scenarios. The top row shows the COVID-19 epidemic and the number of people needing oxygen support per week for four different COVID-19 scenarios – an unmitigated epidemic (where contact rates are reduced by only 20%, red lines in 1st column), mitigation (contact rates are reduced and slow transmission but insufficiently to prevent an epidemic, blue lines in 2nd column), continued suppression (contact rates reduced low enough that numbers of deaths fall and are kept low for 12 months, green lines in 3rd column) and suppression lift (same as suppression but restrictions lifted after 2 months, purple lines in 4th column). The thin dotted horizontal grey line indicates estimated healthcare capacity for a typical African country. The thick black horizontal line beneath each figure shows the period when COVID-19 mitigation or suppression activities are assumed in operation. The upper middle row indicates the assumed duration of interruption where COVID-19 interventions affect different malaria prevention activities (IRS = indoor residual spraying, LLINs = mass distribution of long-lasting insecticide treated nets, SMC = seasonal malaria chemoprevention) or case management of clinical cases with the level of this disruption presented in Table 1. The lower middle row shows the predicted deaths due to COVID-19 per week in each scenario. The bottom row shows predicted malaria deaths per week for each scenario (coloured lines) and for the counter-factual with no COVID-19 induced disruption (black lines). The top coloured lines indicate a scenario when all services are reduced or cease (Table 1, row 1) whereas the bottom dashed coloured lines show the most well-managed scenario (Table 1, row 3). The mitigation and suppression lift scenarios produce similar malaria epidemics. Grey lines in all rows show other scenarios to allow direct comparison. Most malaria cases across SSA occur in the latter half of the year because transmission peaks in West Africa later in the year.

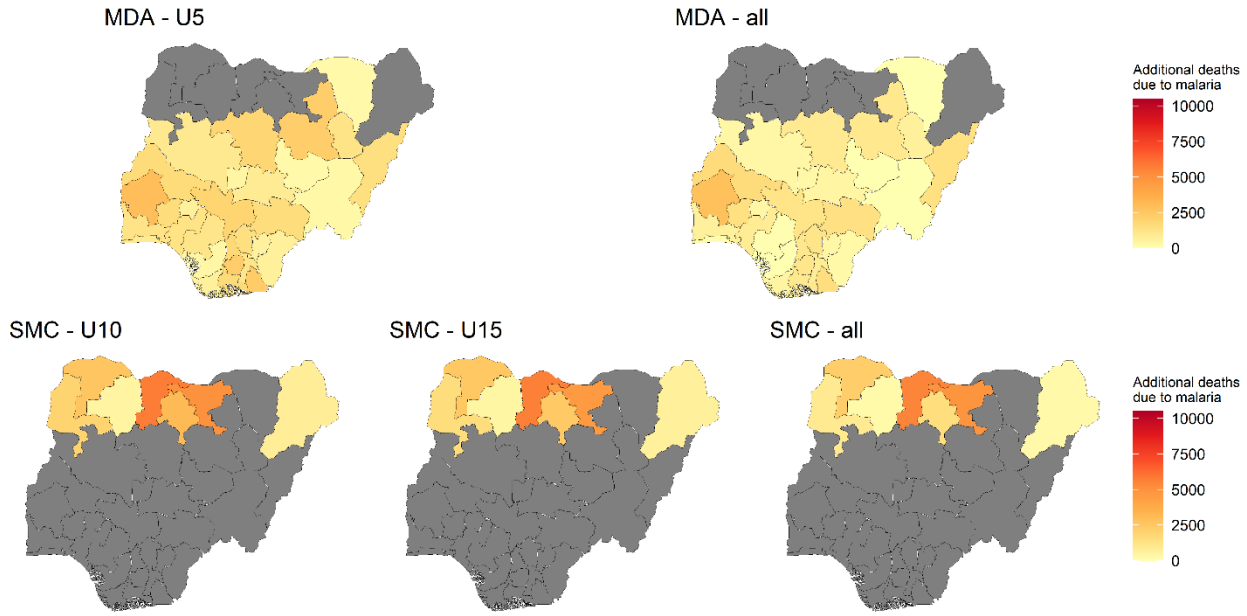


Supplementary Figure 2. Maps showing the impact of COVID-19 based interruption of malaria control activities for the (a) Unmitigated, (b) Suppression and (c) Suppression lift. As shown in Figure 2a for the COVID-19 mitigated scenario, estimated additional deaths per million people when all malaria interventions are ceased (long-lasting insecticide treated net distribution campaigns, seasonal malaria chemoprevention, and clinical treatment of cases) relative to normal service in the absence of COVID-19 for each administrative region. The different periods of service disruption are shown in Supplementary Figure 1. Maps illustrate how overall impact depend on the timing and duration of the period of service interruption and how this overlaps with malaria transmission seasons in different regions of Africa.

