MALARIA CALCULATION

Spreadsheet Documentation

Definitions

- WHO region: designated regions provided by the World Health Organization[1]
- DALY: Disability-Adjusted Life Years (D)
  - Years of life taken by disease from population if it was in a healthy state free from disease
- Treatment Coverage (θ):
  - Ratio between number of people receiving treatment to the estimated number of people needing treatment
- Efficacy (e):
  - Percentage of population receiving treatment that were actually cured

Impact Formula

$$I = \frac{D * e * \Theta}{1 - e * \Theta} \ / \ n$$

- Where:
  - D = DALYs
  - e = Efficacy
  - Θ = Treatment Coverage
  - n = Number of 1st line treatments

Country Data

- **Column A:** Country

- **Column B:** Countries sorted by WHO Region

- **Column C:** Population

- **Column D:** First-line regimen used in respective country
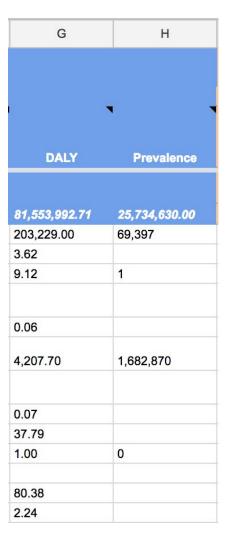
- **Column E:** Treatment coverage for children under 5

	A	B	C	D	E
	Country	WHO Region	Population	1st Line (p.falc.)	% febrile children under 5 receiving any antimalarial treatment
				* = NO P.FALC. 1ST / 2ND LINE FOR THIS	UNICEF global databases 2015 based *16.34%*
	Afghanistan	EMR	28,803,167	AS+SP	18.78%
	Albania	EUR	2,913,021		22.38%
	Algeria	AFR	36,117,637	*	33.38%
	American Samoa	WPR	55,637		5.74%
	Andorra	EUR	84,449		22.38%
	Angola	AFR	23,369,131	AL	29.30%
	Anguilla	AMR	16,373		2.80%
	Antigua and Barbuda	AMR	94,661		2.80%
	Argentina	AMR	41,223,889	*	2.80%
	Armenia	EUR	2,877,311	*	22.38%
	Aruba	AMR	101,669		2.80%
	Australia	WPR	22,031,750		5.74%
	Austria	EUR	8,363,404		22.38%

DALY Data

- **Column G:** DALYs lost to malaria

- **Column H:** Prevalence
  (indigenous confirmed cases)

G	H
DALY	**Prevalence**
81,553,992.71	*25,734,630.00*
203,229.00	69,397
3.62	
9.12	1
0.06	
4,207.70	1,682,870
0.07	
37.79	
1.00	0
80.38	
2.24	

P. falc

DALY Data

- **Column I:** Percentage of malaria cases that are p. falc

- **Column J:** Estimated p. falc DALY
  - Col G (DALYs) * Col I (% p. falc)

- **Column K:** Estimated p. falc prevalence
  - Col H (prevalence) * Col I (% p. falc)

% p. falc.	Estimated p. falc. DALY	Estimated p. falc. prevalence (prevalence * % p. falc)
		Col H * Col I
	77,294,165.75	22,301,016.40
9.00%	18,290.61	6,245.73
0.00%	0.00	0.00
98.00%	8.94	0.98
	0.00	0.00
0.00%	0.00	0.00
100.00%	4,207.70	1,682,870.00
	0.00	0.00
	0.00	0.00
	0.00	0.00
0.00%	0.00	0.00
	0.00	0.00
	0.00	0.00
0.00%	0.00	0.00

P. falc Efficacy Data

- **Range AK: AX** - Country-level efficacy data from the WHO is used first. If no country-level data is available, regional efficacy averages are used. In extreme cases where regional efficacy data is unavailable, global averages are used.

AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX
						p. falc							
						Estimated Efficacy							
AL	AS+SP	DHA-PPQ	AS+MQ	AS+AQ	CQ+PQ	AL+PQ	QN+CL	DHA-PPQ+PQ	ART+NQ	ART+PPQ	QN+D	SP	AS+MQ+PQ
						DO NOT include into website (average							
97.43%	95.60%	100.00%	97.23%	87.69%	42.20%	83.31%	83.31%	83.31%	83.31%	93.80%	91.00%	40.50%	96.00%
97.43%	89.53%	97.74%	97.23%	87.69%	42.20%	83.31%	83.31%	83.31%	83.31%	93.80%	91.00%	40.50%	96.00%
98.36%	82.25%	97.25%	97.12%	86.08%	42.20%	83.31%	83.31%	83.31%	83.31%	93.80%	91.00%	40.50%	96.00%
82.40%	89.53%	98.20%	97.23%	85.00%	42.20%	83.31%	83.31%	83.31%	83.31%	93.80%	91.00%	40.50%	96.00%
97.43%	89.53%	97.74%	97.23%	87.69%	42.20%	83.31%	83.31%	83.31%	83.31%	93.80%	91.00%	40.50%	96.00%
98.36%	82.25%	97.25%	97.12%	86.08%	42.20%	83.31%	83.31%	83.31%	83.31%	93.80%	91.00%	40.50%	96.00%
99.67%	98.00%	97.74%	96.38%	100.00%	42.20%	83.31%	83.31%	83.31%	83.31%	93.80%	91.00%	40.50%	96.00%
99.67%	98.00%	97.74%	96.38%	100.00%	42.20%	83.31%	83.31%	83.31%	83.31%	93.80%	91.00%	40.50%	96.00%
99.67%	98.00%	97.74%	96.38%	100.00%	42.20%	83.31%	83.31%	83.31%	83.31%	93.80%	91.00%	40.50%	96.00%
97.43%	89.53%	97.74%	97.23%	87.69%	42.20%	83.31%	83.31%	83.31%	83.31%	93.80%	91.00%	40.50%	96.00%
99.67%	98.00%	97.74%	96.38%	100.00%	42.20%	83.31%	83.31%	83.31%	83.31%	93.80%	91.00%	40.50%	96.00%
82.40%	89.53%	98.20%	97.23%	85.00%	42.20%	83.31%	83.31%	83.31%	83.31%	93.80%	91.00%	40.50%	96.00%
97.43%	89.53%	97.74%	97.23%	87.69%	42.20%	83.31%	83.31%	83.31%	83.31%	93.80%	91.00%	40.50%	96.00%

Impact

- **Range AY:BL -** Impact of specific drug or drug combination

$$\frac{\text{p. falc DALYS} \times \text{treatment coverage} \times \text{efficacy}}{1 - \text{treatment coverage} \times \text{efficacy}}$$

- If multiple drug regimens are used in a certain country, we divide impact by the number of drug regimens

	BI	BJ	BK	BL	BM
	Impact of ART+PPQ	Impact of QN+D	Impact of SP	Impact of AS+MQ+PQ	IMPACT of P.falc
					Col AY + Col AZ+ Col BA+ Col BB+
	43.63	1,463.91	0.55	0.35	52,339,086.26
	0.00	0.00	0.00	0.00	4,001.12
	0.00	0.00	0.00	0.00	0.00
	0.29	0.28	0.10	0.30	3.48
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	1,703.58
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00

P. vivax

DALY Data

- **Column BP:** Percentage of malaria cases that are p. vivax

- **Column BQ:** Estimated p. vivax DALY
  - Col G (DALYs) * Col BP (% p. vivax)

- **Column BR:** Estimated p. Vivax prevalence
  - Col H (prevalence) * Col BP (% p. vivax)

- **Column BS:** Treatment coverage for children under 5

BO	BP	BQ	BR	BS
1st Line (p.vivax.)	% p. vivax	Estimated p. vivax DALY	Estimated p. vivax prevalence	p. vivax treatment coverage
* = NO P.FALC. 1ST / 2ND LINE FOR THIS		Col G* ColBP	Col H* ColBP	Col E if Col AC = CQ+PQ
		4,091,805.22	3,367,180.38	16.34%
CQ+PQ	93%	189,002.97	64,539.21	18.78%
		0.00	0.00	22.38%
CQ	0%	0.00	0.00	33.38%
		0.00	0.00	5.74%
		0.00	0.00	22.38%
*	0%	0.00	0.00	29.30%
		0.00	0.00	2.80%
		0.00	0.00	2.80%
CQ+PQ	100%	37.79	0.00	2.80%
CQ+PQ		0.00	0.00	22.38%
		0.00	0.00	2.80%
		0.00	0.00	5.74%
		0.00	0.00	22.38%

P. vivax Efficacy Data

- **Range CA: CG** - Country-level efficacy data from the WHO is used first. If no country-level data is available, regional efficacy averages are used. In extreme cases where regional efficacy data is unavailable, global averages are used.

