

# Malaria Update

SFR Utbildningsdag 26/9



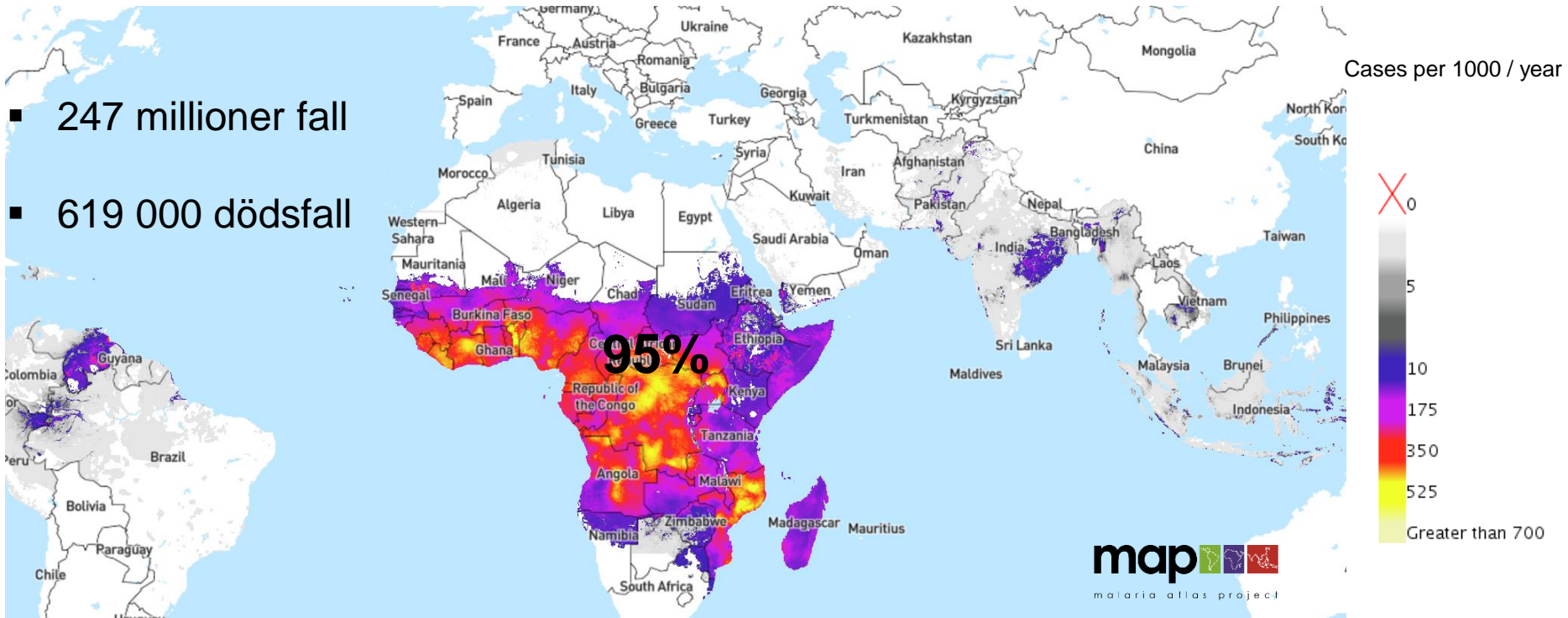
Katja Wyss  
PhD Infektionsläkare  
ME Infektionssjukdomar  
Karolinska Universitetssjukhuset

# Malaria global situation

- WHO rapport 2022:

- 247 millioner fall

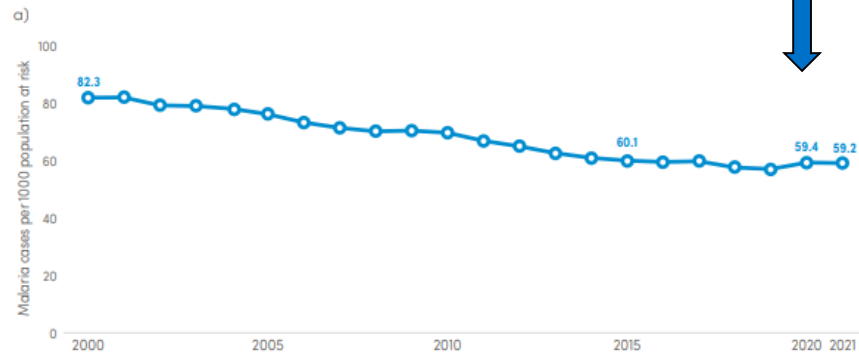
- 619 000 dödsfall



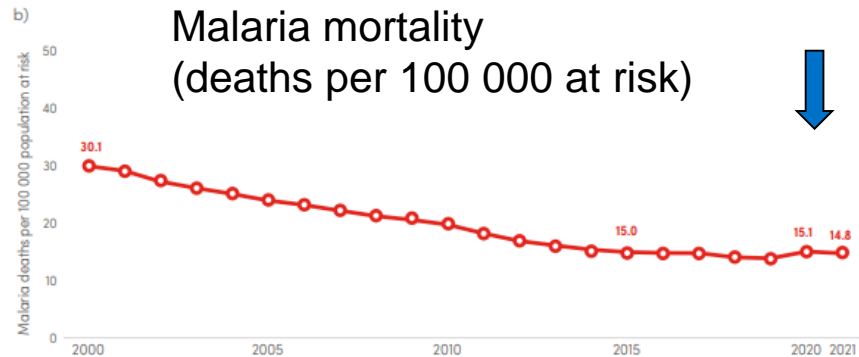
# Global trend



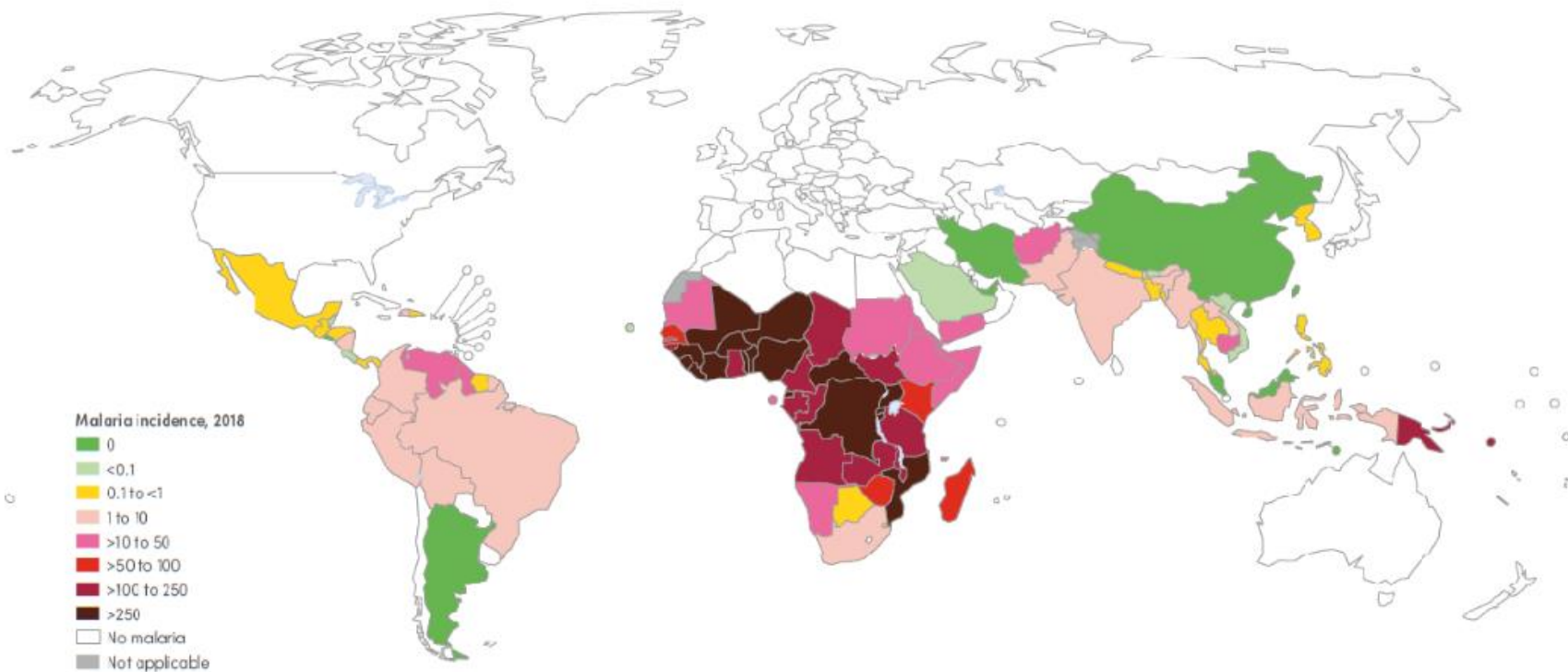
Malaria case incidence  
(cases per 1000 at risk)



Malaria mortality  
(deaths per 100 000 at risk)