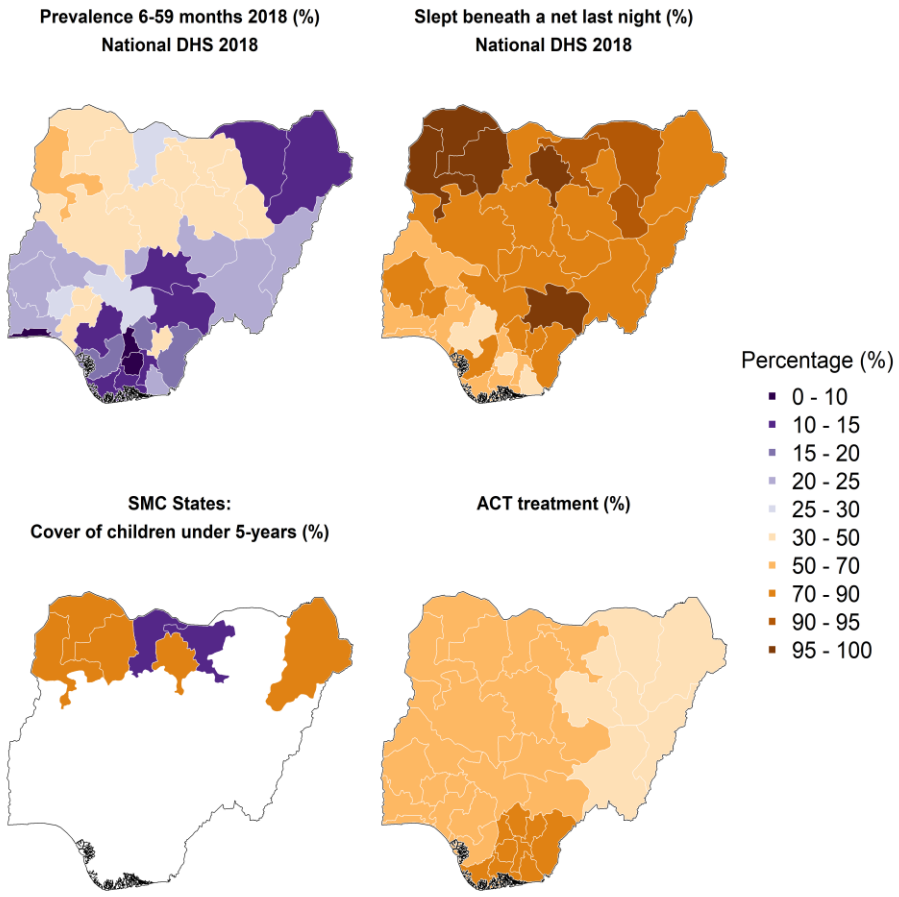
Supplementary Figure 3. Univariate and multivariate sensitivity analyses of the effect of model parameters on the magnitude and duration of COVID-19 epidemics in sub-Saharan Africa. (a) Univariate sensitivity analysis showing the differences in the number of people needing supplemental oxygen, and the duration of the epidemic for four value of R_0 (2–3.5) across the four COVID-19 intervention scenarios (using default parameters shown in Supplementary Table 11). Note that in the mitigation scenario a 6-month period of social distancing results in a rebound epidemic for R_0 values < 3.0. In this plot the dotted lines show the same runs with 12 months of social distancing measures which prevents the rebound epidemic. (b–e) Multivariate sensitivity analysis for the COVID-19 mitigation scenario using the range of parameters outlined in Supplementary Table 11. (b) Epidemic trajectories for the 500 different simulations showing the variability in the shape of the epidemic. Runs are coloured according to the potential period that malaria services might be interrupted which are estimated from the different individual epidemic curves. This period of service disruption starts from when mitigation measures are initiated and continues until the time healthcare capacity is no-longer over-burdened. Again, note that in the mitigation scenario social distancing measures are only maintained for 6 months so there may be a rebound epidemic. (c) the relationship between the assumed level of R_0 and level of social distancing during the mitigation period (% reduction in the contact rate) and the period of service interruption. Each point represents a single realisation of the 500 runs. Values where healthcare was still over capacity a year after the arrival of the epidemic are grouped at a year of service interruption. Panel shows higher R_0 values and less effective mitigation measures reduce the time services may be disrupted (d). A histogram showing period of potential service interruption for the 500 runs. Bar colour indicates the numbers of deaths due to COVID-19 for the different simulations and show a high number of COVID-19 deaths can occur with a short period of interruption (for example, from a high R_0) or from an epidemic that causes a longer period of disruption (for example, a low R_0 and a rebound epidemic once mitigation measures are relaxed). The period of service disruption used in the default mitigation scenario in the main paper analysis is shown with a vertical dashed line in panel (e). Histogram showing the distribution of the number of COVID-19 deaths from the 500 runs of the multivariate sensitivity analysis. This distribution of was used to generate 95% uncertainty interval estimates for COVID-19 mitigation scenario deaths in Table 1. Histogram colours show the R_0 values used in that simulation.



