

# The potential impact of health service disruptions on the burden of malaria:

a modelling analysis for countries  
in sub-Saharan Africa



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# Table of contents

<b>Acknowledgments</b>	<b>v</b>
<b>List of abbreviations</b>	<b>vi</b>
<b>Background</b>	<b>1</b>
<b>Analysis</b>	<b>2</b>
<b>Key results</b>	<b>5</b>
<b>Key messages</b>	<b>7</b>
<b>References</b>	<b>9</b>
<b>Annex 1. How to read the graphs</b>	<b>10</b>
<b>Annex 2. Model results for countries with ITN campaigns scheduled in 2020</b>	<b>12</b>
<b>Annex 3. Model results for countries without ITN campaigns scheduled in 2020</b>	<b>22</b>
<b>Annex 4. Planned ITN, SMC and IRS campaigns in 2020 by country, sub-Saharan Africa</b>	<b>28</b>



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1. Telethon Kids Institute
2. Curtin University
3. Imperial College London
4. Institute for Disease Modeling
5. University of Oxford

# List of abbreviations

ACTs	artemisinin-based combination therapies
GMP	Global Malaria Programme
IRS	indoor residual spraying
ITNs	insecticide treated nets
MDA	mass drug administration
<i>pfhrp2</i>	<i>Plasmodium falciparum</i> histidine-rich protein
<i>PfPR</i>	<i>Plasmodium falciparum</i> parasite prevalence
SMC	seasonal malaria chemoprevention
SSA	sub-Saharan Africa
WHO	World Health Organization



# Background

Since 2000, the world has seen unprecedented progress against the burden of malaria following massive investments in providing effective prevention and treatment interventions to populations at risk in malaria-endemic countries (1). Malaria case incidence declined by 30%, from 80 per 1000 population in 2000 to 57 per 1000 population in 2018. During the same period, the malaria mortality incidence rate declined by 60% – from 25 to 10 per 100 000 population at risk. By far, the majority of these gains have been due to reductions in the burden of malaria in sub-Saharan Africa (SSA), a region that still accounts for over 90% of malaria cases and deaths globally. These massive gains have been achieved despite important gaps in prevention and access to treatment, along with periods of conflict and other humanitarian emergencies. By all indications, however, the current COVID-19 pandemic will likely be the biggest threat faced by global efforts to reduce the malaria burden, especially in SSA where health systems are fragile.

The WHO Global Malaria Programme (GMP) maintains a platform to track and analyse potential threats to malaria control and elimination (<http://apps.who.int/malaria/maps/threats/>), including drug and insecticide resistance, *Plasmodium falciparum* histidine-rich protein (*pfhrp2*) deletions and the spread of new invasive mosquito species. GMP has also used modelling as a tool to guide potential interventions in response to these threats, including during public health emergencies. For example, during the humanitarian crisis in Borno State (Nigeria), modelling was used to estimate the potential impact of different types of interventions. Based on this analysis, four rounds of age-targeted mass drug administration (MDA) were delivered by the local health authority and the WHO polio and health emergencies teams, reaching more than 1.2 million children under the age of 5. It was estimated that the MDA campaign prevented about 10 000 children from dying of malaria. A similar analysis performed following the Ebola crisis in West Africa demonstrated the utility of modelling both the threats to malaria service delivery and the impact of potential mitigating strategies for planning and decision-making, as well as to raise awareness among policy-makers (2).

The COVID-19 pandemic represents a new threat to malaria service delivery. As the virus begins to spread in malaria-endemic countries, including in SSA (3), their fragile health systems will likely be overwhelmed. Indeed, the recent Ebola outbreak in West Africa demonstrated that a sudden increase in demand for health services can lead to substantial increases in morbidity and mortality from other diseases, including malaria. In response to this threat, WHO GMP has recently released guidance to help countries ensure the maintenance of their malaria services in the context of the COVID-19 pandemic (4).

GMP has also been working with several modelling teams to analyse the potential impact on malaria burden of different service disruption scenarios. The outputs of these modelling exercises reinforce the message that country programmes and ministries of health must ensure the continuity of malaria prevention and treatment services during the response to COVID-19. The results of these analyses are presented in this document. It is important to note that this analysis does not consider the impact of disruptions to indoor residual spraying (IRS) and seasonal malaria chemoprevention (SMC).

# Analysis

## **Malaria transmission seasonality**

Using the modelling framework previously employed in WHO's *Global technical strategy for malaria 2016–2030* (5), normalized malaria incidence in cases per person per year was calculated for SSA countries, assuming 35 days between peak rainfall and peak malaria incidence (Fig. 1). The resulting information can be used to understand the timing of COVID-19-related service disruptions with respect to malaria transmission seasons and can assist programmes in determining the optimal timing for mitigation activities with respect to COVID-19-related service disruptions.

The analysis shows clear seasonality varying by country, but with a broad regional signal. Peak malaria transmission starts later in the year in West Africa than in East and Central African countries. For many of the Sahelian countries in West Africa that implement SMC, peak transmission is likely to be reached in September. If the spread of COVID-19 continues along its current trajectory, the peak malaria season in these countries is likely to overlap with COVID-19-related disruptions.

## **Scenarios of service disruptions**

The main interventions that could experience disruptions because of the COVID-19 pandemic are: campaign and continuous distributions of insecticide treated nets (ITNs); IRS; SMC; and access to diagnosis and effective malaria treatment. This analysis focuses on the impacts of disruptions to ITN mass campaigns and continuous distributions, as well as access to effective malaria treatment. Twenty-seven SSA countries, which account for 85% of the malaria cases and deaths in the region, have plans to implement ITN mass campaigns by the end of 2020. These countries are: Benin, Cameroon, Central African Republic, Chad, Comoros, Côte d'Ivoire, Democratic Republic of the Congo, Eritrea, Ethiopia, Ghana, Guinea-Bissau, Kenya, Mali, Mauritania, Mozambique, Niger, Nigeria, Rwanda, Sierra Leone, Somalia, South Sudan, Sudan, Togo, Uganda, United Republic of Tanzania, Zambia and Zimbabwe.

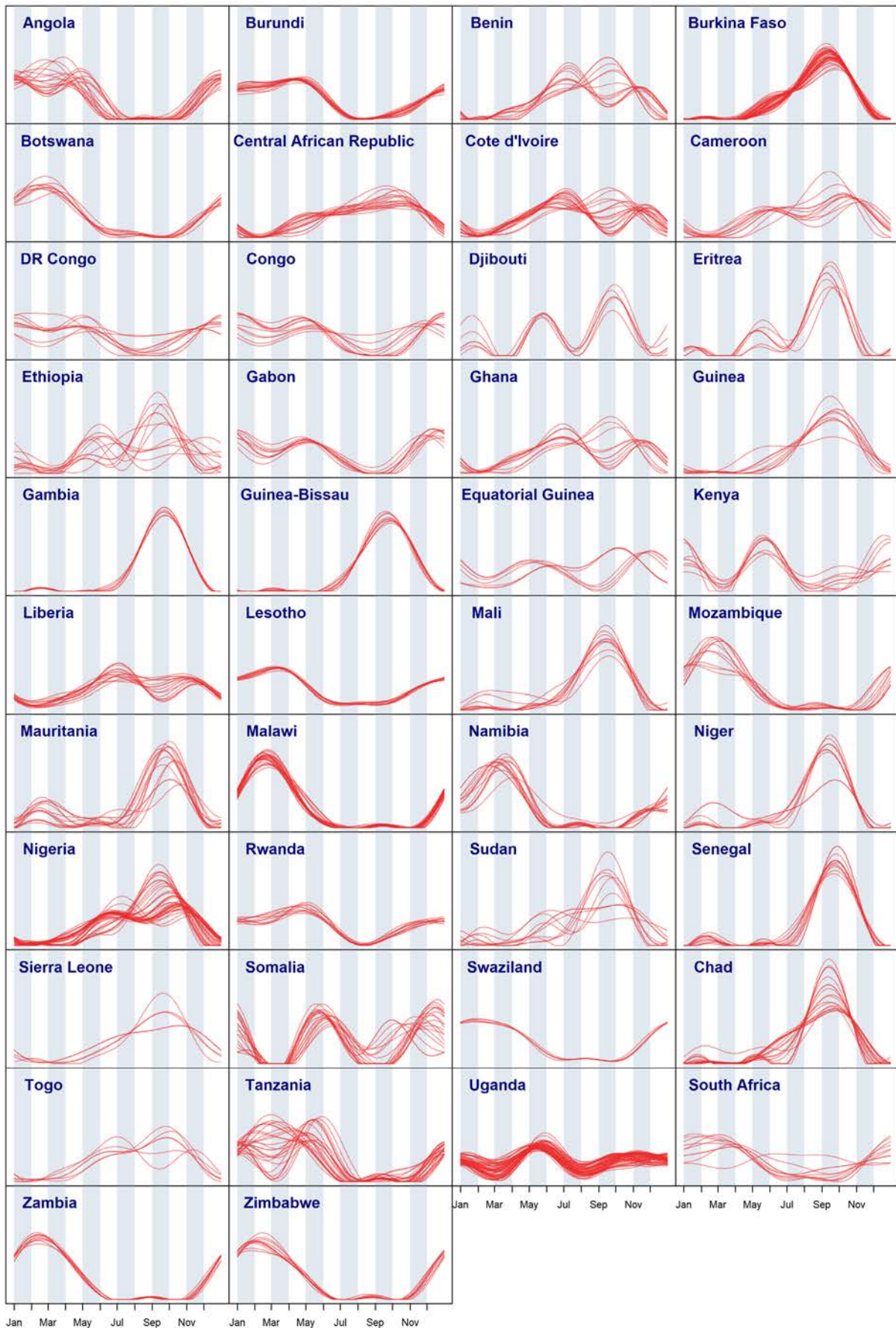
The potential impacts on malaria cases and deaths were estimated with respect to nine different scenarios of malaria service disruption (Box 1). The counterfactual for each scenario was the best estimate of what ITN and case management coverage would be in 2020 if the expected ITN campaigns were implemented as planned and there were no disruptions in access to malaria treatment.

A geospatial modelling framework established by the Malaria Atlas Project (MAP) was used to estimate the impact of these scenarios for the period April–December 2020. The framework uses extensive survey and programmatic data on *Plasmodium falciparum* parasite prevalence (PfPR) and intervention coverage to infer geographical patterns of endemicity through time. This framework also informs the malaria case estimations for moderate- and high-transmission countries in Africa for WHO's *World malaria report*.

For this analysis, the modelling framework was repurposed to investigate the plausible impacts on PfPR of the nine scenarios of reduced access to ITNs and malaria treatment. It was first used to infer a 5x5 km map of annualized PfPR for the year 2020 under the different scenarios. Next, the resulting PfPR scenarios were propagated through a second model that estimated the corresponding annual incidence of

FIG. 1

**Seasonality of malaria by country in sub Saharan Africa**



uncomplicated clinical malaria (6). Finally, a third modelling framework was used to estimate the corresponding mortality attributable to malaria (7).

The estimated levels of *PfPR*, cases and deaths for each service disruption scenario were then compared to the “business as usual” prediction (assuming no service disruption) for 2020 to estimate the excess morbidity and mortality expected under reduced coverage levels. Annex 1 shows an example of the main results and the best way to interpret the graphs. Estimates were also aggregated by country (Annexes 2 and 3) and for the whole SSA region (Fig. 2 & Table 1).