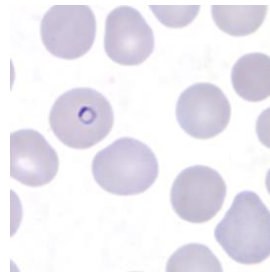
# Endemiska länder



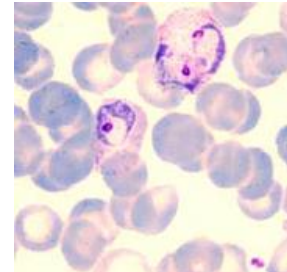
# Parasiten - Plasmodium

- Protozo (encellig)
- 120 arter
- 5 infekterar människan

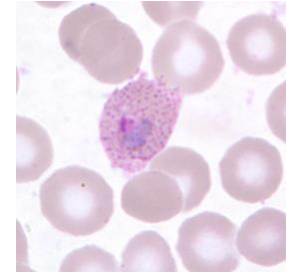
*Förekommer även mindre utbrott med "simian malaria"*



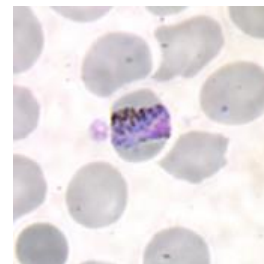
*P. falciparum*



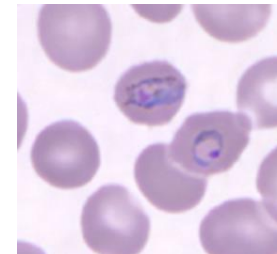
*P. vivax*



*P. ovale*



*P. knowlesii*



*P. malariae*

# Malariaparasitens livscykel

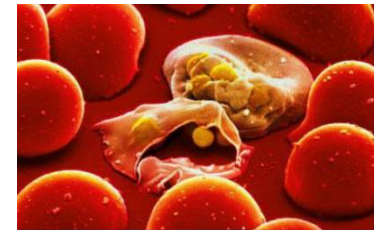
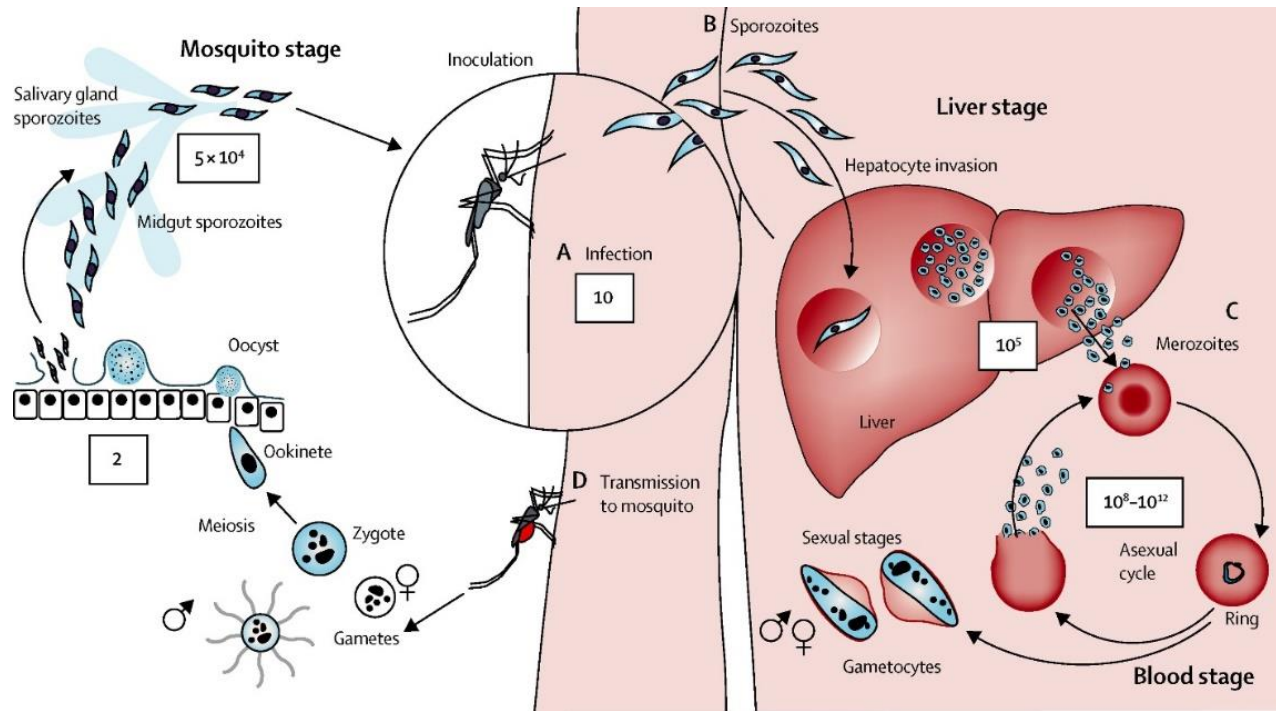


Foto: Lennart Nilsson

*Plasmodium falciparum*

# Alternativa transmissionsvägar

- Transfusion av blodprodukter
  - Räcker med bara 10 infekterade rdbk
  - Överförs i alla fraktioner (erythrocyter, plasma, trombocyter)
  - Alla Plasmodium arter kan överleva i lagrat blod, även vid frysning
- Kongenital malaria
- Organ donation



***Förekommer fall inom sjukvården!***

***2016-2018 6 fall av sjukhus associerad malaria i EU***



# Malaria i Sverige

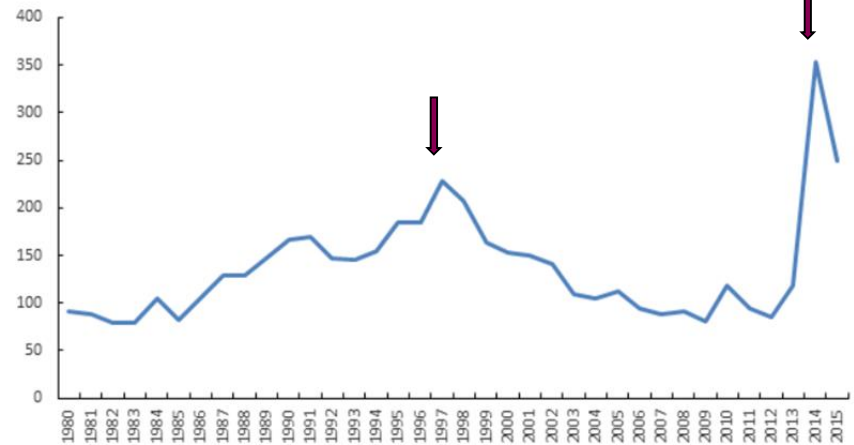
Nationell bevakning sedan 1987 -  
**Folkhälsomyndigheten**

Anmälningsplikt

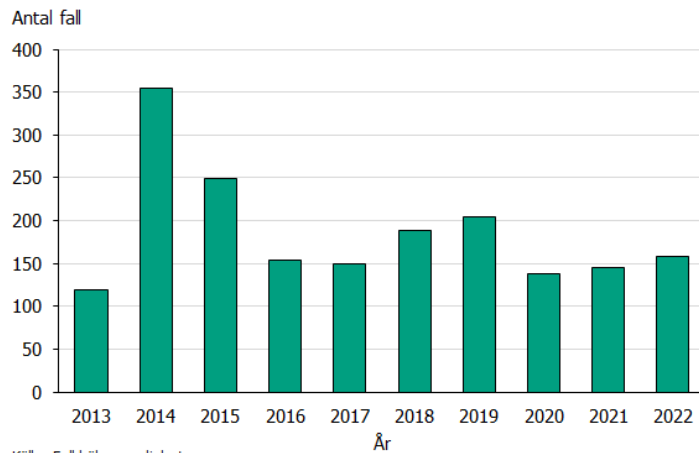
100-300 fall/år



Antal anmälda fall 1980-2015



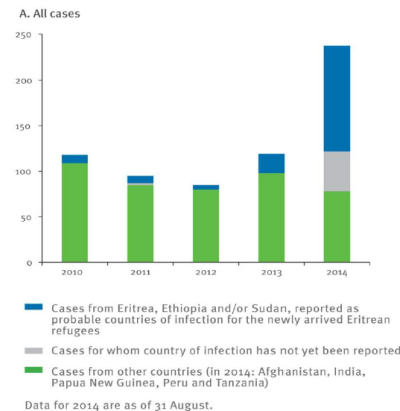
Figur 1. Antalet rapporterade fall av malaria under åren 2013–2022.



Källa: Folkhälsomyndigheten

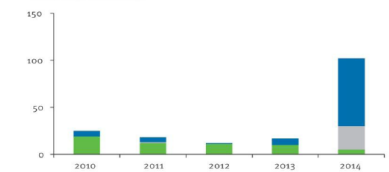
FIGURE 2

Number of malaria cases, by origin of infection, reported per year to the Public Health Agency, Sweden 2010–14 (n=654)

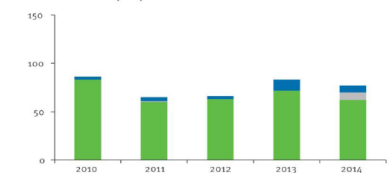


Data for 2014 are as of 31 August.