	CA	CB	CC	CD	CE	CF	CG
vivax							
			Estimated Efficacy				
	CQ+PQ	AL	AL+PQ	CQ	AS+AQ	DHA-PPQ+PQ	CQ+PG
						red is average of	
	91%	100%	97%	100%	52%	82%	82%
	100%	79%	97%	96%	52%	82%	82%
	97%	50%	97%	81%	52%	82%	82%
	97%	79%	97%	92%	52%	82%	82%
	100%	79%	97%	96%	52%	82%	82%
	97%	50%	97%	81%	52%	82%	82%
	90%	97%	97%	90%	52%	82%	82%
	90%	97%	97%	90%	52%	82%	82%
	90%	97%	97%	90%	52%	82%	82%
	100%	79%	97%	96%	52%	82%	82%
	90%	97%	97%	90%	52%	82%	82%
	97%	79%	97%	92%	52%	82%	82%
	100%	79%	97%	96%	52%	82%	82%
	100%	79%	97%	96%	52%	82%	82%
	90%	97%	97%	90%	52%	82%	82%
	91%	100%	97%	100%	52%	82%	82%

Impact

- **Range CH:CN -** Impact of specific drug or drug combination

$$\frac{p.\text{ vivax DALYS } \times \text{ treatment coverage } \times \text{ efficacy}}{1 - \text{treatment coverage } \times \text{ efficacy}}$$

- If multiple drug regimens are used in a certain country, we divide impact by the number of drug regimens.

	CH	CI	CJ	CK	CL	CM	CN	CO
	Impact							
	CQ+PQ	AL	AL+PQ	CQ	AS+AQ	DHA-PPQ+PQ	CQ+PG	IMPACT of P.VIVAX
								Col BQ* ColBS* ColCA/(1-
	208,206.98	53,210.30	1,379.07	262,605.05	4,212.31	37.83	37.83	529,689.36
	39,109.15	0.00	0.00	0.00	0.00	0.00	0.00	39,109.15
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.98
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.10

Company Rankings

- **Column CQ:** Originator Company
- **Column CR:** Drug(s) patented by company
- **Column CS:** Final impact of company

Example: Sanofi produced the drugs AS+AQ, AS+SP, CQ+PQ, and AS+MQ+PQ. The sum of the impacts of those specific drugs (=$BC$5+$AZ$5+$BD$5+$CH$5+$BL$5+CL5, is the impact that Sanofi has on global malaria drug treatment.

According to the model, Sanofi saves 22,815,935.95 years of life with its patented drugs, and ranks second on the list.

Company	Drug(s)	Final Impact
Novartis	AL	29,747,257.66
Sanofi	AS+AQ; AS+SP; CQ+PQ; AS+MQ+PQ	22,815,935.95
Bayer Healthcare	CQ	262,623.97
Public Sector	AS+MQ	15,035.40
Chongqing Tonghe Pharmaceutical Co. Ltd.	DHA-PPQ	14,710.89
Pfizer	D	731.95
Artepharm	ART+PPQ	43.63
GlaxoSmithKline	AT+PG	37.83
Imperial Chemical Industries	PG	18.91288289
F. Hoffmann-La Roche Ltd	SP	0.55
Taisho Pharmaceuticals	CL	646.2928272
	Total	52,857,043.03

Manufacturer Rankings

Our impact scores can be used to assess the performance of companies involved in the manufacturing sector of the pharmaceutical industry. Manufacturing and distribution data provided by the WHO provides important information such as cost, drug strength, and the total number of units (TNU) of each drug that are involved in shipments of a variety of medicines.

This data can be used to determine the proportion of certain classes of drugs that each manufacturer in the database is responsible for shipping.

Manufacturer Rankings

We are able to calculate the lives saved from individual shipments of drugs so that the total number of lives saved by manufacturer can be determined. The calculation that is used is:

TNU / (365 * DD)

- Where:
    - TNU = total number of units, or, number of pills sent in a specific order
    - DD = the daily dose, or the assumed average maintenance dose per day for a drug

This allows us to calculate the total lives saved due to a single drug or the total lives saved for that drug due to an individual manufacturer. We can use the proportion of total lives saved by a manufacturer to estimate the proportion of the total impact that will be attributed to that company in terms of DALYs.