#### **Box 1: Service disruption scenarios**

- Scenario 1:** No ITN campaigns, continuous ITN distributions reduced by 25%
- Scenario 2:** No ITN campaigns, continuous ITN distributions reduced by 50%
- Scenario 3:** No ITN campaigns, continuous ITN distributions reduced by 75%
- Scenario 4:** No ITN campaigns, access to effective antimalarial treatment reduced by 25%
- Scenario 5:** No ITN campaigns, access to effective antimalarial treatment reduced by 50%
- Scenario 6:** No ITN campaigns, access to effective antimalarial treatment reduced by 75%
- Scenario 7:** No ITN campaigns, both continuous ITN distributions and access to effective antimalarial treatment reduced by 25%
- Scenario 8:** No ITN campaigns, both continuous ITN distributions and access to effective antimalarial treatment reduced by 50%
- Scenario 9:** No ITN campaigns, both continuous ITN distributions and access to effective antimalarial treatment reduced by 75%

# Key results

## Notes to help with interpretation of results

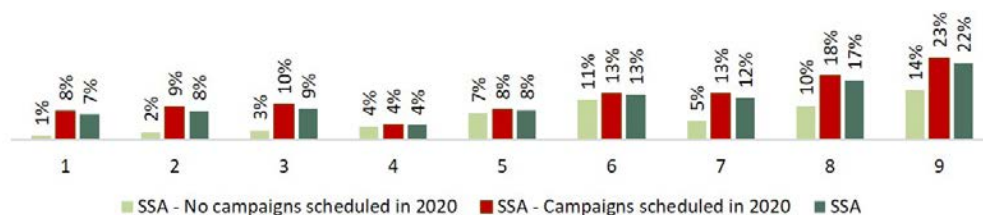
In most malaria-endemic countries in SSA, ITNs represent the main vector control intervention. Approximately 80% of ITNs are distributed through mass campaigns that are implemented every three years, while the remaining nets are delivered mainly through continuous distribution. ITN mass campaigns need to be implemented every three years to ensure effective coverage of the population with this intervention. Some African countries deploy a mix of ITNs and IRS, generally in different geographical areas rather than together. The impact of disruptions to IRS and SMC is not included in this analysis. Fourteen Sahelian countries implement SMC: Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Mali, Niger, Nigeria, Senegal and Togo. Annexes 2 and 3 present the key model results by country. Annex 4 summarises country plans for ITN, IRS and SMC plans in 2020. The baseline figures for malaria cases and deaths used in the analysis are those reported in the *World malaria report 2019*.

The models consider that cancellations of ITN campaigns and disruptions of continuous distributions in 2020 would reduce effective coverage, and thus increase the risk of malaria infection and, by extension, the number of malaria cases. Note that not everyone who gets infected with malaria will develop disease, as some people may have partial immunity. Disruptions in access to effective antimalarial treatment may also increase the number of cases, as reductions in treatment could increase malaria transmission. The combined effect of these disruptions would lead to more cases than if one or the other were disrupted. Additionally, the higher the number of cases, the higher the mortality under reduced access to effective treatment, as the fraction of cases progressing to death would rise. Analysis was not possible for Botswana, Comoros, Cabo Verde, Djibouti, Eswatini and Sao Tome & Principe, due to the relatively low number of cases and deaths while Lesotho is considered malaria-free.

FIG. 2.

### Sub-Saharan Africa – percentage increase in cases and deaths by scenario of malaria service disruption

Fig. 2a. sub-Saharan Africa – percentage increase in cases



**Scenarios:** No ITN campaigns in all scenarios. Change is compared to “business as usual” scenario. CD = continuous distribution, AM = antimalarial. 1: CD -25%, 2: CD -50%, 3: CD -75%, 4: AM -25%, 5: AM -50%, 6: AM -75%, 7: CD & AM -25%, 8: CD & AM -50%, 9: CD & AM -75%

Fig. 2b. sub-Saharan Africa - percentage increase in deaths

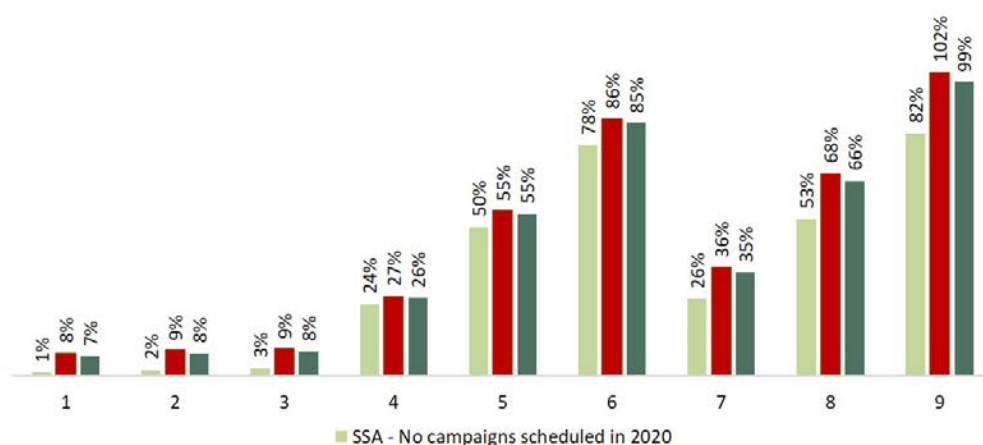


TABLE 1.

**Sub-Saharan Africa – number of cases and deaths by scenario of malaria service disruption**

	CASES			DEATHS		
	COUNTRIES WITH NO ITN CAMPAIGNS SCHEDULED IN 2020	COUNTRIES WITH ITN CAMPAIGNS SCHEDULED IN 2020	ALL COUNTRIES	COUNTRIES WITH NO ITN CAMPAIGNS SCHEDULED IN 2020	COUNTRIES WITH ITN CAMPAIGNS SCHEDULED IN 2020	ALL COUNTRIES
<b>Case count at baseline, 2018*</b>	32 263 915	182 960 103	215 224 018	61 822	324 621	386 443
<b>Scenario 1</b>	32 629 775	197 898 185	230 527 960	62 489	349 194	411 684
<b>Scenario 2</b>	32 943 635	199 855 171	232 798 807	63 079	352 445	415 524
<b>Scenario 3</b>	33 096 137	200 930 863	234 026 999	63 368	354 223	417 591
<b>Scenario 4</b>	33 454 693	190 626 785	224 081 479	76 782	411 120	487 903
<b>Scenario 5</b>	34 659 356	198 448 314	233 107 671	92 774	504 640	597 414
<b>Scenario 6</b>	35 875 813	206 407 978	242 283 792	109 816	605 375	715 191
<b>Scenario 7</b>	33 950 706	206 506 522	240 457 228	77 889	443 041	520 930
<b>Scenario 8</b>	35 332 153	215 701 697	251 033 850	94 557	545 610	640 167
<b>Scenario 9</b>	36 696 044	224 886 788	261 582 832	112 337	656 251	768 588

\* Source *World malaria report 2019*

1. In 2020, 26 out of 46 countries in SSA that were included in the analysis are due for national universal ITN campaigns. If ITN campaigns are not implemented this year, malaria cases and deaths will increase by up to 10%, even if access to effective malaria treatment is maintained at current levels (**Scenario 3**). It is estimated that there would be between 5 and 17 million additional cases (**Scenarios 1-3**) and up to 30 000 lives would be lost to malaria compared to the 2018 baseline. About 70% of these additional deaths would be of children under the age of 5.

**Scenarios:** No ITN campaigns in all scenarios. Change is compared to "business as usual" scenario.  
 CD = continuous distribution, AM = antimalarial. 1: CD -25%, 2: CD -50%, 3: CD -75%, 4: AM -25%,  
 5: AM -50%, 6: AM -75%, 7: CD & AM -25%, 8: CD & AM -50%, 9: CD & AM -75%



2. If the 2020 ITN campaigns are cancelled and continuous distributions and access to effective malaria treatment are also severely disrupted (i.e., reduced by 75%) in these countries (**Scenario 9**), the consequences will be devastating. Malaria cases are estimated to increase by 23%, while deaths would increase by 102%. There would be an estimated 225 million cases and 656 000 deaths, with 70% of deaths among children under the age of 5.
3. For the 15 countries included in this analysis where ITN campaigns are not scheduled in 2020, if continuous distributions are reduced by 25% and access to effective malaria treatment is maintained at current levels (**Scenario 1**), there will be no significant increases in cases and deaths, and estimates are line with the expected normal trends in malaria morbidity and mortality.
4. However, even with ITN coverage at expected levels, severe disruptions in case management would result in dramatic increases in the malaria burden in these countries (**Scenario 6**). The number of malaria cases is estimated to rise from 32 million to 37 million, representing a 14% increase. Malaria deaths will also rise to an estimated 112 000, an increase of 82%.
5. When all SSA countries are combined and analysed under a scenario in which ITN campaigns are not implemented and continuous distributions and access to effective antimalarial treatment are reduced by up to 75% (**Scenario 9**), the results suggest that by the end of 2020, there could be an estimated 769 000 malaria deaths; of these, approximately 70% would be among children under the age of 5. This would represent an estimated increase of 22% in cases and 100% in deaths relative to the 2018 baseline estimates. This implies that the estimated malaria deaths in SSA alone could exceed 743 000, which was the entire estimated global malaria burden in 2000 (1).
6. Under **Scenario 9**, all countries would likely see increases in malaria deaths of 20% or more compared to a 2018 baseline. Table 2 categorizes countries by percentage increase in malaria deaths.

TABLE 2.  
**Percentage increase in malaria deaths by country in SSA under Scenario 9**

% INCREASE IN MALARIA DEATHS	COUNTRY
20% to 50%	Chad, Central African Republic, Equatorial Guinea, Eritrea, Guinea, Somalia, South Sudan, , Eswatini, Mali, Niger
>50 to 75%	Burkina Faso, Cameroon, Congo, Ethiopia, Sudan
>75% to 100%	Benin, Burundi, Democratic Republic of the Congo, Madagascar, Malawi, Mauritania, Mozambique, Rwanda, Senegal
>100% to 150%	Angola, Côte d'Ivoire, Gabon, Gambia, Ghana, Kenya, Liberia, Nigeria, South Africa, Togo, United Republic of Tanzania, Zimbabwe
>150% to 200%	Namibia, Zambia
>200%	Guinea Bissau, Uganda

# Key messages

1. It is critical that malaria endemic countries minimize any disruptions of malaria prevention and treatment during the COVID-19 response. Failure to do so could lead to catastrophic loss of life. Under the worst-case scenario presented in this analysis (**Scenario 9**). The death toll in SSA in 2020 would exceed the total number of malaria deaths reported globally in the year 2000.
2. Although the current analysis does not factor in the effects of disrupting SMC and IRS, their disruption would also lead to considerable loss of lives. It is critical that these interventions be implemented as planned.
3. To help countries maintain malaria prevention, diagnosis and treatment, WHO, with extensive support from its partners, has recently developed guidance on tailoring malaria interventions in the COVID-19 response (4).
4. Access to and use of ITNs should be maintained through campaigns that are adapted to protect health workers and communities from COVID-19. Case management of malaria, including prompt diagnostic testing and treatment, should continue, delivered safely within the package of essential health services.
5. In addition to the impact of disrupting SMC and IRS, modelling scenarios do not account for possible disruptions to global commodity supply chains. There is also limited understanding of the spread of COVID-19, its epidemiology and how it interacts with malaria in SSA. As more data become available, the models will be updated, and countries will be provided with relevant information with which to tailor their response, including through novel mitigation approaches such as age-expanded SMC and MDA, and highly adaptable delivery approaches, such as presumptive treatment of patients suspected to have malaria.



# References

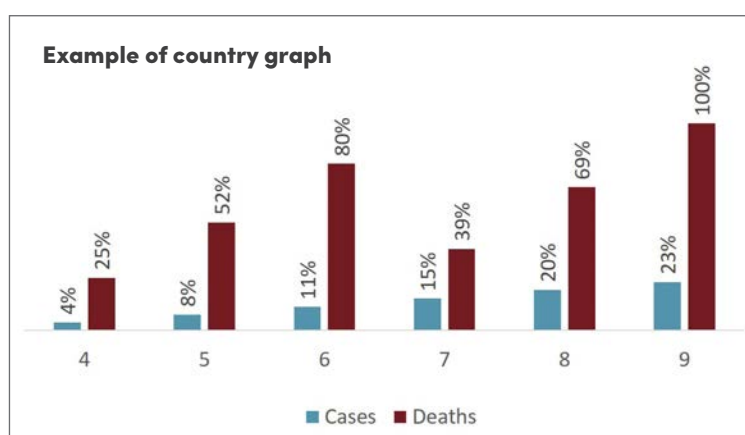
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# Annex 1.

## How to read these graphs

**Important reminder:** Models, such as the one used to project the percentage increases in malaria cases and deaths described here, are best used as tools to compare different scenarios. These estimates should be used to understand the potential negative impacts on malaria cases and deaths that different disruptions to essential malaria services might have. These models are attempts to understand real-world scenarios using the best available data. However, these model estimates have important uncertainties, which should be taken into consideration.

The **plots** show the potential relative increases in malaria cases (blue bars) and malaria deaths (red bars) over the baseline levels for the year 2020 under the nine different scenarios of disrupted malaria services. The scenarios are numbered, and the legend is shown on the right. In Scenarios 1–3, countries do not implement the mass campaigns scheduled for 2020, and continuous ITN distributions are reduced by varying amounts; access to effective malaria treatment remains at baseline levels. In Scenarios 5–7, there are no 2020 mass ITN campaigns, continuous ITN distributions remain at baseline levels and access to effective antimalarial treatment is reduced by varying levels. In Scenarios 7–9, there are no 2020 mass ITN campaigns, continuous ITN distributions and access to effective antimalarial treatment are all reduced by varying levels.