B. *Plasmodium vivax*

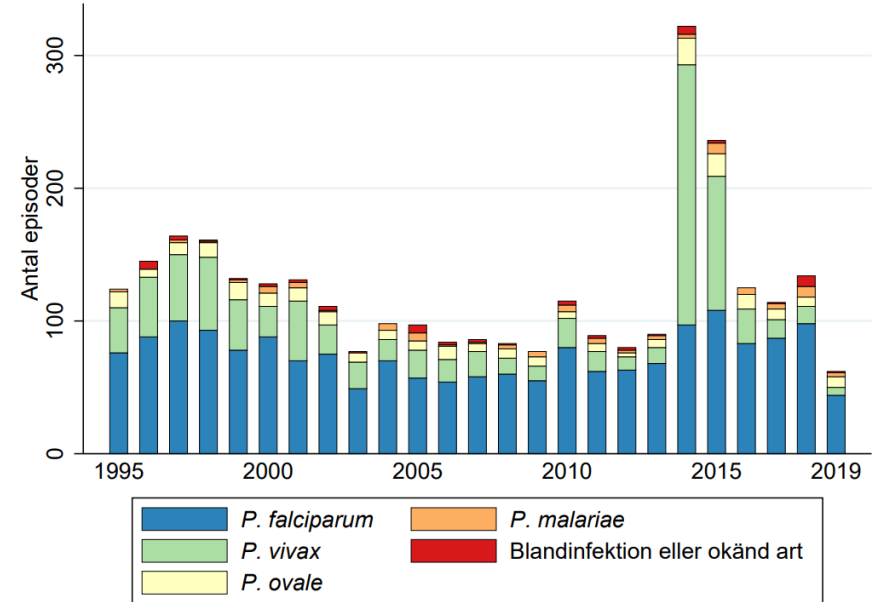
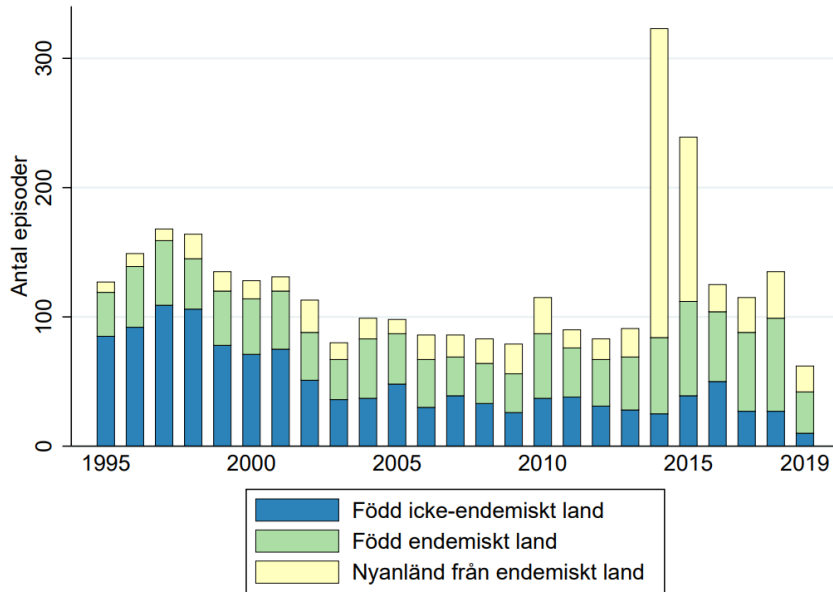


C. *Plasmodium falciparum*

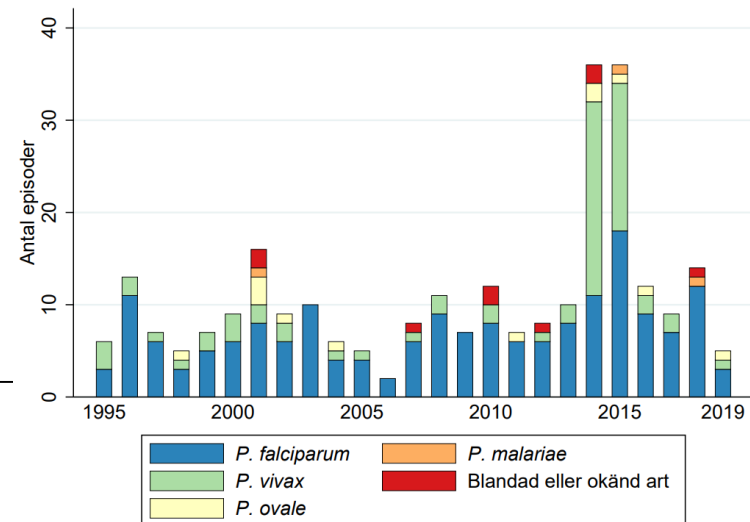




# Malaria i Sverige: Patientursprung och species

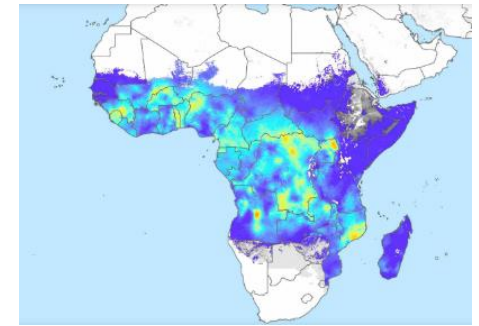


Allvarliga malaria fall  
~8% (n=238/3069)



# Studie 2019-2020

## Screening av migranter



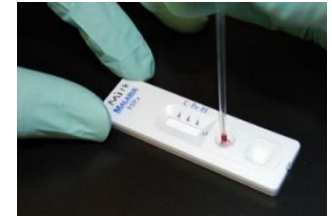
Vuxna och barn från sub-Sahara Afrika

### Samma dag

Malaria antigen snabbtest

CareStart™ Malaria Pf/PAN (HRP2/pLDH) Ag Combo RDT

Hemoglobin concentration (Hemocue™)



### Senare

Realtids PCR för *P. falciparum*, *P. ovale*, *P. malariae* och *P. vivax*

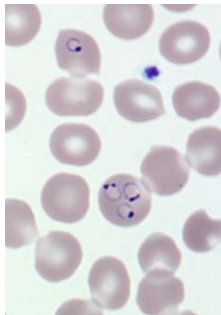
Serologi med ELISA and Luminex



Alla malariapositiva individer kallas till inf-/barn-mottagning för bekräftande prov och behandling

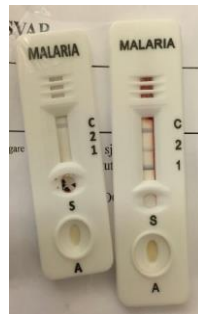
# Malaria - diagnostik

## Mikroskopi



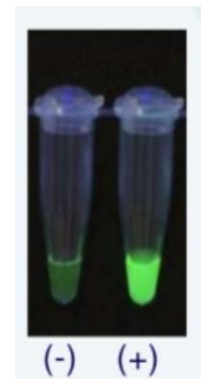
- 10-50 parasiter/ $\mu$ l
- alla arter, kvantitativt
- aktuell infektion

## Snabbtest



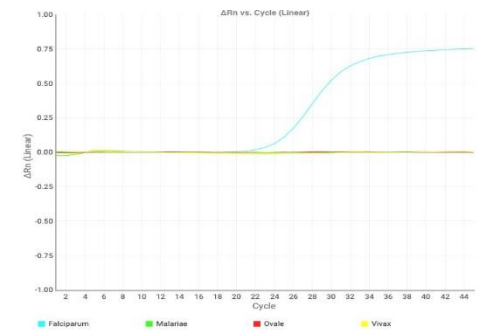
- 40-100 parasiter/ $\mu$ l
- P falc / non-falcip
- pLDH *Plasmodium* spec Ag / HRP2 –P falc
- kan vara falskt negativ!