Manufacturer Rankings

The WHO's Global Price Reporting Mechanism allows us to track 29 manufacturers of drugs that target malaria. We track two malaria drugs that Micro Labs Ltd. manufactures: Primaquine and Quinine. Let's calculate the DALYs saved by Primaquine:

Using our formula we find that, in 2015, Primaquine alone saved a total of 201,505.02 lives. We can also see that all regimens containing Primaquine produced by Micro Labs Ltd. were calculated to have saved 255.71 lives. This means that Micro Labs Ltd.'s Primaquine contributed 0.13% of all lives saved by Primaquine.

We also know from our previous calculations that Primaquine alleviates 356,903.33 DALYs globally. Therefore, we can state that **Primaquine produced by Micro Labs Ltd. alleviates 452.9065914 DALYs.**

Manufacturer Rankings

The same process can be repeated for Quinine.

Quinine: 101.0214386 DALYs alleviated for Micro Labs Ltd.

Summing the DALYs alleviated by both drugs yields **553.9280, which can be considered Micro Labs Ltd.'s global impact on malaria in 2015.**

Example: Drug Score
Impact of AS+MQ in Cambodia in 2010

Cambodia utilizes two drug regimens: AS+MQ and DHA-PPQ+PQ. We are only calculating the impact of AS+MQ, a drug that targets p. falc malaria.

$$I = \frac{71{,}734.74 * .3\% * 96.05\%}{1 - .3\% * 96.05\%} \Big/ 2$$

DALYs p. falc = 71,734.74

Efficacy = 96.05%

Treatment Coverage = .3%

Number of 1st line treatments = 2

Using this equation we arrive at **the final impact of AS+MQ in Cambodia in 2010: 103.65.**

Example: Disease Score
Impact of malaria drugs in 2010

- Column BM lists the sum of the impact of drugs used to treat p. falc malaria in a respective country. Cell BM5 sums these numbers. Therefore: cell BM5, or **53,060,925.50**, is the global impact of drugs targeting p. falc malaria.
- Column CO lists the sum of all drug impacts in each respective country. Cell CO5 sums these numbers. Therefore: cell CO5, or **536,436.73**, is the global impact of drugs targeting p. vivax malaria.
- The sum of cells BM5 and CO5, **53,597,362.23**, can be considered the impact of malaria drugs in 2010.

Example: Company Score
Impact of Sanofi in 2010

Sanofi produces the drugs **AS+AQ, AS+SP, CQ+PQ, and AS+MQ+PQ**.

These four drugs target both p. falc and p. vivax malaria.

Recall the process taken to derive a single drug's impact score in a specific country. We now need to sum the impact of these drugs in every country they are administered to derive **Sanofi's global impact on malaria in 2010**.

Example: Company Score *(continued)*

Impact of Sanofi on malaria in 2010

Drug	Global Impact (2010)
AS+SP *(p. falc)*	2,054,295.52
AS+AQ *(p. falc)*	21,270,134.82
CQ+PQ *(p. falc)*	552.96
AS+MQ+PQ *(p. falc)*	0.33
CQ+PQ *(p. vivax)*	208,206.98
AS+AQ *(p. vivax)*	4,212.31

2,054,295.52 + 21,270,134.82 + 552.96 + 0.33 + 208,206.98 + 4,212.31 = **23,537,402.92** can be considered the global impact of Sanofi in 2010.

Example: Country Score
Impact of malaria drugs in Afghanistan in 2010

According to the WHO, Afghanistan administers two antimalarials: **AS+SP** and **CQ+PQ**, targeting p. falc and p. vivax respectively. In countries where multiple regimens are utilized to treat a subtype of malaria, the impact is divided by the number of separate regimens.

AS+SP

$$I = \frac{18{,}290.61 * 18.78\% * 95.6\%}{1 - 18.78\% * 95.6\%}$$

$$I = \textbf{4,001.12}$$

CQ+PQ

$$I = \frac{189{,}002.97 * 18.78\% * 91\%}{1 - 18.78\% * 91\%}$$

$$I = \textbf{39,109.15}$$

Summing these two impacts gives us **the impact of malaria drugs in Afghanistan in 2010: 43,110.27.**