### Scenarios

- 1: No ITN campaigns, continuous ITN distributions reduced by 25%
- 2: No ITN campaigns, continuous ITN distributions reduced by 50%
- 3: No ITN campaigns, continuous ITN distributions reduced by 75%
- 4: No ITN campaigns, access to effective antimalarial treatment reduced by 25%
- 5: No ITN campaigns, access to effective antimalarial treatment reduced by 50%
- 6: No ITN campaigns, access to effective antimalarial treatment reduced by 75%
- 7: No ITN campaigns, both continuous ITN distributions and access to effective antimalarial treatment reduced by 25%
- 8: No ITN campaigns, both continuous ITN distributions and access to effective antimalarial treatment reduced by 50%
- 9: No ITN campaigns, both continuous ITN distributions and access to effective antimalarial treatment reduced by 75%

The data in the table indicate potential malaria deaths in 2020 as a function of the modelled percentage increase in deaths under each scenario (as shown in the plot) applied to the all-ages and under-5 death baseline counts reported in the *World malaria report 2019*, adjusted to scale for population size. The baseline data, representing deaths in the 2018 calendar year, are shown in grey in the first line of the table.

At the bottom of each page, an abbreviated legend reminds readers of the nine different scenarios for disrupted malaria services that were modelled here.

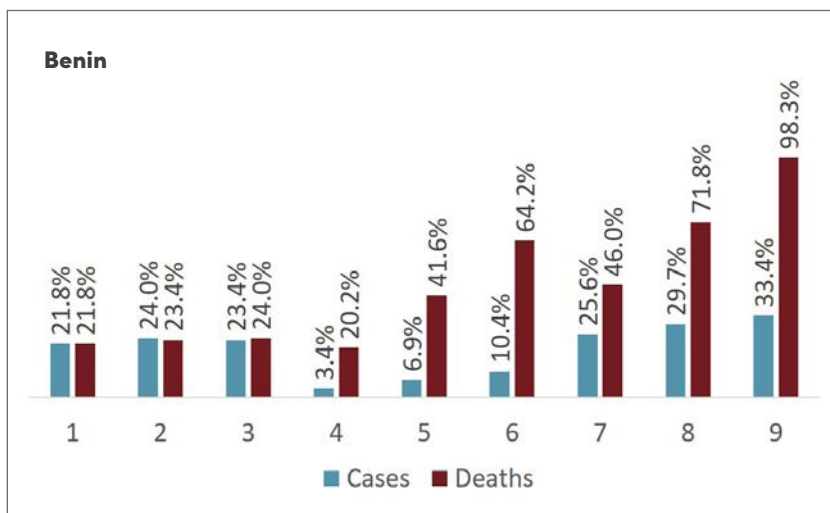
SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	13 000
Scenario 1	13 500
Scenario 2	13 700
Scenario 3	13 800
Scenario 4	18 000
Scenario 5	22 000
Scenario 6	27 000
Scenario 7	18 000
Scenario 8	22 000
Scenario 9	27 000

**Scenarios:** No ITN campaigns in all scenarios. Change is compared to “business as usual” scenario. CD = continuous distribution, AM = antimalarial. 1: CD -25%, 2: CD -50%, 3: CD -75%, 4: AM -25%, 5: AM -50%, 6: AM -75%, 7: CD & AM -25%, 8: CD & AM -50%, 9: CD & AM -75%

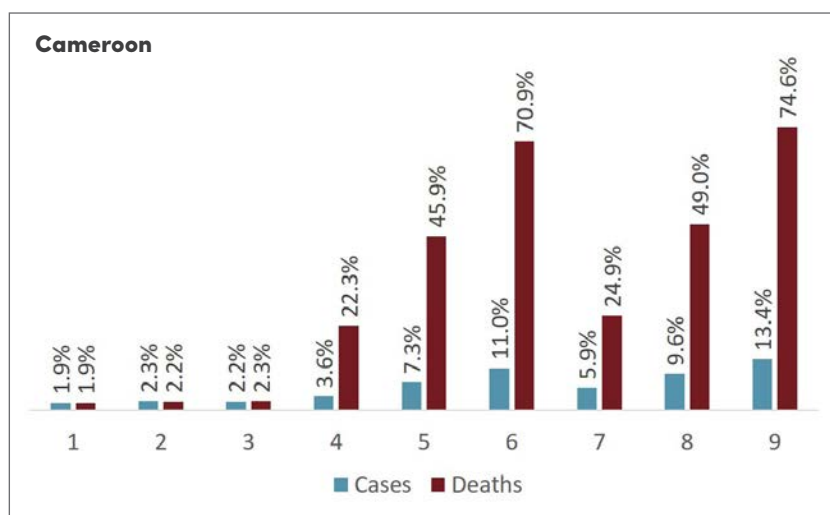
# Annex 2.

## Model results for countries with ITN campaigns scheduled in 2020

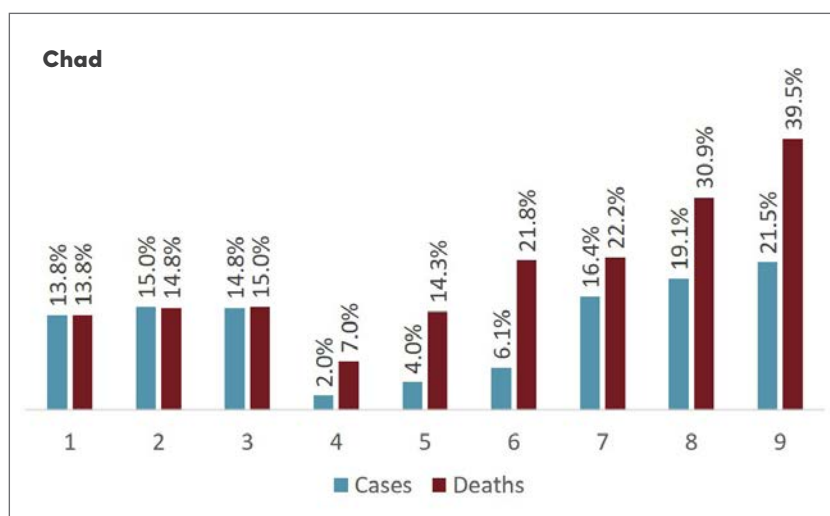
Benin, Cameroon, Central African Republic, Chad, Côte d'Ivoire, Democratic Republic of the Congo, Eritrea, Ethiopia, Ghana, Guinea-Bissau, Kenya, Mali, Mauritania, Mozambique, Niger, Nigeria, Rwanda, Sierra Leone, Somalia, South Sudan, Sudan, Togo, Uganda, United Republic of Tanzania, Zambia and Zimbabwe



SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	7 081
Scenario 1	8 627
Scenario 2	8 736
Scenario 3	8 783
Scenario 4	8 513
Scenario 5	10 028
Scenario 6	11 626
Scenario 7	10 340
Scenario 8	12 167
Scenario 9	14 042

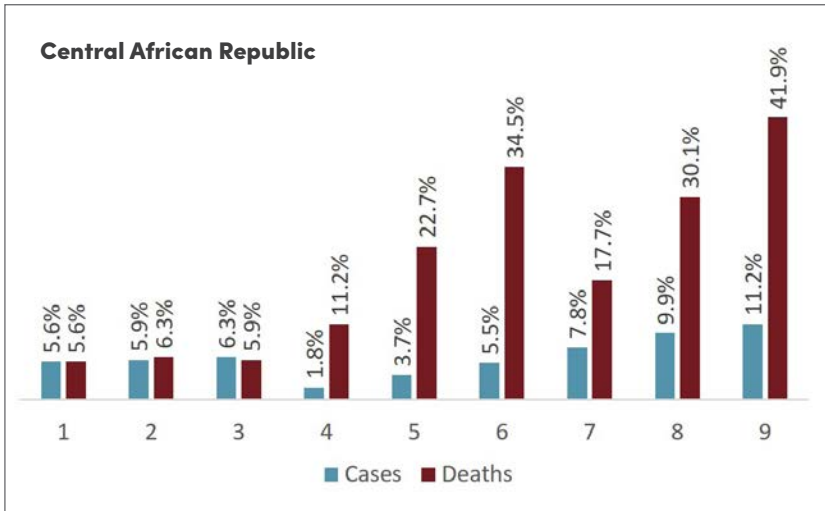


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	11 192
Scenario 1	11 404
Scenario 2	11 443
Scenario 3	11 454
Scenario 4	13 683
Scenario 5	16 327
Scenario 6	19 128
Scenario 7	13 978
Scenario 8	16 675
Scenario 9	19 540

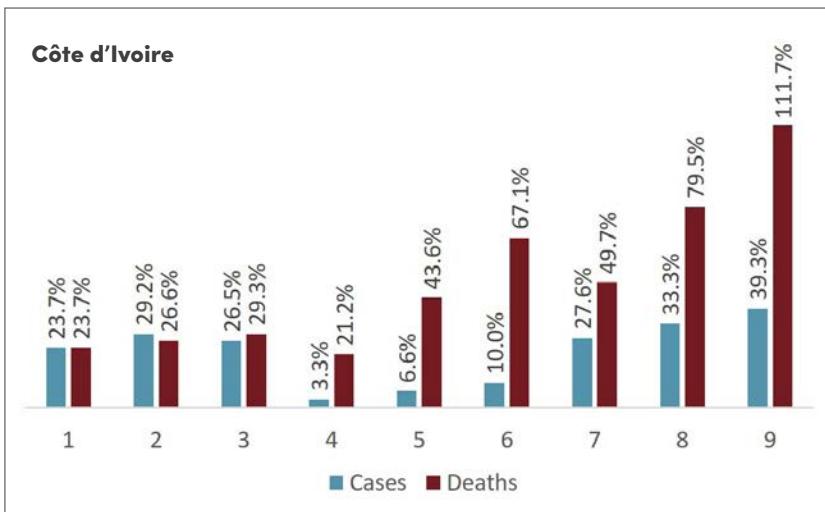


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	8 693
Scenario 1	9 894
Scenario 2	9 981
Scenario 3	9 994
Scenario 4	9 305
Scenario 5	9 937
Scenario 6	10 589
Scenario 7	10 624
Scenario 8	11 382
Scenario 9	12 130

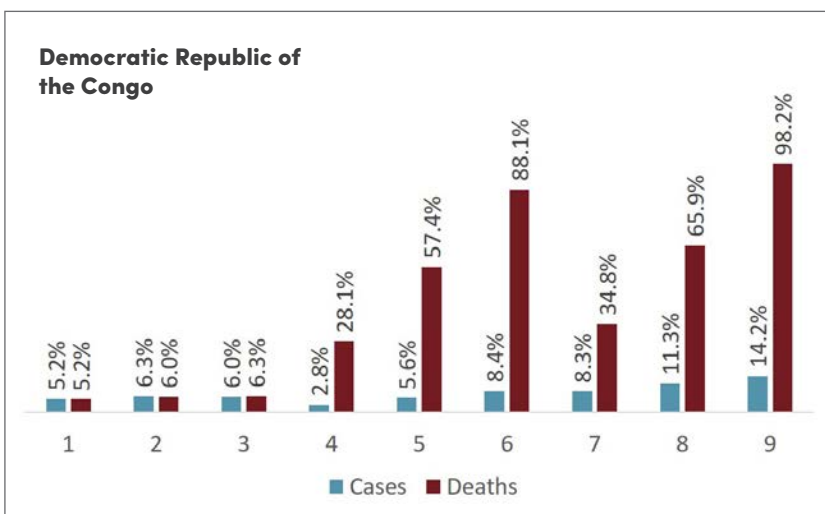
**Scenarios:** No ITN campaigns in all scenarios. Change is compared to “business as usual” scenario. CD = continuous distribution, AM = antimalarial. 1: CD -25%, 2: CD -50%, 3: CD -75%, 4: AM -25%, 5: AM -50%, 6: AM -75%, 7: CD & AM -25%, 8: CD & AM -50%, 9: CD & AM -75%



SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	3 654
Scenario 1	3 860
Scenario 2	3 886
Scenario 3	3 870
Scenario 4	4 063
Scenario 5	4 483
Scenario 6	4 916
Scenario 7	4 301
Scenario 8	4 753
Scenario 9	5 184