## LAMP



- 4-10 parasiter/ $\mu$ l
- ej art specifik
- ej kvantitativt

## PCR



- 0,1-10 parasiter/ $\mu$ l
- alla arter

## Malaria parasite prevalence in Sub-Saharan African migrants screened in Sweden: a cross-sectional study

Andreas Wångdahl,<sup>a,b</sup> Rebecca Tafesse Bogale,<sup>a</sup> Isabelle Eliasson,<sup>a</sup> Ioanna Broumou,<sup>a</sup> Fariba Farooq,<sup>a</sup> Filip Lind,<sup>a</sup> Ganna Vashchuk,<sup>a</sup> Adina Hildell,<sup>a</sup> Suzanne Franson,<sup>a</sup> Emil Hallberg,<sup>a</sup> Isabelle Grip,<sup>a</sup> Irene Nordling,<sup>a</sup> Angelica Gervin,<sup>d</sup> Shelan Kaitoly,<sup>d</sup> Berhane Tekleab,<sup>d</sup> Katja Wyss,<sup>a,c</sup> Ana Requena-Méndez,<sup>a,c,g</sup> Olof Hertting,<sup>e,f</sup> and Anna Färnert<sup>a,c,\*</sup>



<sup>a</sup>Division of Infectious Diseases, Department of Medicine Solna, Karolinska Institutet, Stockholm, Sweden

<sup>b</sup>Department of Infectious Diseases, Västerås Hospital, Västerås, Sweden

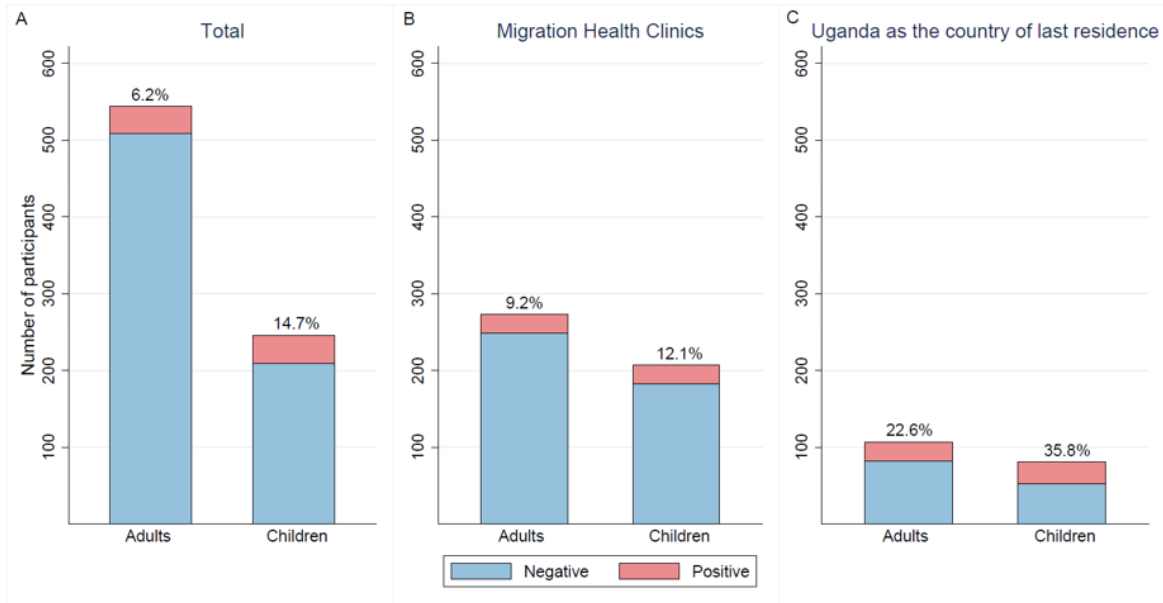
<sup>c</sup>Department of Infectious Diseases, Karolinska University Hospital, Stockholm, Sweden

<sup>d</sup>Rissne Vårdcentral, Migration Health Centre, Region Stockholm, Stockholm, Sweden

<sup>e</sup>Paediatric Infectious Diseases, Astrid Lindgren Children's Hospital, Karolinska University Hospital, Stockholm, Sweden

<sup>f</sup>Department of Women's and Children's Health, Karolinska Institutet, Stockholm, Sweden

<sup>g</sup>Barcelona Institute for Global Health (ISGlobal, University of Barcelona), Spain



- Antal screenade: 789
- PCR positiva: 71 (9%)
- 46 *P. falciparum*
- Kvotflyktingar från Uganda: 53 (28%)
- Fall i familjer till PCR positiva: 47 (60%)
- Bärarskap påvisat upp till 386 dagar efter ankomst

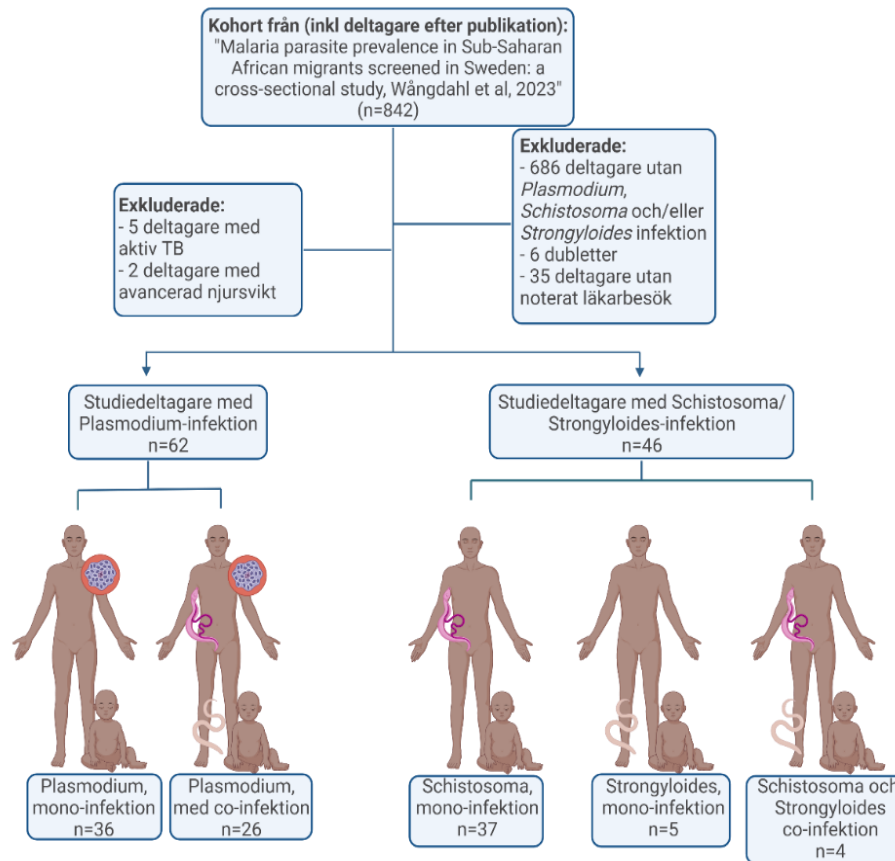
# Konsekvenser av långvarigt asymptomatiskt bärarskap?

- Komplikationer under graviditet (Okell et al 2012)
- Anemi (Siff et al 2016)
- Kognitiv påverkan (Fernando et al 2010)
- Symptomatisk sjukdom (Njama-Meya 2004)
- Burkitts lymphom (Ellis et al 2021)
- Non-burkitts lymphomas? (Bates et al 1997, Bedu-Addo 2002)
- Tropical hypersplenomegaly syndrome /Hyperreactive Malaria Splenomegaly (Leoni et al 2015)

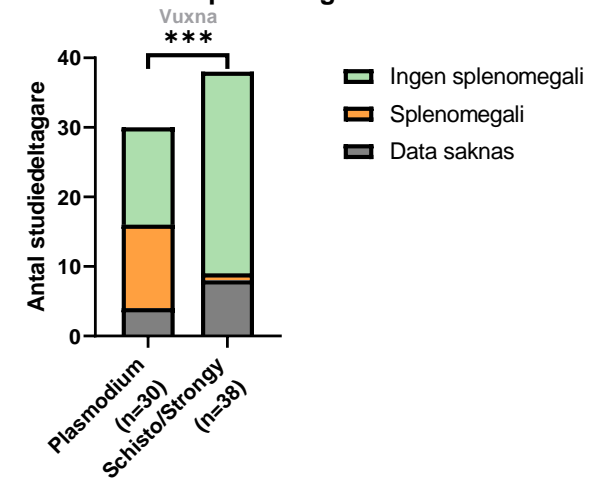


Figure 2 African patient with splenomegaly seen at the Centre for Tropical Diseases, Negar.