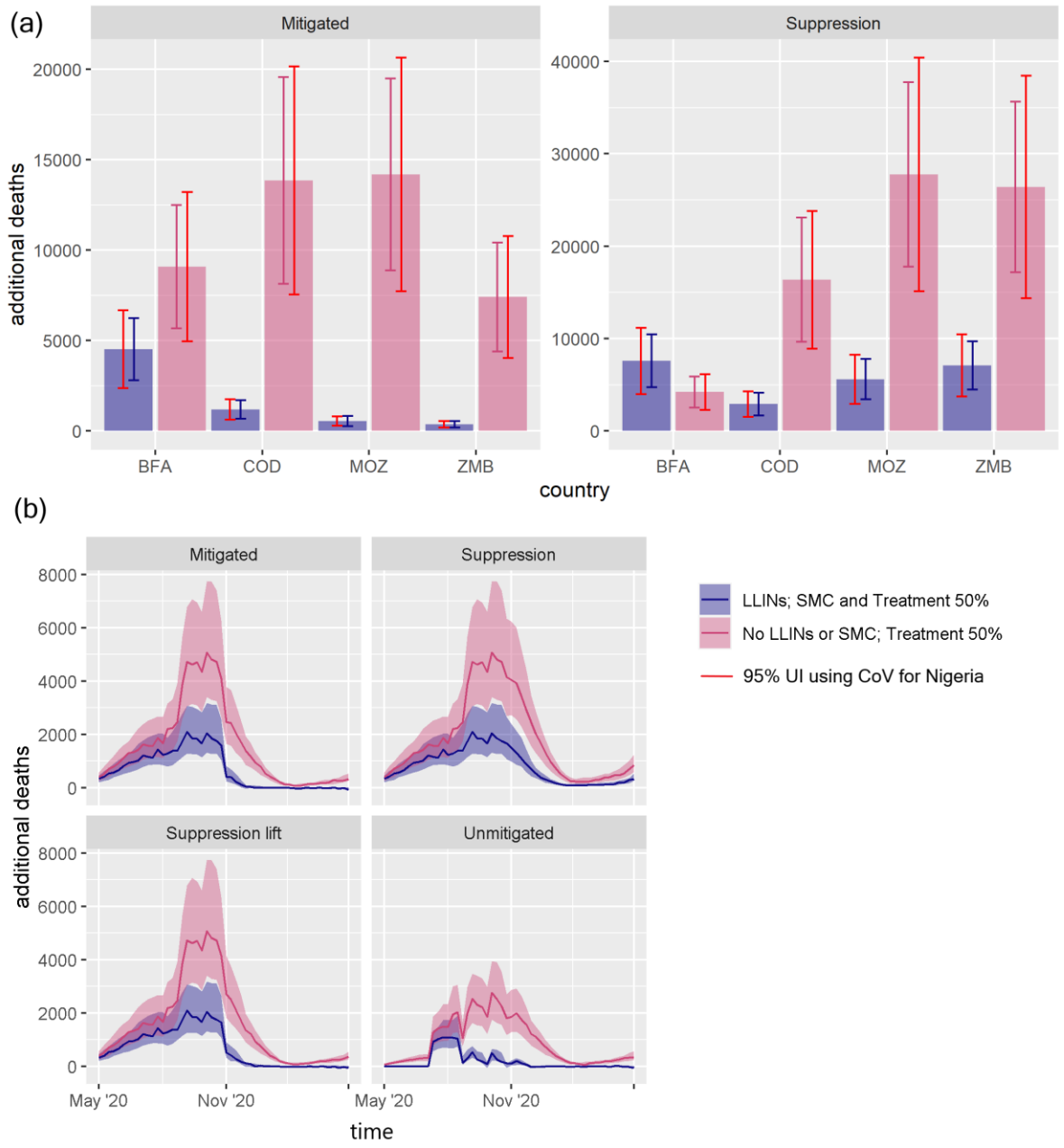
Supplementary Figure 4. Maps showing how the impact malaria mitigation strategies are predicted to vary across sub-Saharan Africa. (a) Expansion of existing seasonal malaria chemoprevention (SMC) in regions where it occurred in the Sahel where it was conducted in 2019. Colours denote additional lives saved by expanding the age of those eligible from under 5 years to under 15 years. (b) The predicted impact of mass drug administration (MDA) using a drug with a prophylactic profile of amodiaquine plus sulfadoxine-pyrimethamine for regions where SMC is not currently conducted. Both figures show scenarios where existing LLIN campaigns were maintained but routine treatment of clinical cases paused during the mitigated COVID-19 epidemic.