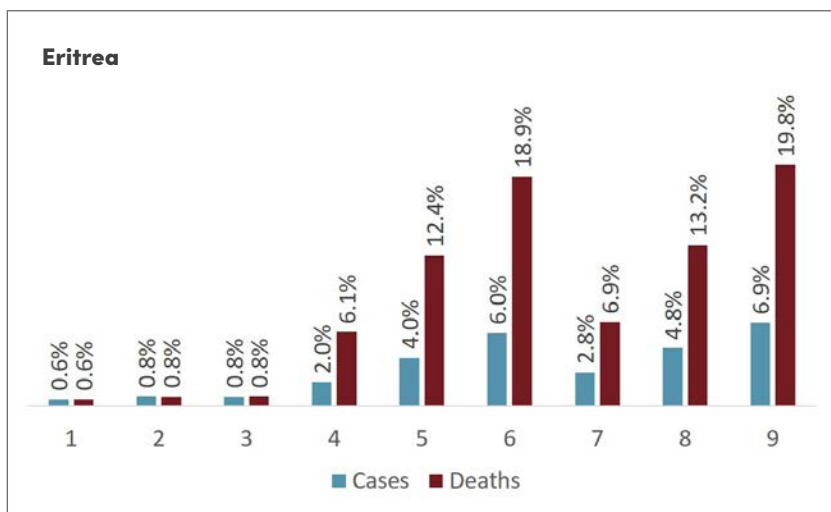


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	9 297
Scenario 1	11 505
Scenario 2	11 766
Scenario 3	12 017
Scenario 4	11 268
Scenario 5	13 349
Scenario 6	15 539
Scenario 7	13 914
Scenario 8	16 684
Scenario 9	19 679

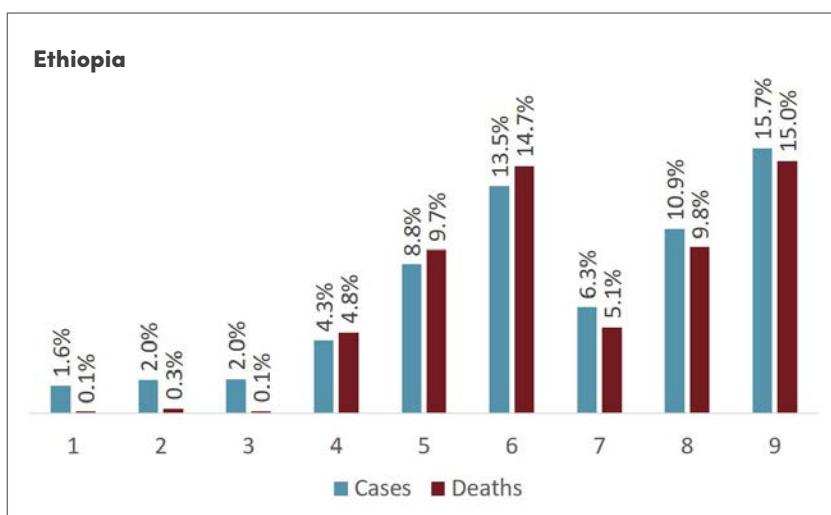


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	44 615
Scenario 1	46 913
Scenario 2	47 285
Scenario 3	47 429
Scenario 4	57 130
Scenario 5	70 239
Scenario 6	83 921
Scenario 7	60 136
Scenario 8	74 015
Scenario 9	88 412

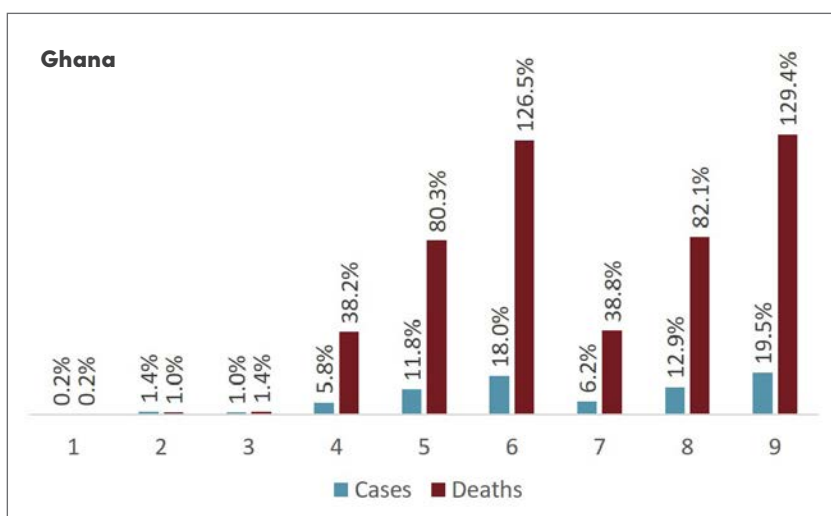
**Scenarios:** No ITN campaigns in all scenarios. Change is compared to “business as usual” scenario. CD = continuous distribution, AM = antimalarial. 1: CD -25%, 2: CD -50%, 3: CD -75%, 4: AM -25%, 5: AM -50%, 6: AM -75%, 7: CD & AM -25%, 8: CD & AM -50%, 9: CD & AM -75%



SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	196
Scenario 1	197
Scenario 2	198
Scenario 3	198
Scenario 4	208
Scenario 5	220
Scenario 6	233
Scenario 7	210
Scenario 8	222
Scenario 9	235

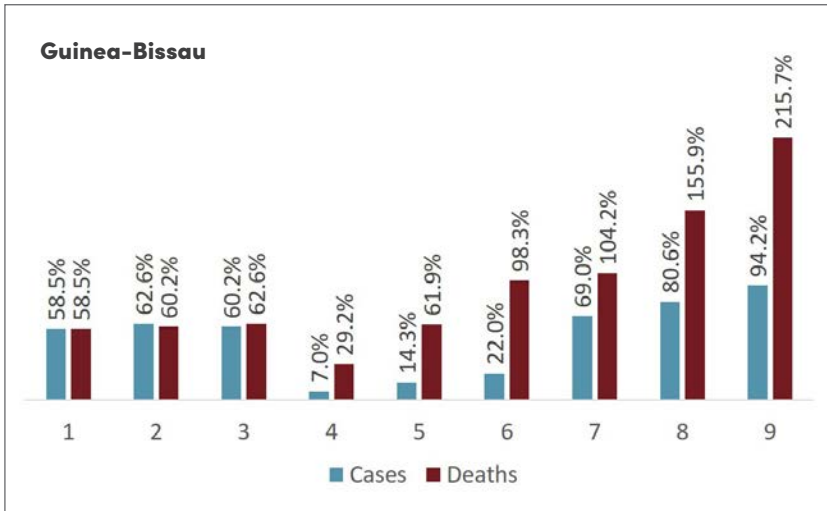


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	4 757
Scenario 1	4 835
Scenario 2	4 851
Scenario 3	4 854
Scenario 4	5 484
Scenario 5	6 263
Scenario 6	7 097
Scenario 7	5 586
Scenario 8	6 384
Scenario 9	7 237

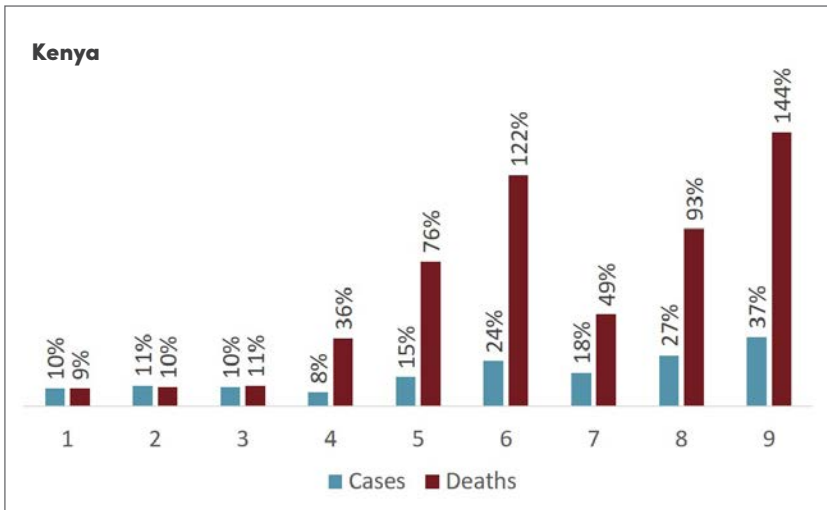


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	11 070
Scenario 1	11 091
Scenario 2	11 183
Scenario 3	11 223
Scenario 4	15 303
Scenario 5	19 964
Scenario 6	25 071
Scenario 7	15 368
Scenario 8	20 157
Scenario 9	25 392

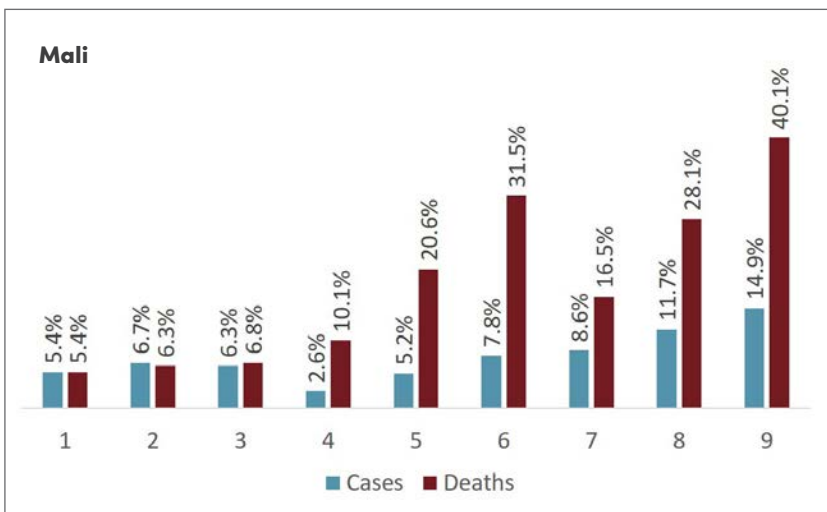
**Scenarios:** No ITN campaigns in all scenarios. Change is compared to “business as usual” scenario. CD = continuous distribution, AM = antimalarial. 1: CD -25%, 2: CD -50%, 3: CD -75%, 4: AM -25%, 5: AM -50%, 6: AM -75%, 7: CD & AM -25%, 8: CD & AM -50%, 9: CD & AM -75%



SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	680
Scenario 1	1 078
Scenario 2	1 089
Scenario 3	1 106
Scenario 4	879
Scenario 5	1 101
Scenario 6	1 348
Scenario 7	1 388
Scenario 8	1 740
Scenario 9	2 147



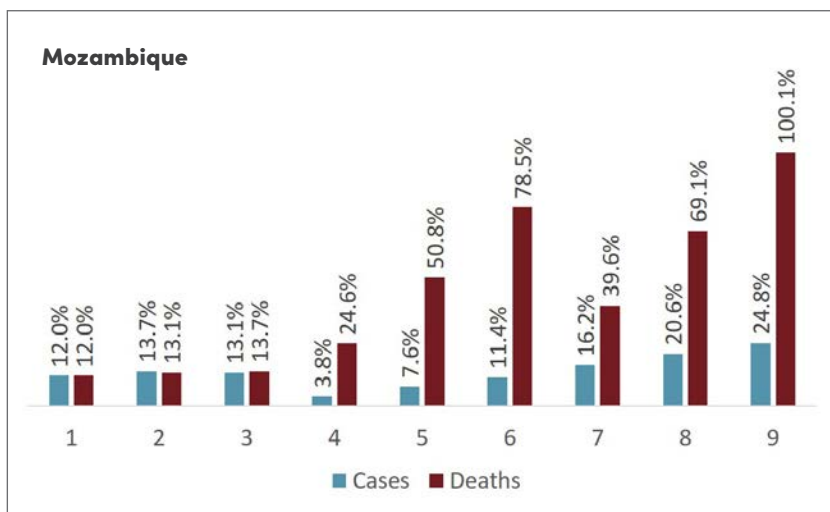
SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	12 416
Scenario 1	13 586
Scenario 2	13 675
Scenario 3	13 765
Scenario 4	16 862
Scenario 5	21 881
Scenario 6	27 516
Scenario 7	18 451
Scenario 8	24 025
Scenario 9	30 345