# Ökad förekomst av splenomegali hos migranter med submikroskopiskt bärarskap av *Plasmodium*



## Förekomst av splenomegali



## Splenomegaly rate

Plasmodium group:  $16/62=26\%$

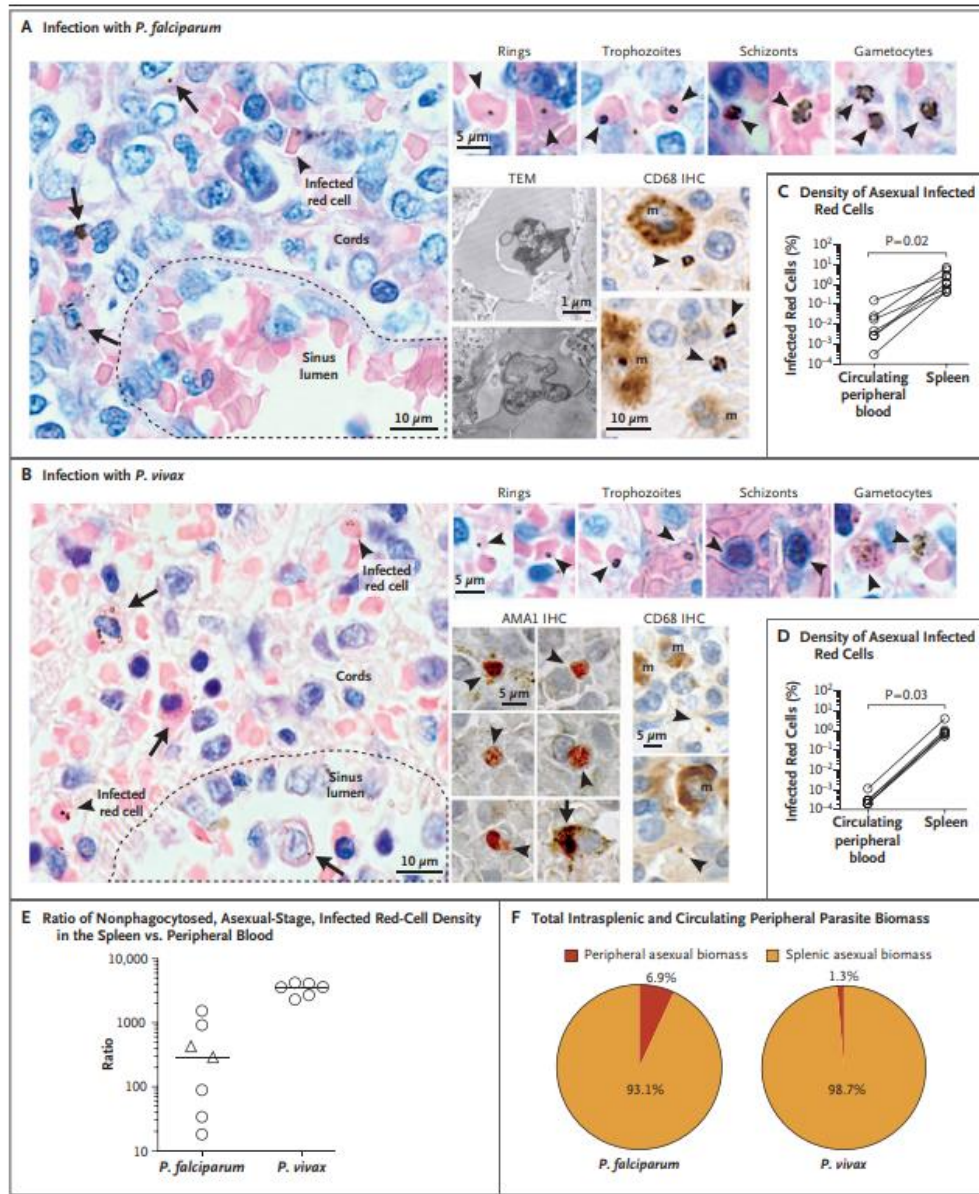
Control group:  $1/46=2\%$

## Hyperreactive Malaria Splenomegali

Full HMS 2/16

Pre-HMS 7/16

# Dold malaria reservoir i mjälten vid kronisk infektion?

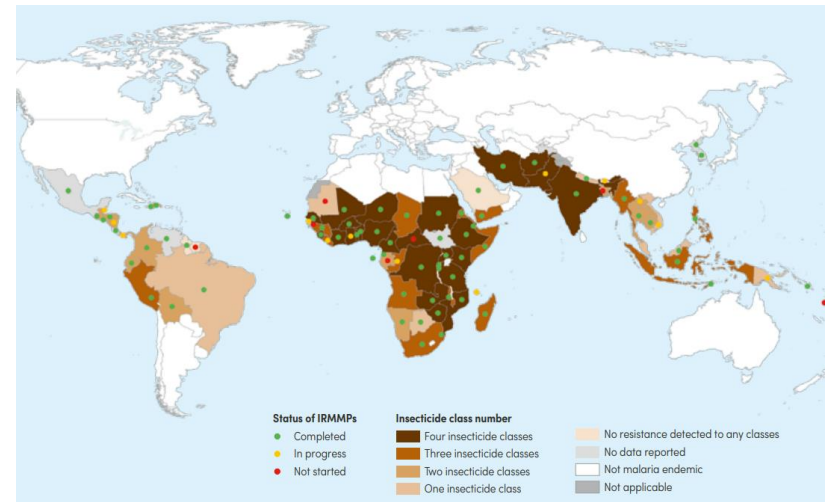


# Utmaningar

## Resistens mot myggmedel

ITNs hittills viktigaste preventiva strategin mot malaria

Myggor resistent mot myggmedel (ffa pyretroider) rapporteras från 88 länder  
-WHO 2021



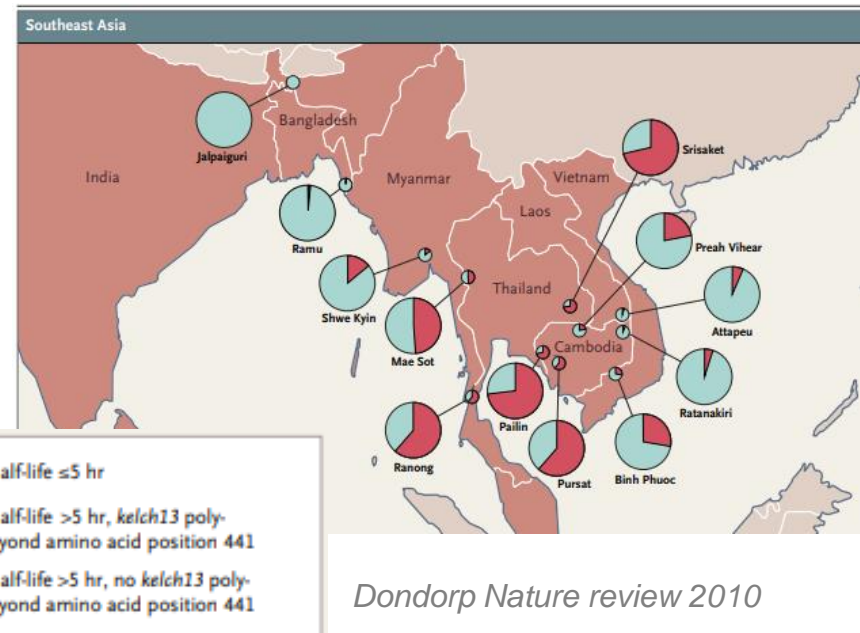
Number of classes to which resistance was confirmed in at least one malaria vector, 2010–2020



## Resistens mot artemisinin

Artemisinin-Resistant Malaria in Western Cambodia  
-Noedl et al NEJM 2008

Spread of Artemisinin Resistance in *P falciparum* Malaria  
-White et al NEJM 2014



Dondorp Nature review 2010



# Nytt hot? -ART resistens i Afrika

## The NEW ENGLAND JOURNAL of MEDICINE

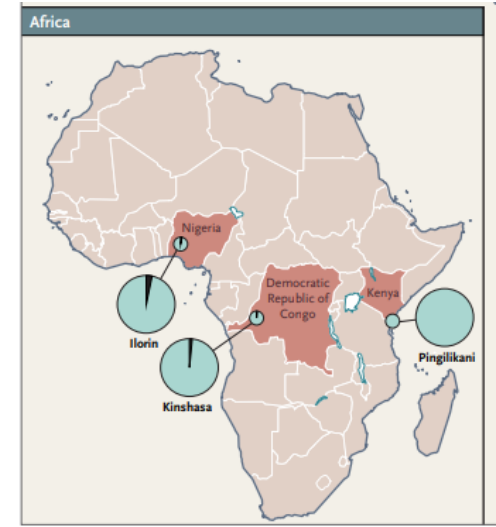
ESTABLISHED IN 1812

SEPTEMBER 23, 2021

VOL. 385 NO. 13

### Evidence of Artemisinin-Resistant Malaria in Africa

Betty Balikagala, M.D., Ph.D., Naoyuki Fukuda, M.D., D.T.M.H., Ph.D., Mie Ikeda, Ph.D., Osbert T. Katuru, B.Sc., Shin-Ichiro Tachibana, Ph.D., Masato Yamauchi, M.P.H., Ph.D., Walter Opio, M.D., Sakurako Emoto, M.D., Denis A. Anywar, M.Sc., Eisaku Kimura, M.D., Ph.D., Nirianne M.Q. Palacpac, Ph.D., Emmanuel I. Odongo-Aginya, Ph.D., Martin Ogwang, M.D., M.M.E.D., Toshihiro Horii, Ph.D., and Toshihiro Mita, M.D., Ph.D.