Supplementary Figure 5. Sub-national impact of how interruption of malaria services due to a mitigation COVID-19 scenario will influence the numbers of malaria deaths in different States of Nigeria. The colour indicates the additional deaths predicted due to service interruption relative to normal service in the absence of COVID-19 for each State. Here the top row corresponds to the scenarios where net distribution is maintained and MDA is expanded, as per Supplementary Table 10, and the bottom row corresponds to scenarios where net distribution is maintained and seasonal malaria chemoprevention is expanded as per Supplementary Table 8. Grey areas denote States where this control intervention was not considered. Expansion of SMC was only evaluated in regions which undertook SMC in 2019 (bottom row) whilst MDA was considered in all other States (top row). All simulations assume that sufficient drugs are available.



Supplementary Figure 6. Nigeria-specific data inputs for the malaria model estimations. (A) Malaria prevalence by microscopy in children 6–59 months of age. (B) Percentage of children sleeping under an insecticidal net the previous night. (C) Estimates of seasonal malaria chemoprevention coverage calculated by dividing the number of doses administered by the proportion of the target age group. (D) Estimates of the percentage of child malaria cases receiving artemisinin combination therapy (ACT). Both (A), (B) and (D) were estimated from Demographic and Health Surveys (DHS) data.[7] All estimates were at the state level other than (D) which was presented at the regional level.



Supplementary Figure 7. Multivariate uncertainty analysis for the malaria transmission model. The true model uncertainty was quantified by calculating the additional clinical malaria cases, malaria deaths, and years of life lost due to malaria, using an additional 20 draws from the joint posterior distribution of the fitted model parameters. These simulations were performed for all 37 administrative 1 units in Nigeria, and 40 other units across four countries – Zambia (all provinces included), Mozambique, Democratic Republic of the Congo and Burkina Faso – and for each COVID-19 and malaria scenario. We used the outcomes for the Nigeria administrative units to calculate the coefficient of variation (CoV) and tested the application of a Normal approximation to compare the uncertainty intervals (UI) for the other countries. (a) Shows the 95% UI for each of the four countries (pink and purple error bars) with the Normal approximation (red bars). Results indicate that the uncertainty generated using both methods was broadly similar. (b) Illustration of how malaria parameter uncertainty influences estimates of the additional weekly deaths due to malaria in Nigeria over the year May 2020–April 2021 for each of the four COVID-19 scenarios. Two different levels of malaria service interruption are considered for each scenario, the first where LLINs and SMC are ceased and case management is reduced by 50% (pink line, Supplementary Table 1 row 1), and the second when only case management is reduced by 50% (purple line, Supplementary Table 1, row 3). The dark lines represent point estimates of the difference between the levels of malaria service interruption and no COVID-19 induced disruption whilst the shaded regions represent the 95% UIs.

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