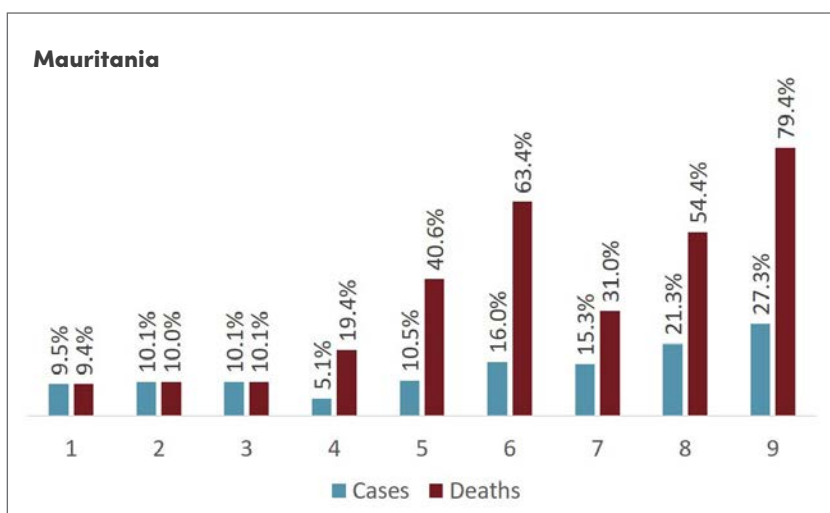
SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	11 848
Scenario 1	12 485
Scenario 2	12 597
Scenario 3	12 648
Scenario 4	13 042
Scenario 5	14 286
Scenario 6	15 582
Scenario 7	13 809
Scenario 8	15 172
Scenario 9	16 603

**Scenarios:** No ITN campaigns in all scenarios. Change is compared to "business as usual" scenario.  
 CD = continuous distribution, AM = antimalarial. 1: CD -25%, 2: CD -50%, 3: CD -75%, 4: AM -25%,  
 5: AM -50%, 6: AM -75%, 7: CD & AM -25%, 8: CD & AM -50%, 9: CD & AM -75%

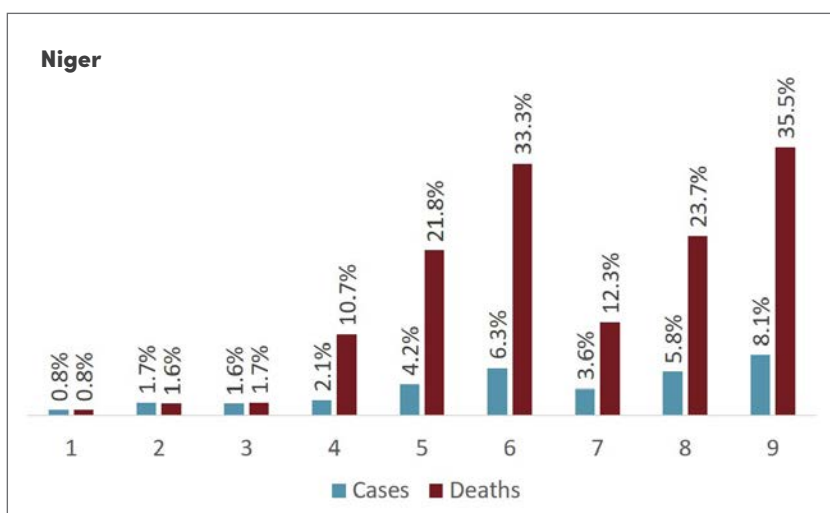




SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	14 426
Scenario 1	16 150
Scenario 2	16 322
Scenario 3	16 405
Scenario 4	17 978
Scenario 5	21 752
Scenario 6	25 750
Scenario 7	20 134
Scenario 8	24 388
Scenario 9	28 860

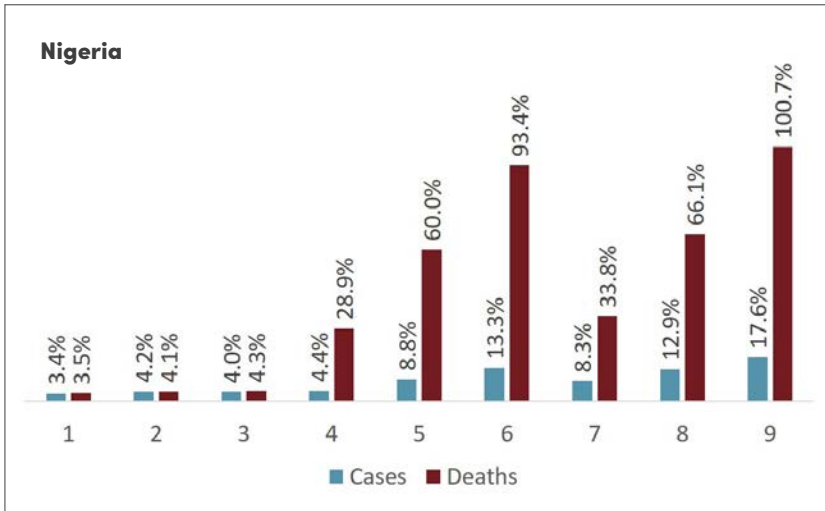


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	1 397
Scenario 1	1 529
Scenario 2	1 537
Scenario 3	1 538
Scenario 4	1 669
Scenario 5	1 964
Scenario 6	2 283
Scenario 7	1 831
Scenario 8	2 157
Scenario 9	2 506

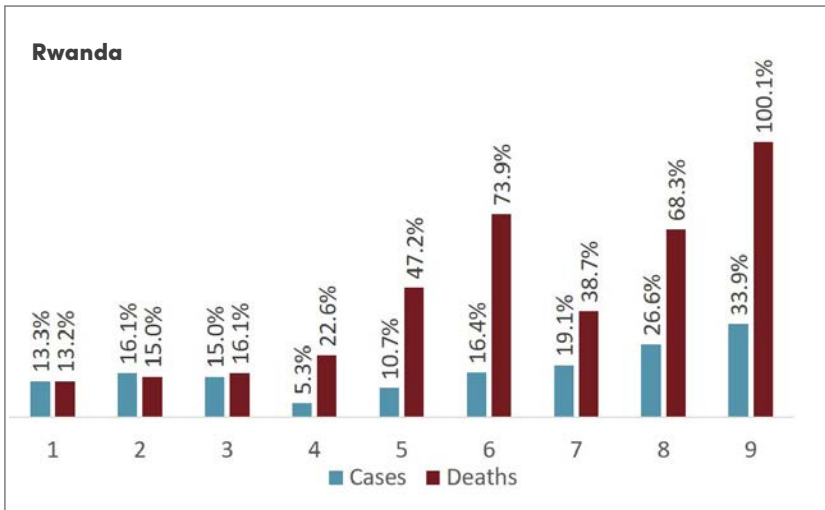


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	17 084
Scenario 1	17 224
Scenario 2	17 357
Scenario 3	17 379
Scenario 4	18 916
Scenario 5	20 811
Scenario 6	22 769
Scenario 7	19 192
Scenario 8	21 133
Scenario 9	23 143

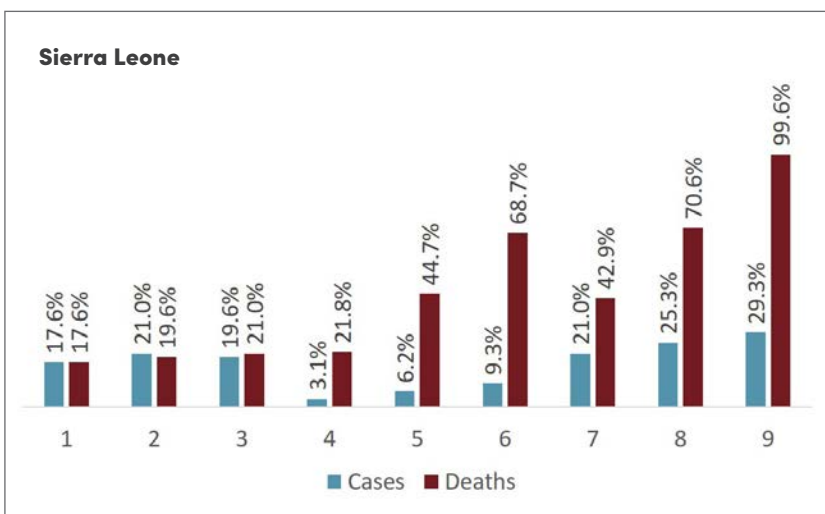
**Scenarios:** No ITN campaigns in all scenarios. Change is compared to “business as usual” scenario. CD = continuous distribution, AM = antimalarial. 1: CD -25%, 2: CD -50%, 3: CD -75%, 4: AM -25%, 5: AM -50%, 6: AM -75%, 7: CD & AM -25%, 8: CD & AM -50%, 9: CD & AM -75%



SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	95 844
Scenario 1	99 197
Scenario 2	99 764
Scenario 3	99 935
Scenario 4	123 543
Scenario 5	153 369
Scenario 6	185 341
Scenario 7	128 227
Scenario 8	159 165
Scenario 9	192 358

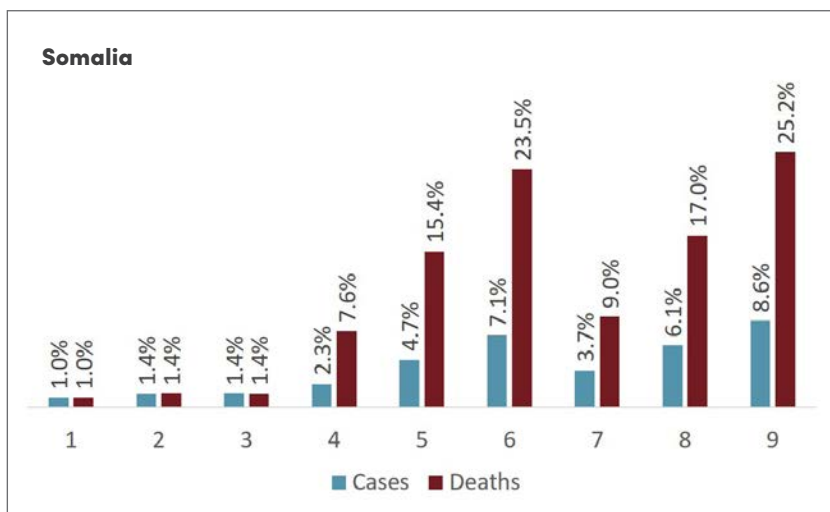


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	3 244
Scenario 1	3 674
Scenario 2	3 730
Scenario 3	3 767
Scenario 4	3 978
Scenario 5	4 776
Scenario 6	5 640
Scenario 7	4 500
Scenario 8	5 460
Scenario 9	6 491

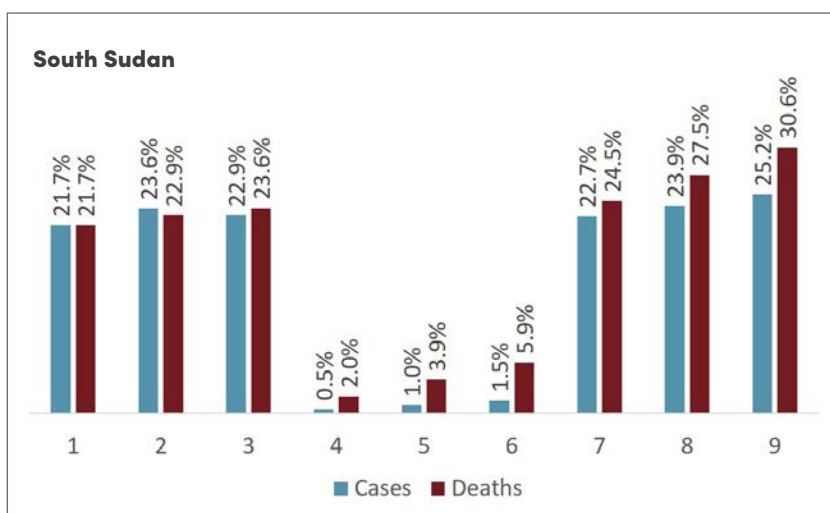


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	6 564
Scenario 1	7 719
Scenario 2	7 848
Scenario 3	7 942
Scenario 4	7 993
Scenario 5	9 497
Scenario 6	11 073
Scenario 7	9 380
Scenario 8	11 201
Scenario 9	13 103