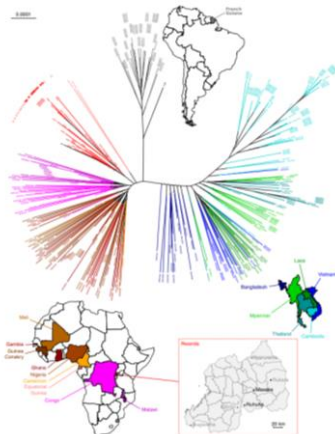
The Journal of Infectious Diseases

BRIEF REPORT

### High Prevalence of *Plasmodium falciparum* K13 Mutations in Rwanda Is Associated With Slow Parasite Clearance After Treatment With Artemether-Lur

Judith Straimer,<sup>1</sup> Preetam Gandhi,<sup>1</sup> Esther K. Schmitt<sup>1</sup>

<sup>1</sup>Novartis Institutes for Biomedical Research, Basel, Switzerland



nature microbiology

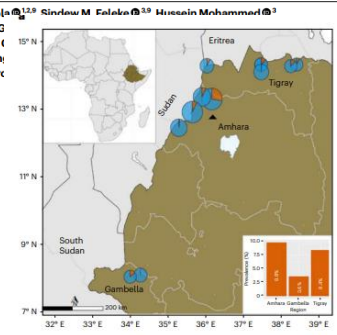
Analysis

<https://doi.org/10.1038/s41564-023-01461-4>

### *Plasmodium falciparum* resistant to artemisinin and diagnostics have emerged in Ethiopia

Abebe A. Fole<sup>1,2,3</sup>, Sirtaw M. Faleko<sup>1,2,3</sup>, Hussein Mohammed<sup>1,2,3</sup>, Bokretson G. Rebecca M., Jane Cunnin, Beyene Petric

h 2023  
r 2023  
August 2023  
ates



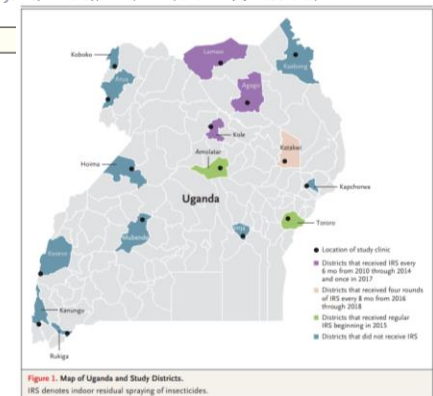
**Fig. 1 | Prevalence of K13 and key drug-resistance mutations in Ethiopia.**  
a. Spatial distribution of K13 G229 mutation at the district (pie charts) and regional (bar plot) levels. Colours indicate mutation status and pie chart size is proportional to sample size per district. The black triangle indicates the location where K13 G229 mutation was reported previously. b. Prevalence of non-synonymous mutations across the K13 gene, coloured according to WHO

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

### Evolution of Partial Resistance to Artemisinins in Malaria Parasites in Uganda

Melissa D. Conrad, Ph.D., Victor Asua, M.Sc., Shreya Garg, B.S., David Giesbrecht, Ph.D., Karamoko Niaré, Ph.D., Sawyer Smith, B.S., Jane F. Namuganga, M.H.S., Thomas Katairo, M.Sc., Jennifer Legac, B.S., Rebecca M. Crudale, B.S., Patrick K. Tumwebaze, M.Sc., Samuel L. Nsoby, Ph.D., Roland A. Cooper, Ph.D., Moses R. Kanya, M.B., Ch.B., Ph.D., Grant Dorsey, M.D., Ph.D., Jeffrey A. Bailey, M.D., Ph.D., and Philip J. Rosenthal, M.D.



**Figure 1. Map of Uganda and Study Districts.**  
IRS denotes indoor residual spraying of insecticides.

# Och bland resenärer?

## *pfk13*-Independent Treatment Failure in Four Imported Cases of *Plasmodium falciparum* Malaria Treated with Artemether-Lumefantrine in the United Kingdom

Colin J. Sutherland,<sup>a,b</sup> Paul Lansdell,<sup>a</sup> Mandy Sanders,<sup>c</sup> Julian Muwanguzi,<sup>b</sup> Donnelly A. van Schalkwyk,<sup>b</sup> Harparkash Kaur,<sup>b</sup> Debbie Nolder,<sup>a</sup> Julie Tucker,<sup>a</sup> Hayley M. Bennett,<sup>c</sup> Thomas D. Otto,<sup>c</sup> Matthew Berriman,<sup>c</sup> Trupti A. Patel,<sup>d</sup> Roderick Lynn,<sup>e</sup> Effrossyni Gkrania-Klotsas,<sup>f</sup> Peter L. Chiodini<sup>a,d</sup>

Public Health England Malaria Reference Laboratory, London School of Hygiene & Tropical Medicine, London, United Kingdom<sup>a</sup>; Department of Immunology & Infection, Faculty of Infectious & Tropical Diseases, London School of Hygiene & Tropical Medicine, London, United Kingdom<sup>b</sup>; Wellcome Trust Sanger Institute, Hinxton, United Kingdom<sup>c</sup>; Hospital for Tropical Diseases, London, United Kingdom<sup>d</sup>; Haematology Department, Addenbrooke's Hospital, Cambridge University Hospitals NHS Foundation Trust, Cambridge, United Kingdom<sup>e</sup>; Infectious Diseases Department, Addenbrooke's Hospital, Cambridge University Hospitals NHS Foundation Trust, Cambridge, United Kingdom<sup>f</sup>

**ABSTRACT** We present case histories of four patients treated with artemether-lumefantrine for falciparum malaria in UK hospitals in 2015 to 2016. Each subsequently presented with recurrent symptoms and *Plasmodium falciparum* parasite within 6 weeks of treatment with no intervening travel to countries where malar endemic. Parasite isolates, all of African origin, harbored variants at some candidate resistance loci. No evidence of *pfk13*-mediated artemisinin resistance was found. Failure for signs of unsatisfactory antimalarial efficacy among imported cases of malaria is recommended.

Clinical Infectious Diseases

BRIEF REPORT

## Circulation of an Artemisinin-Resistant Malaria Lineage in a Traveler Returning from East Africa to France

Romain Coppée,<sup>1,2,3,4</sup> Justine Bailly,<sup>1,2,4</sup> Véronique Sarrasin,<sup>1,2</sup> Bertin Vianou,<sup>3</sup> Boris-Enoch Zinsou,<sup>3</sup> Edith Mazars,<sup>4</sup> Hugues Georges,<sup>5</sup> Samia Hamane,<sup>4</sup> Rose-Anne Lavergne,<sup>6</sup> Eric Dannaoui,<sup>4</sup> Betty Balikagala,<sup>9</sup> Naoyuki Fukuda,<sup>9</sup> Emmanuel I. Odongo-Aginya,<sup>10</sup> Toshihiro Mita,<sup>9</sup> Sandrine Houzé,<sup>1,2</sup> and Jérôme Clain<sup>1,2</sup>; on behalf of the French National Malaria Reference Center Study Group

<sup>1</sup>Université de Paris, IRD, MERIT, Paris, France; <sup>2</sup>Centre National de Référence du Paludisme, AP-HP, Hôpital Bichat-Claude Bernard, Paris, France; <sup>3</sup>Institut de Recherche Clinique du Bénin, Cotonou, Bénin; <sup>4</sup>Laboratoire de microbiologie, Pôle de Biologie-hygiène, Centre Hospitalier de Valenciennes, Valenciennes, France; <sup>5</sup>Service de Réanimation Médicale et Maladies Infectieuses, Hôpital Châtilliez, Tourcoing, France; <sup>6</sup>Laboratoire de Parasitologie-Mycologie, AP-HP, Groupe Hospitalier Saint-Louis Lariboisière Fernand-Widal, Paris, France; <sup>7</sup>Laboratoire de Parasitologie-Mycologie, Institut de Biologie, Centre Hospitalier Universitaire de Nantes, Nantes, France; <sup>8</sup>Laboratoire de Parasitologie-Mycologie, AP-HP, Département de Microbiologie, Hôpital Européen Georges Pompidou, Paris, France; <sup>9</sup>Department of Tropical Medicine and Parasitology, School of Medicine, Juntendo University, Hongo, Bunkyo-ku, Tokyo, Japan; and <sup>10</sup>Faculty of Medicine, Gulu University, Gulu, Uganda

Clinical Infectious Diseases

MAJOR ARTICLE

## High Rate of Treatment Failures in Nonimmune Travelers Treated With Artemether-Lumefantrine for Uncomplicated *Plasmodium falciparum* Malaria in Sweden: Retrospective Comparative Analysis of Effectiveness and Case Series

Klara Sonden,<sup>1</sup> Katja Wyss,<sup>2</sup> Irina Jovel,<sup>3</sup> Antero Vieira da Silva,<sup>4</sup> Anton Pohanka,<sup>4,5</sup> Muhammad Asghar,<sup>1</sup> Manijeh Vafa Homani,<sup>1</sup> Lars L. Gustafsson,<sup>1,2</sup> Urban Hellgren,<sup>4,5</sup> and Anna Färnert,<sup>1,2</sup>

<sup>1</sup>Unit of Infectious Diseases, Department of Medicine Solna, Karolinska Institutet; <sup>2</sup>Department of Emergency Medicine, Karolinska University Hospital Solna; <sup>3</sup>Department of Microbiology, Tumor and Cell Biology, Karolinska Institutet; <sup>4</sup>Department of Clinical Pharmacology, Karolinska University Hospital Huddinge; <sup>5</sup>Division of Clinical Pharmacology, Department of Laboratory Medicine, Karolinska Institutet; <sup>6</sup>Department of Infectious Diseases, Karolinska University Hospital; and <sup>7</sup>Unit of Infectious Diseases, Department of Medicine Huddinge, Karolinska Institutet, Stockholm, Sweden