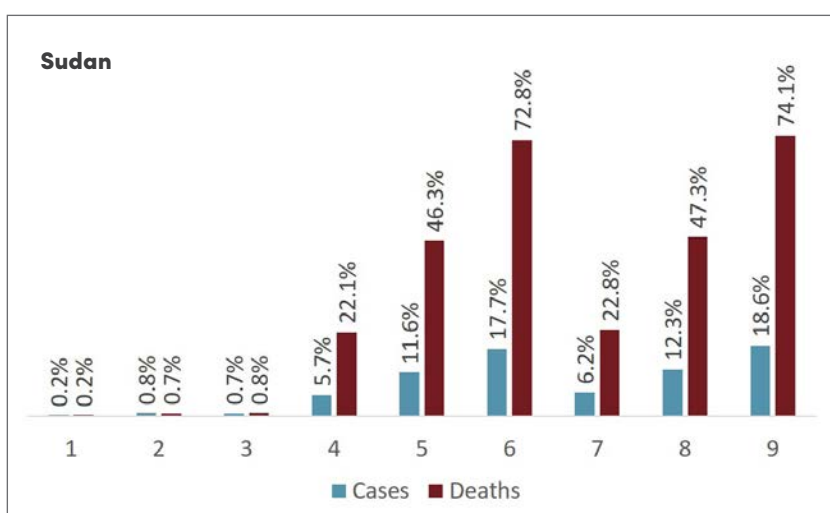
**Scenarios:** No ITN campaigns in all scenarios. Change is compared to "business as usual" scenario.  
 CD = continuous distribution, AM = antimalarial. 1: CD -25%, 2: CD -50%, 3: CD -75%, 4: AM -25%,  
 5: AM -50%, 6: AM -75%, 7: CD & AM -25%, 8: CD & AM -50%, 9: CD & AM -75%



SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	1 316
Scenario 1	1 329
Scenario 2	1 334
Scenario 3	1 334
Scenario 4	1 415
Scenario 5	1 519
Scenario 6	1 626
Scenario 7	1 434
Scenario 8	1 539
Scenario 9	1 647

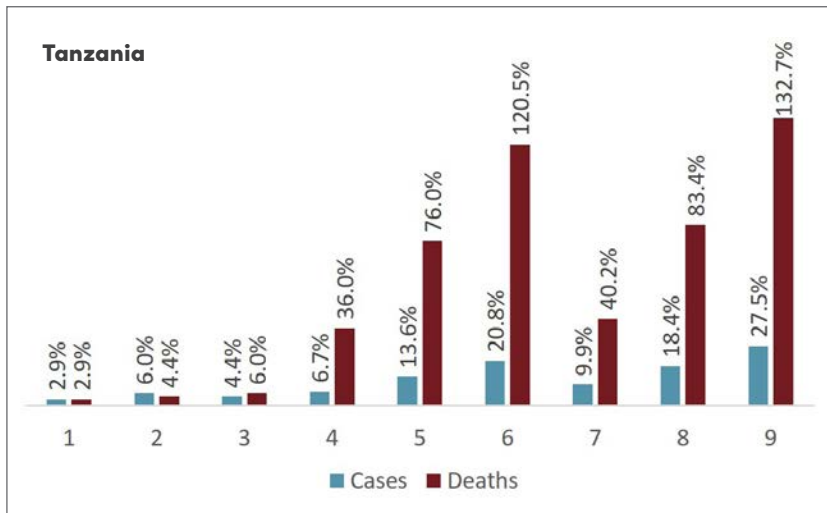


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	5 356
Scenario 1	6 519
Scenario 2	6 581
Scenario 3	6 622
Scenario 4	5 461
Scenario 5	5 566
Scenario 6	5 672
Scenario 7	6 668
Scenario 8	6 828
Scenario 9	6 997

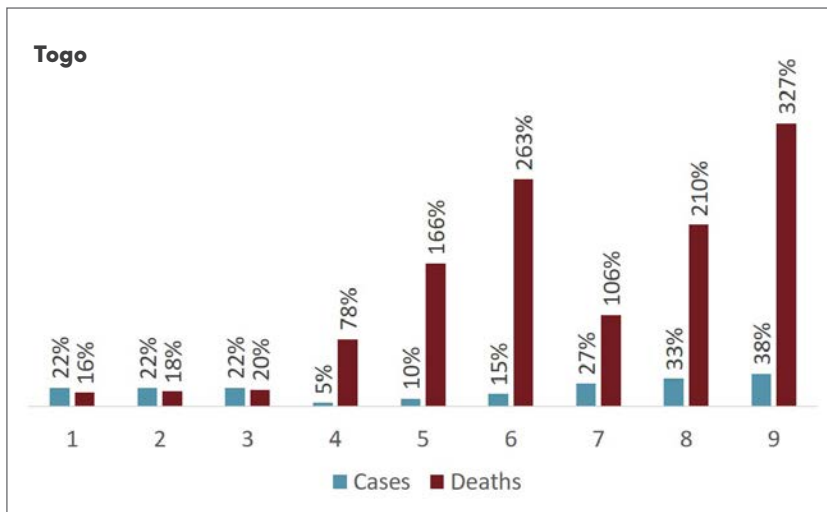


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	5 003
Scenario 1	5 015
Scenario 2	5 038
Scenario 3	5 043
Scenario 4	6 110
Scenario 5	7 321
Scenario 6	8 644
Scenario 7	6 142
Scenario 8	7 371
Scenario 9	8 709

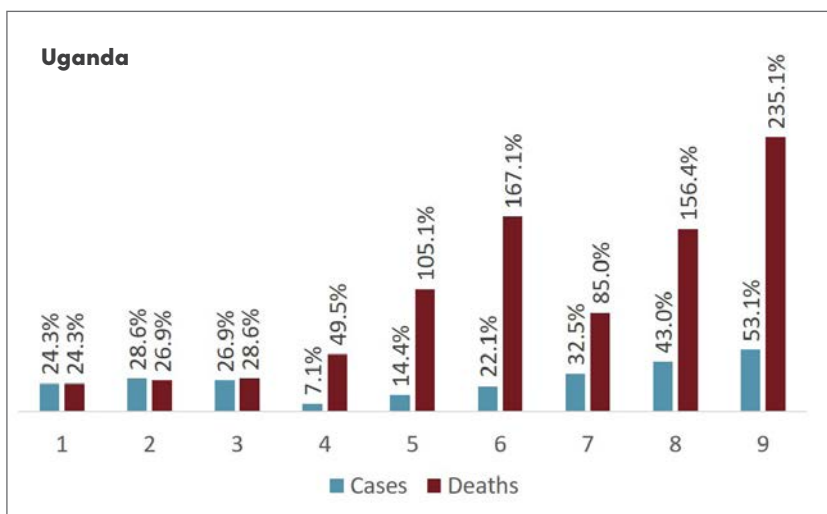
**Scenarios:** No ITN campaigns in all scenarios. Change is compared to “business as usual” scenario. CD = continuous distribution, AM = antimalarial. 1: CD -25%, 2: CD -50%, 3: CD -75%, 4: AM -25%, 5: AM -50%, 6: AM -75%, 7: CD & AM -25%, 8: CD & AM -50%, 9: CD & AM -75%



SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	21 550
Scenario 1	22 177
Scenario 2	22 499
Scenario 3	22 838
Scenario 4	29 302
Scenario 5	37 938
Scenario 6	47 508
Scenario 7	30 206
Scenario 8	39 531
Scenario 9	50 149

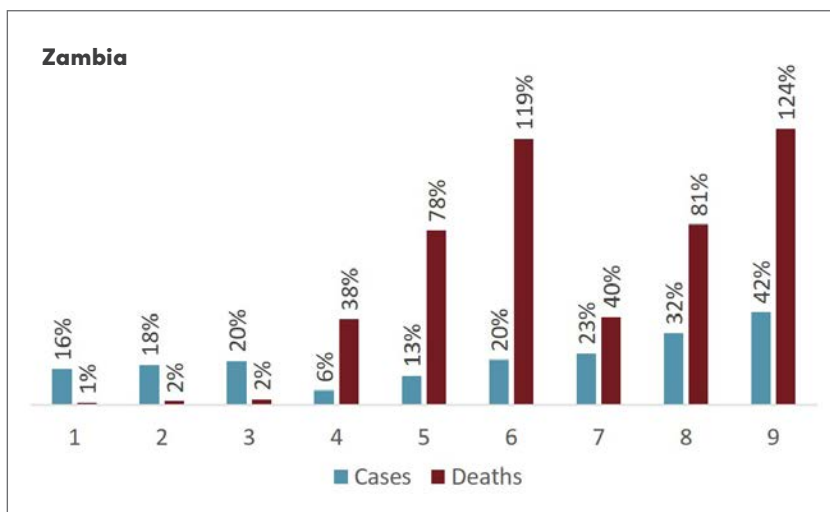


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	5 132
Scenario 1	6 583
Scenario 2	6 624
Scenario 3	6 617
Scenario 4	6 406
Scenario 5	7 782
Scenario 6	9 262
Scenario 7	8 199
Scenario 8	9 946
Scenario 9	11 769

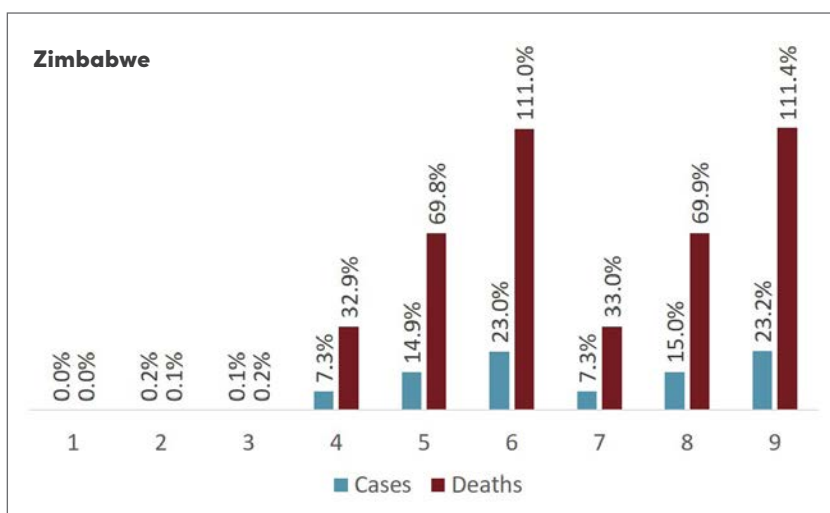


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	13 203
Scenario 1	16 412
Scenario 2	16 758
Scenario 3	16 974
Scenario 4	19 736
Scenario 5	27 078
Scenario 6	35 271
Scenario 7	24 432
Scenario 8	33 848
Scenario 9	44 249

**Scenarios:** No ITN campaigns in all scenarios. Change is compared to "business as usual" scenario.  
 CD = continuous distribution, AM = antimalarial. 1: CD -25%, 2: CD -50%, 3: CD -75%, 4: AM -25%,  
 5: AM -50%, 6: AM -75%, 7: CD & AM -25%, 8: CD & AM -50%, 9: CD & AM -75%



SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	7 519
Scenario 1	8 712
Scenario 2	8 880
Scenario 3	9 004
Scenario 4	10 903
Scenario 5	14 669
Scenario 6	18 838
Scenario 7	12 618
Scenario 8	17 145
Scenario 9	22 186

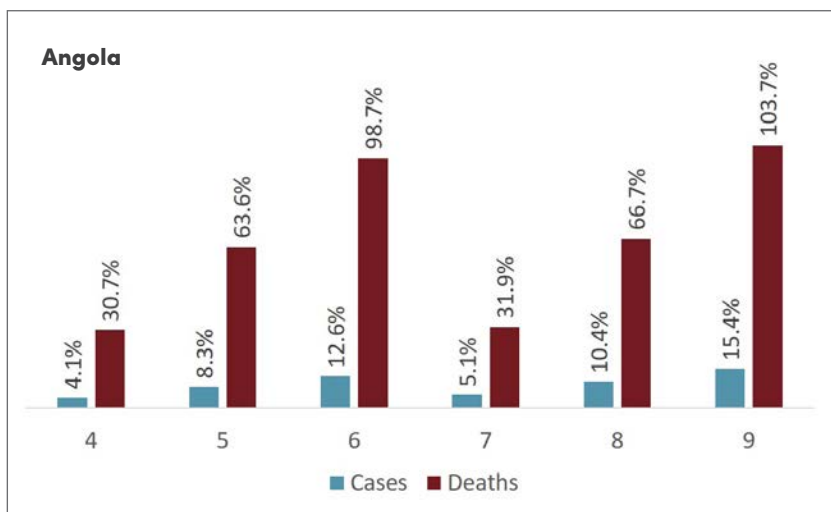


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	1 484
Scenario 1	1 481
Scenario 2	1 485
Scenario 3	1 487
Scenario 4	1 972
Scenario 5	2 519
Scenario 6	3 132
Scenario 7	1 973
Scenario 8	2 522
Scenario 9	3 138

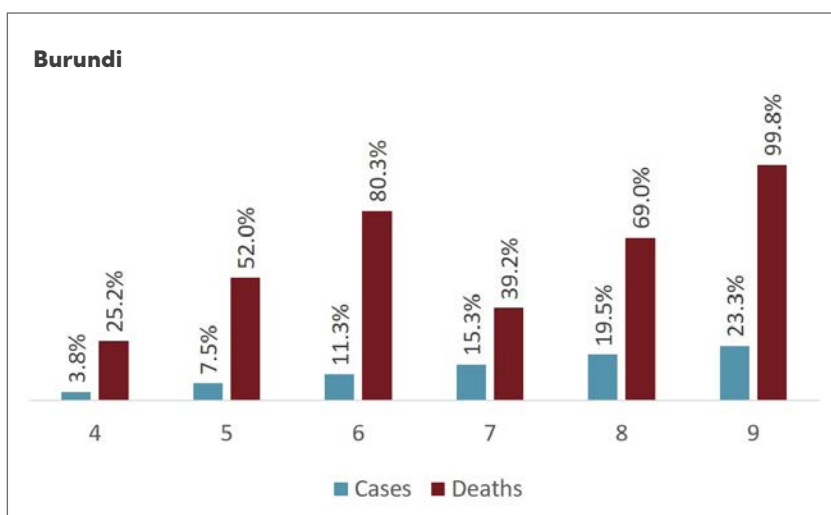
**Scenarios:** No ITN campaigns in all scenarios. Change is compared to “business as usual” scenario. CD = continuous distribution, AM = antimalarial. 1: CD -25%, 2: CD -50%, 3: CD -75%, 4: AM -25%, 5: AM -50%, 6: AM -75%, 7: CD & AM -25%, 8: CD & AM -50%, 9: CD & AM -75%

# **Annex 3. Model results for countries without ITN campaigns scheduled in 2020**

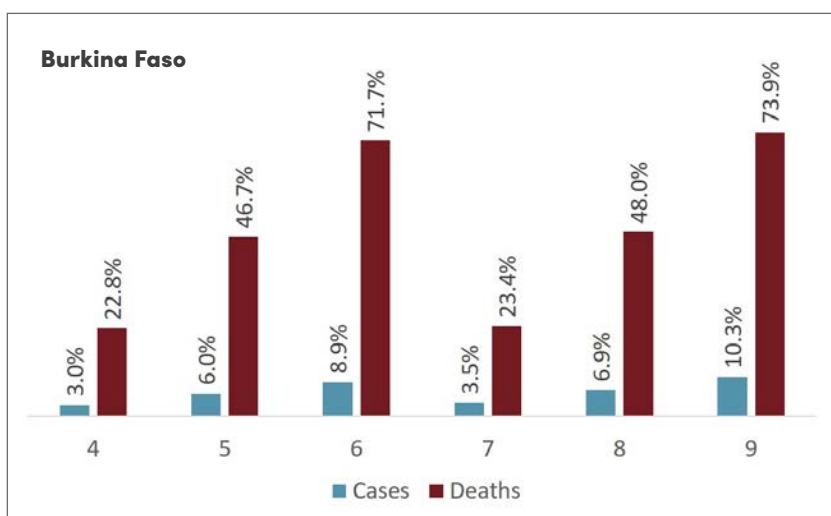
Angola, Burkina Faso, Burundi, Congo, Equatorial Guinea, Gabon, Gambia, Guinea, Liberia, Madagascar, Malawi, Namibia, Senegal and South Africa



SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	13 425
Scenario 4	17 547
Scenario 5	21 962
Scenario 6	26 672
Scenario 7	17 711
Scenario 8	22 385
Scenario 9	27 348



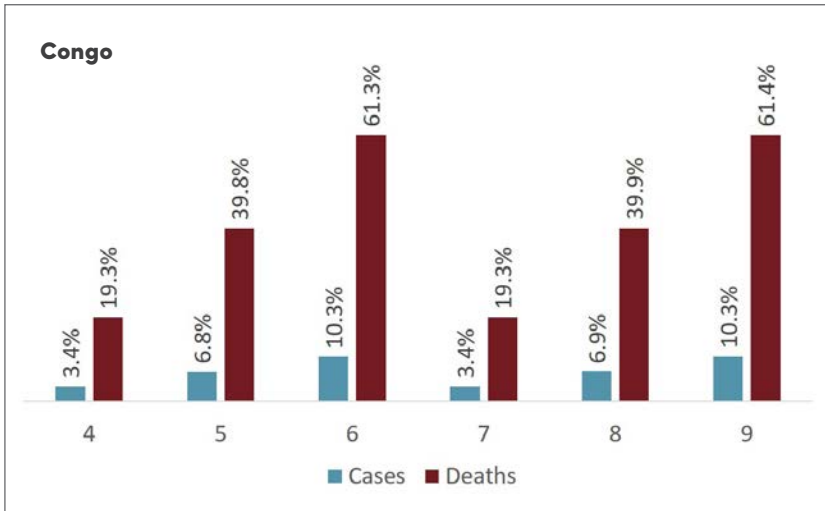
SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	5 118
Scenario 4	6 409
Scenario 5	7 780
Scenario 6	9 230
Scenario 7	7 124
Scenario 8	8 650
Scenario 9	10 227



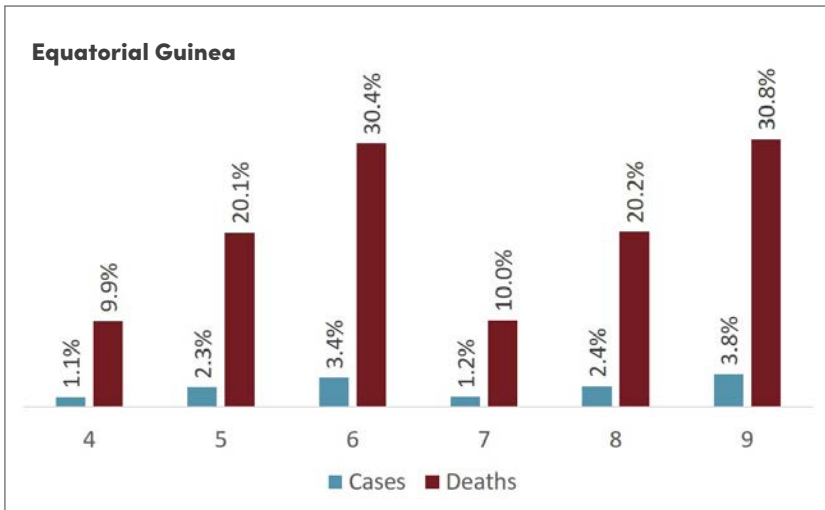
SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	12 725
Scenario 4	15 627
Scenario 5	18 671
Scenario 6	21 855
Scenario 7	15 703
Scenario 8	18 831
Scenario 9	22 134

**Scenarios:** No ITN campaigns in all scenarios. Change is compared to “business as usual” scenario. CD = continuous distribution, AM = antimalarial. 1: CD -25%, 2: CD -50%, 3: CD -75%, 4: AM -25%, 5: AM -50%, 6: AM -75%, 7: CD & AM -25%, 8: CD & AM -50%, 9: CD & AM -75%

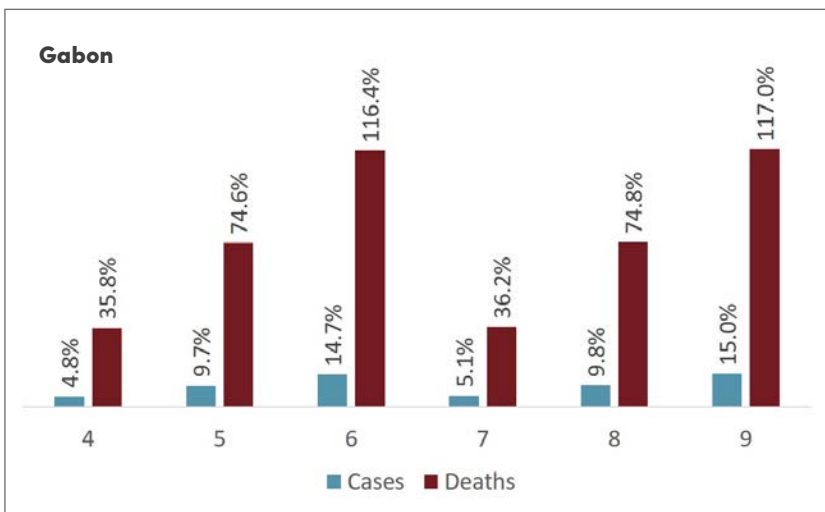




SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	1 961
Scenario 4	2 340
Scenario 5	2 741
Scenario 6	3 164
Scenario 7	2 340
Scenario 8	2 744
Scenario 9	3 165



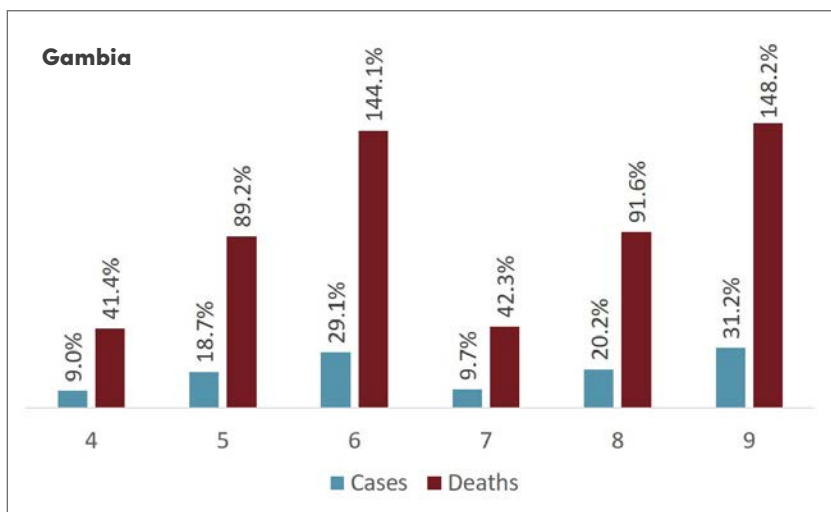
SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	659
Scenario 4	725
Scenario 5	791
Scenario 6	859
Scenario 7	725
Scenario 8	792
Scenario 9	862



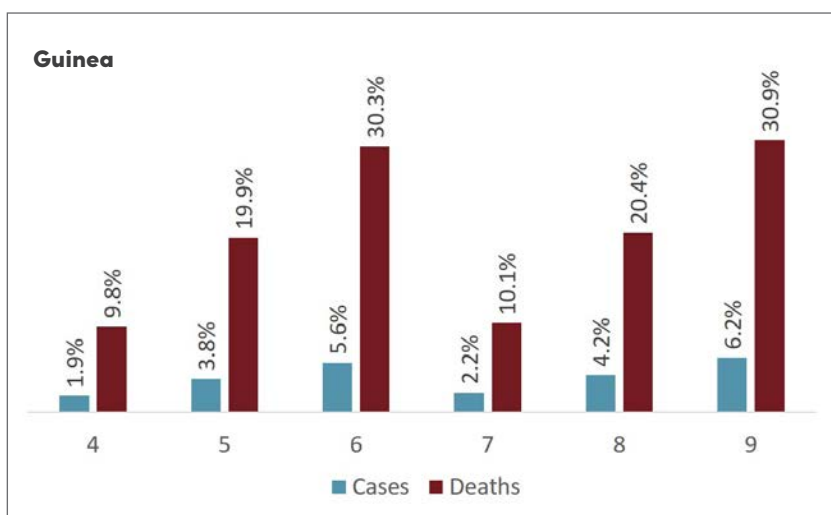
SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	528
Scenario 4	717
Scenario 5	922
Scenario 6	1 142
Scenario 7	719
Scenario 8	923
Scenario 9	1 146

**Scenarios:** No ITN campaigns in all scenarios. Change is compared to "business as usual" scenario.  
 CD = continuous distribution, AM = antimalarial. 1: CD -25%, 2: CD -50%, 3: CD -75%, 4: AM -25%,  
 5: AM -50%, 6: AM -75%, 7: CD & AM -25%, 8: CD & AM -50%, 9: CD & AM -75%