JM JOURNAL OF TRAVEL MEDICINE

Journal of Travel Medicine, 2023, 1–9  
https://doi.org/10.1093/jtm/taad114  
Original Article

Original Article

## Emergence of artemisinin-based combination treatment failure in patients returning from sub-Saharan Africa with *P. falciparum* malaria

Tamar Grossman<sup>1</sup>, PhD Dr<sup>1</sup>, Julia Vainer, MSc Dr<sup>1</sup>, Yael Paran, MD<sup>2,3</sup>, Liora Studentsky, MSc Dr<sup>1</sup>, Uri Manor<sup>4</sup>, MD Professor<sup>3,4</sup>, Ron Dzikowski, PhD Professor<sup>5</sup> and Eli Schwartz, MD, DTMH<sup>3,4</sup>

<sup>1</sup>Parasitology Reference Laboratory, Public Health Laboratories—Jerusalem (PHL-J), Public Health Services (PHS), Ministry of Health (MOH), Jerusalem 9134302, Israel; <sup>2</sup>Infectious Disease Department, Tel Aviv Sourasky Medical Center, Tel Aviv 64239, Israel; <sup>3</sup>Faculty of Medicine, Tel Aviv University, Tel Aviv 69978, Israel; <sup>4</sup>The Center for Geographic Medicine, Sheba Medical Center, Tel HaShomer 5262000, Israel and <sup>5</sup>Department of Microbiology & Molecular Genetics, The Kuvim Center for the Study of Infectious and Tropical Diseases, IMRIC, The Hebrew University-Hadassah Medical School, Jerusalem 91120, Israel

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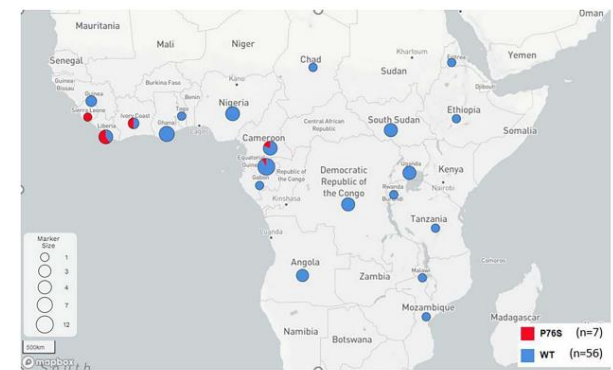


Figure 5. The geographic distribution of Pfcornin (P76S) status of 63 patients returning from Africa; place of travel and associated relative frequency of Pfcornin mutation P76S in patients arriving from Africa (n = 63; seven patients who had visited more than one area were not included; circle size is in proportion to the number of patients from a country; maps were generated using Microact<sup>SM</sup>, a dynamic version can be found at <https://microact.org/project/AVIqRHEVtBmHtBLJae7zn-5g-5-geographic-distribution-and-pfcornin-p76>

# AL-treatment failure -When to suspect resistance?

Early failure: residual parasites by microscopy day 3

Late treatment failure: Clinical and laboratory-confirmed malaria recrudescence (positive blood smear) *reappearing* 7–42 days after clinical and microscopy negative interval.

*Because artemisininins are fast-acting, early failures suggest artemisinin resistance, while late failures could result from a reduced effectiveness of artemisinin or lumefantrine, or both.*

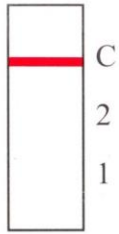
How to treat?

- Prolonged (5-6 days) AL
- Switch to Atovaquone+Proguanil /Mefloquine
- Triple combination? ART -lumefantrine+amodiaquone dihydroART-piperaquine+mefloquine

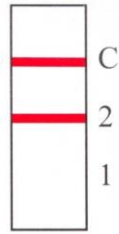
# *P. falciparum* HRP2/3 gen deletion

## CareStart pLDH Malaria (Pf-pLDH/pan-pLDH)

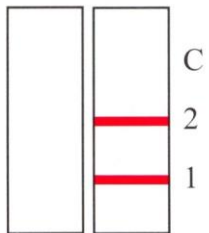
Interpretation of the test



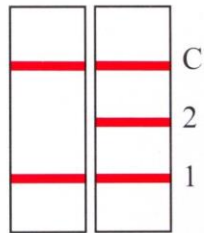
Negative



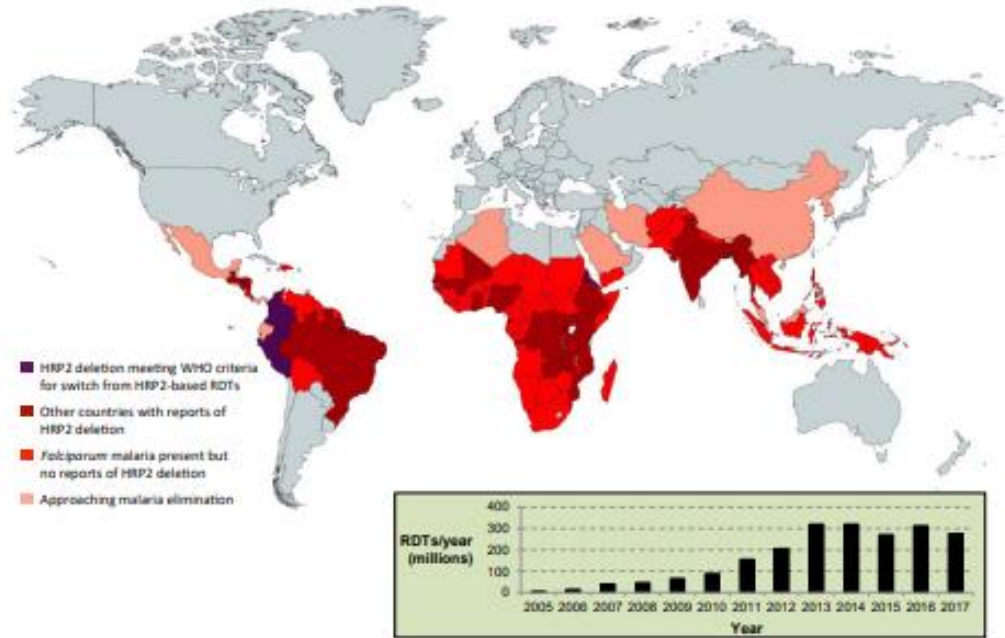
Positive  
(*P. vivax*)



Invalid



Positive  
(*P. falciparum*)

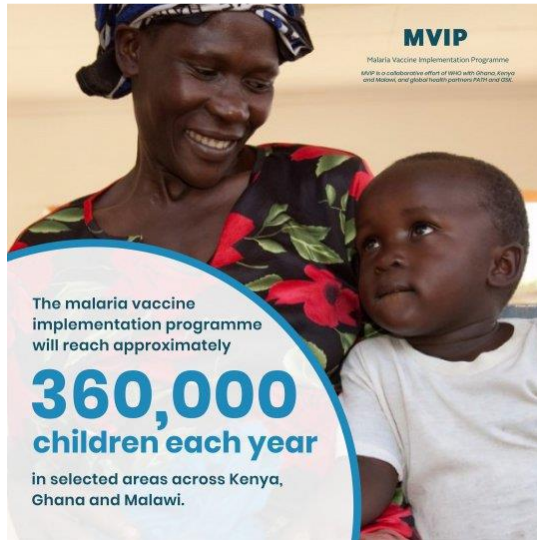


Trends in Parasitology

**Figure 4. Deployment of Malaria Rapid Diagnostic Tests (mRDTs): Reports of Histidine-Rich Protein 2 (HRP2) Deletion and Overall Supply of mRDTs Per Year.**

The map shows the global distribution of *falciparum* malaria (identifying countries nearing malaria elimination) and illustrates countries with reports of HRP2 deletion<sup>viii</sup>, including Peru, Columbia, and Eritrea, where World Health Organisation (WHO) criteria for switching from HRP2-based mRDTs have been met. The map was created with [mapchart.net](http://mapchart.net). The inset graph shows the annual supply of all mRDTs from 2005 to 2017 in millions (data from WHO Malaria Reports<sup>xiv</sup>).

# Nytt hopp?



## The NEW ENGLAND JOURNAL of MEDICINE

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### Seven-Year Efficacy of RTS,S/AS01 Malaria Vaccine among Young African Children

Ally Olotu, Ph.D., Gregory Fegan, Ph.D., Juliana Wambua, M.Sc., George Nyang'wa, Amanda Leach, M.R.C.P.C.H., Marc Lievens, M.Sc., David C. Kaslow, M.D., Patricia Nj Kevin Marsh, F.R.C.P., and Philip Bejon, Ph.D.