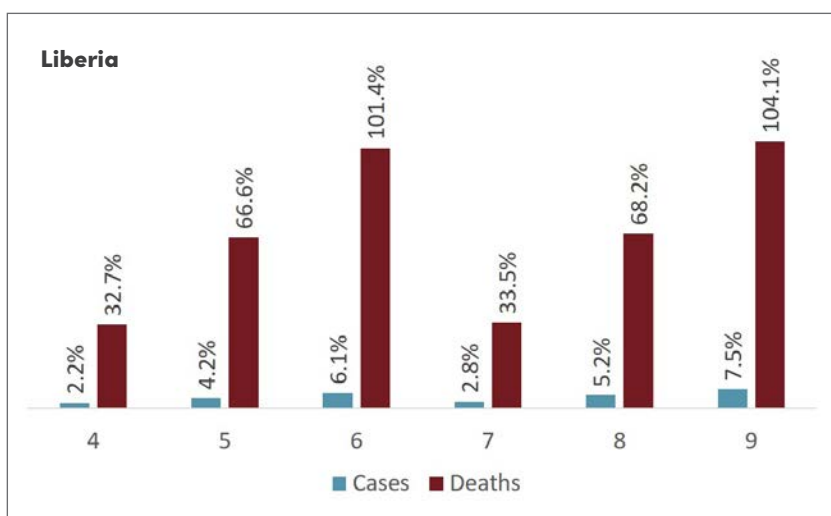




SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	688
Scenario 4	973
Scenario 5	1 302
Scenario 6	1 680
Scenario 7	979
Scenario 8	1 318
Scenario 9	1 707

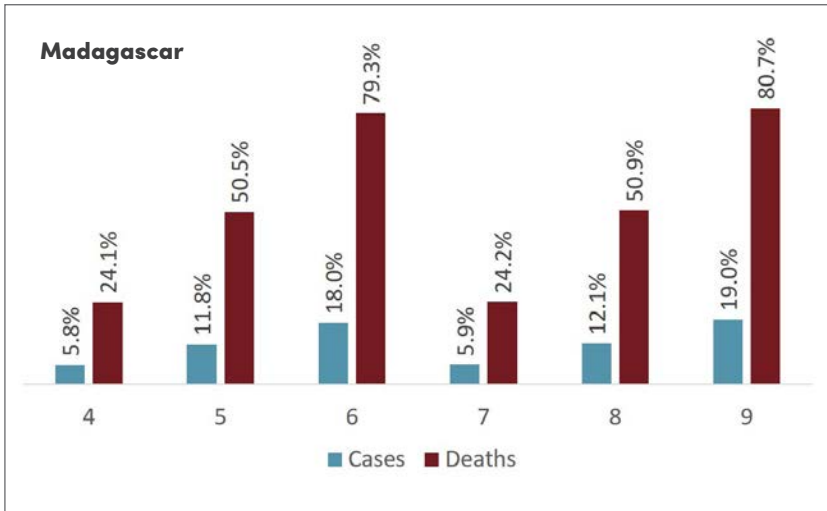


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	8 1203
Scenario 4	9 006
Scenario 5	9 833
Scenario 6	10 685
Scenario 7	9 034
Scenario 8	9 878
Scenario 9	10 741

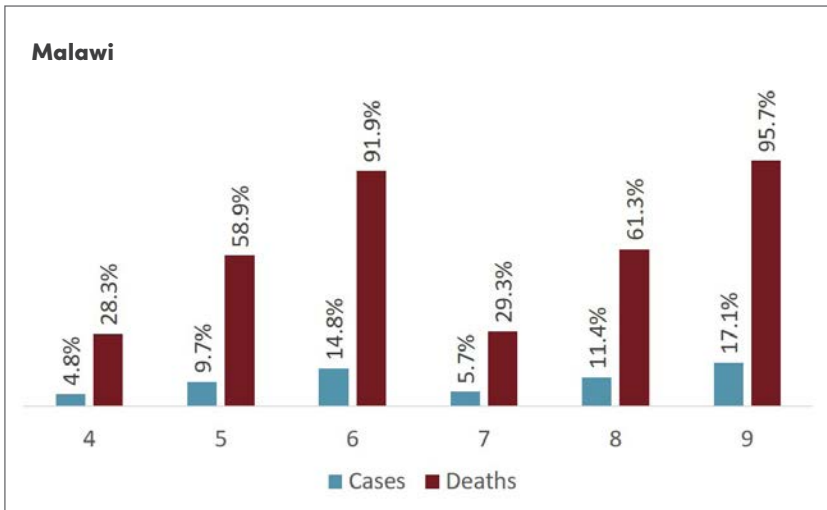


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	2 006
Scenario 4	2 663
Scenario 5	3 342
Scenario 6	4 041
Scenario 7	2 678
Scenario 8	3 374
Scenario 9	4 094

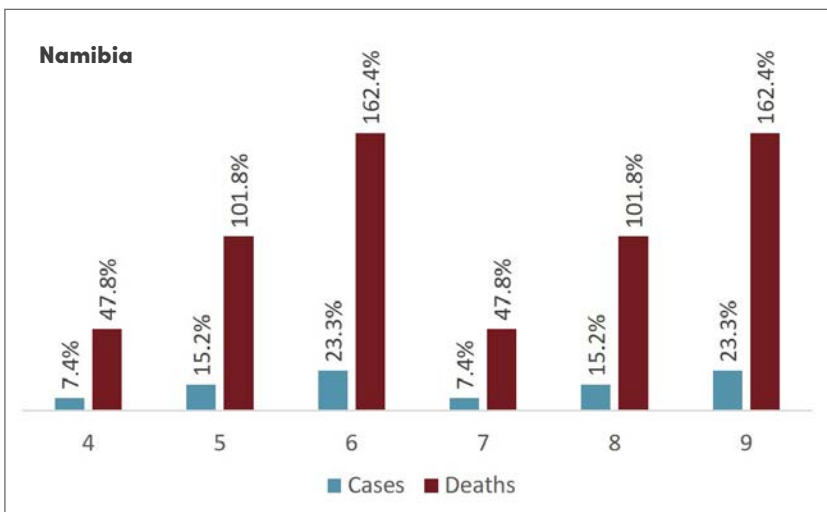
**Scenarios:** No ITN campaigns in all scenarios. Change is compared to “business as usual” scenario. CD = continuous distribution, AM = antimalarial. 1: CD -25%, 2: CD -50%, 3: CD -75%, 4: AM -25%, 5: AM -50%, 6: AM -75%, 7: CD & AM -25%, 8: CD & AM -50%, 9: CD & AM -75%



SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	5 350
Scenario 4	6 638
Scenario 5	8 049
Scenario 6	9 592
Scenario 7	6 642
Scenario 8	8 074
Scenario 9	9 668

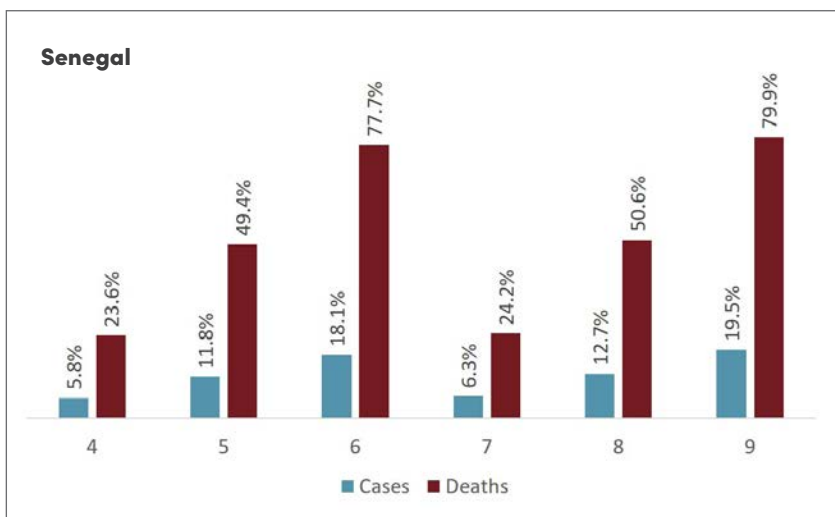


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	6 478
Scenario 4	8 310
Scenario 5	10 292
Scenario 6	12 429
Scenario 7	8 379
Scenario 8	10 446
Scenario 9	12 679

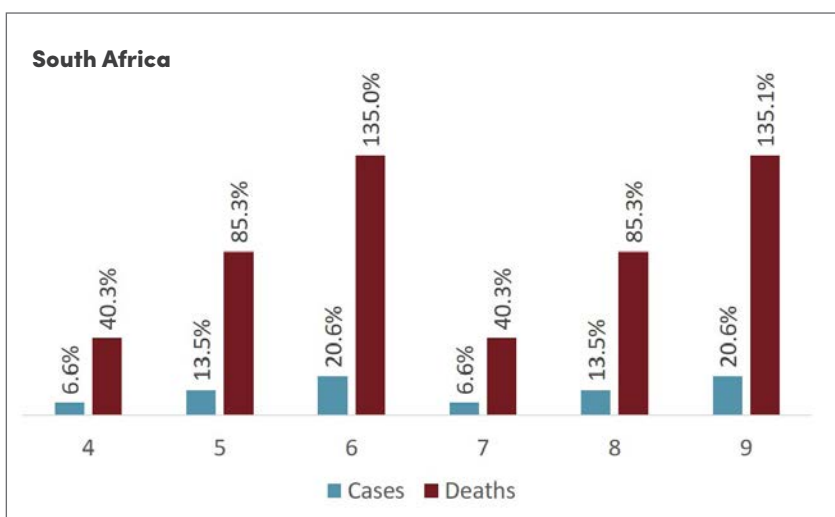


SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	132
Scenario 4	195
Scenario 5	266
Scenario 6	346
Scenario 7	195
Scenario 8	266
Scenario 9	346

**Scenarios:** No ITN campaigns in all scenarios. Change is compared to "business as usual" scenario.  
 CD = continuous distribution, AM = antimalarial. 1: CD -25%, 2: CD -50%, 3: CD -75%, 4: AM -25%,  
 5: AM -50%, 6: AM -75%, 7: CD & AM -25%, 8: CD & AM -50%, 9: CD & AM -75%



SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	4 480
Scenario 4	5 537
Scenario 5	6 695
Scenario 6	7 960
Scenario 7	5 563
Scenario 8	6 747
Scenario 9	8 058



SCENARIO	DEATHS (COUNT)
2018 Baseline (WMR 2019)	69
Scenario 4	97
Scenario 5	128
Scenario 6	162
Scenario 7	97
Scenario 8	128
Scenario 9	162

**Scenarios:** No ITN campaigns in all scenarios. Change is compared to “business as usual” scenario. CD = continuous distribution, AM = antimalarial. 1: CD -25%, 2: CD -50%, 3: CD -75%, 4: AM -25%, 5: AM -50%, 6: AM -75%, 7: CD & AM -25%, 8: CD & AM -50%, 9: CD & AM -75%

**Annex 4.  
Planned ITN, SMC and  
IRS campaigns in 2020  
by country, sub-Saharan  
Africa**

COUNTRY	CAMPAIGNS SCHEDULE IN 2020		
	INSECTICIDE-TREATED NETS – MASS DISTRIBUTION	INDOOR RESIDUAL SPRAYING	SEASONAL MALARIA CHEMOPREVENTION
Angola	No	Yes	No
Benin	Yes	Yes	Yes
Botswana	No	Yes	No
Burkina Faso	No	Yes	Yes
Burundi	No	Yes	No
Cabo Verde	No	Yes	No
Cameroon	Yes	Yes	Yes
Central African Republic	Yes	No	No
Chad	Yes	No	Yes
Comoros	Yes	Yes	No
Congo	No	No	No
Côte d'Ivoire	Yes	Yes	Yes
Democratic Republic of the Congo	Yes	No	No
Djibouti	No	Yes	No
Equatorial Guinea	No	No	No
Eritrea	Yes	Yes	No
Eswatini	No	Yes	No
Ethiopia	Yes	Yes	No
Gabon	No	No	No
Gambia	No	Yes	Yes
Ghana	Yes	Yes	No
Guinea	No	Yes	Yes
Guinea-Bissau	Yes	No	Yes
Kenya	Yes	Yes	No
Lesotho	No	No	No
Liberia	No	Yes	No
Madagascar	No	Yes	No
Malawi	No	Yes	No
Mali	Yes	Yes	Yes
Mauritania	Yes	No	Yes
Mozambique	Yes	Yes	No
Namibia	No	Yes	No
Niger	Yes	Yes	Yes
Nigeria	Yes	No	Yes
Rwanda	Yes	Yes	No
Sao Tome and Principe	No	No	No
Senegal	No	Yes	Yes
Sierra Leone	Yes	Yes	No
Somalia	Yes	No	No
South Africa	No	Yes	No
South Sudan	Yes	No	No
Sudan	Yes	No	No
Togo	Yes	No	Yes
Uganda	Yes	Yes	No
United Republic of Tanzania	Yes	Yes	No
Zambia	Yes	Yes	No
Zimbabwe	Yes	Yes	No



THE MALARIA ATLAS PROJECT



For further information  
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