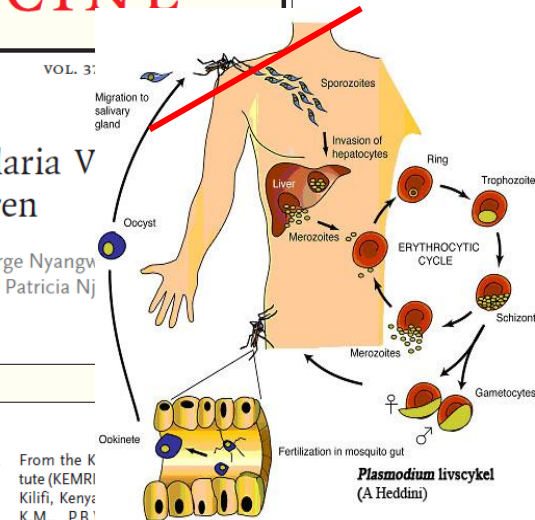
#### ABSTRACT

#### BACKGROUND

The candidate malaria vaccine RTS,S/AS01 is being evaluated in order to inform a decision regarding its inclusion in routine vaccination schedules.

#### METHODS

We conducted 7 years of follow-up in children who had been randomly assigned, at 5 to 17 months of age, to receive three doses of either the RTS,S/AS01 vaccine or a rabies (control) vaccine. The end point was clinical malaria (temperature of  $\geq 37.5^{\circ}\text{C}$  and infection with *Plasmodium falciparum* of  $>2500$  parasites per cubic millimeter). In an analysis that was not prespecified, the malaria exposure of each child was estimated with the use of information on the prevalence of malaria among residents within a 1-km radius of the child's home. Vaccine efficacy was defined as 1 minus the hazard ratio or the incidence-rate ratio, multiplied by 100, in the RTS,S/AS01 group versus the control group.



From the KEMRI Kilifi, Kenya (K.M., P.B.), Bagamoyo, Tanzania (A.O.); the Nuffield Department of Medicine, University of Oxford, Oxford, United Kingdom (G.F., K.M., P.B.); GlaxoSmithKline Vaccines, Wavre, Belgium (A.L., M.L.); and PATH, Seattle (D.C.K.). Address reprint requests to Dr. Bejon at the KEMRI-Wellcome Trust Research Programme, P.O. Box 230, Kilifi, Kenya, or at pbejon@kemri-wellcome.org.

N Engl J Med 2016;374:2519-29.  
DOI: 10.1056/NEJMoa1515257



-> Mosquirix™ rekommenderas av WHO sedan Okt 2021 som storskalig bekämpning av malaria bland barn i medel och högendemiska länder

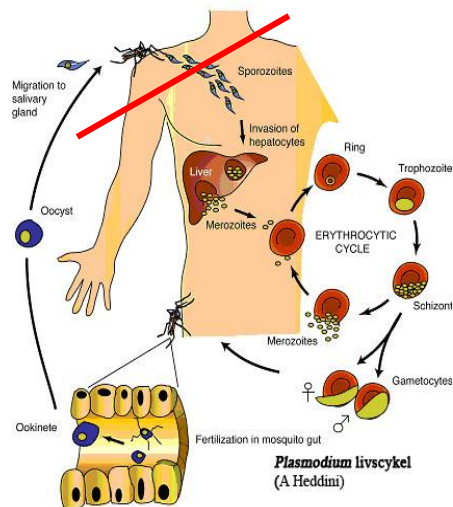
# Efficacy and immunogenicity of R21/Matrix-M vaccine against clinical malaria after 2 years' follow-up in children in Burkina Faso: a phase 1/2b randomised controlled trial



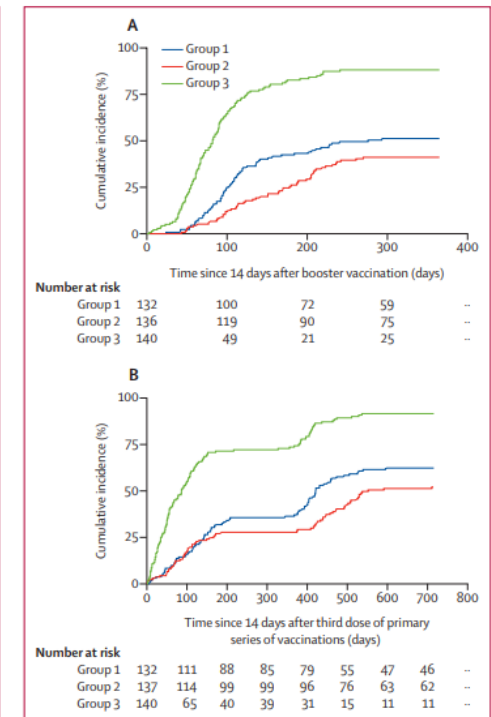
Mehreen S Dattoo\*, Hamtandi Magloire Natama\*, Athanase Somé†, Duncan Bellamy†, Ousmane Traoré, Toussaint Rouamba, Marc Christian Tahita, N Félix André Ido, Prisca Yameogo, Daniel Valia, Aida Millogo, Florence Ouedraogo, Rachidatou Soma, Seydou Sawadogo, Faizatou Sorgho, Karim Derra, Eli Rouamba, Fernando Ramos-Lopez, Matthew Cairns, Samuel Provstgaard-Morys, Jeremy Aboagye, Alison Lawrie, Rachel Roberts, Innocent Valéa, Hermann Sorgho, Nicola Williams, Gregory Glenn, Louis Fries, Jenny Reimer, Katie J Ewer, Umesh Shaligram, Adrian V S Hill‡, Halidou Tinto‡

## Summary

**Background** Malaria is a leading cause of morbidity and mortality worldwide. We previously reported the efficacy of the R21/Matrix-M malaria vaccine, which reached the WHO-specified goal of 75% or greater efficacy over 12 months in the target population of African children. Here, we report the safety, immunogenicity, and efficacy results at 12 months following administration of a booster vaccination.



80% efficacy  
after 3 doses



**Figure 2: Kaplan-Meier estimates of the time to first episode of clinical malaria according to the primary case definition**  
The primary case definition of clinical malaria in this study was the presence of an axillary temperature of 37.5°C or greater and *Plasmodium falciparum* parasite density greater than 5000 asexual forms per  $\mu\text{L}$ . Analyses of vaccine efficacy included all participants who received a booster vaccination. (A) Data beginning from 14 days to 12 months after the booster vaccination. (B) Data beginning from 14 days to 24 months after the primary series of vaccinations. Group 1 received 5  $\mu\text{g}$  R21/25  $\mu\text{g}$  Matrix-M, group 2 received 5  $\mu\text{g}$  R21/50  $\mu\text{g}$  Matrix-M, and group 3, the control group, received the RabiVax-S rabies vaccine.

# Mer på gång..

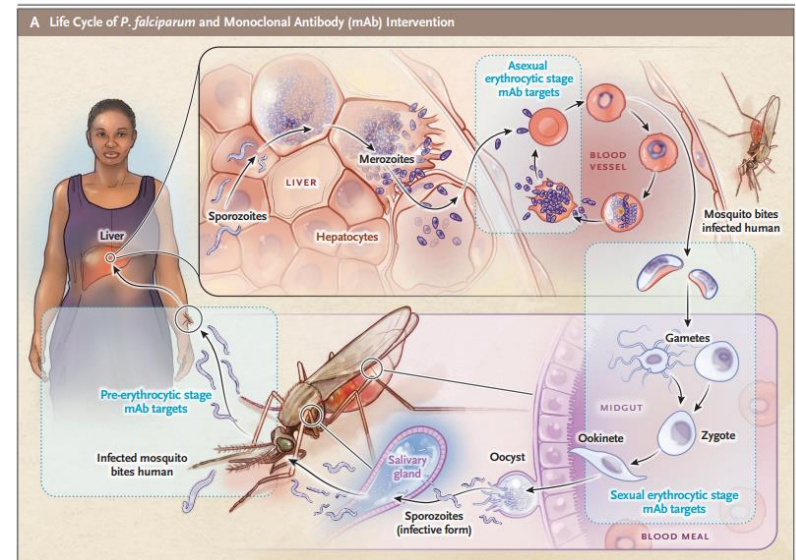
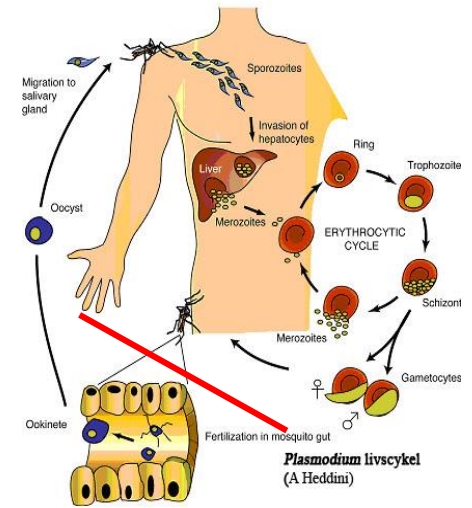
- Transmission blocking vaccines
- mRNA vaccine (BioNTech)
- Monoklonal antikroppar som förebyggande behandling
- P vivax vaccines

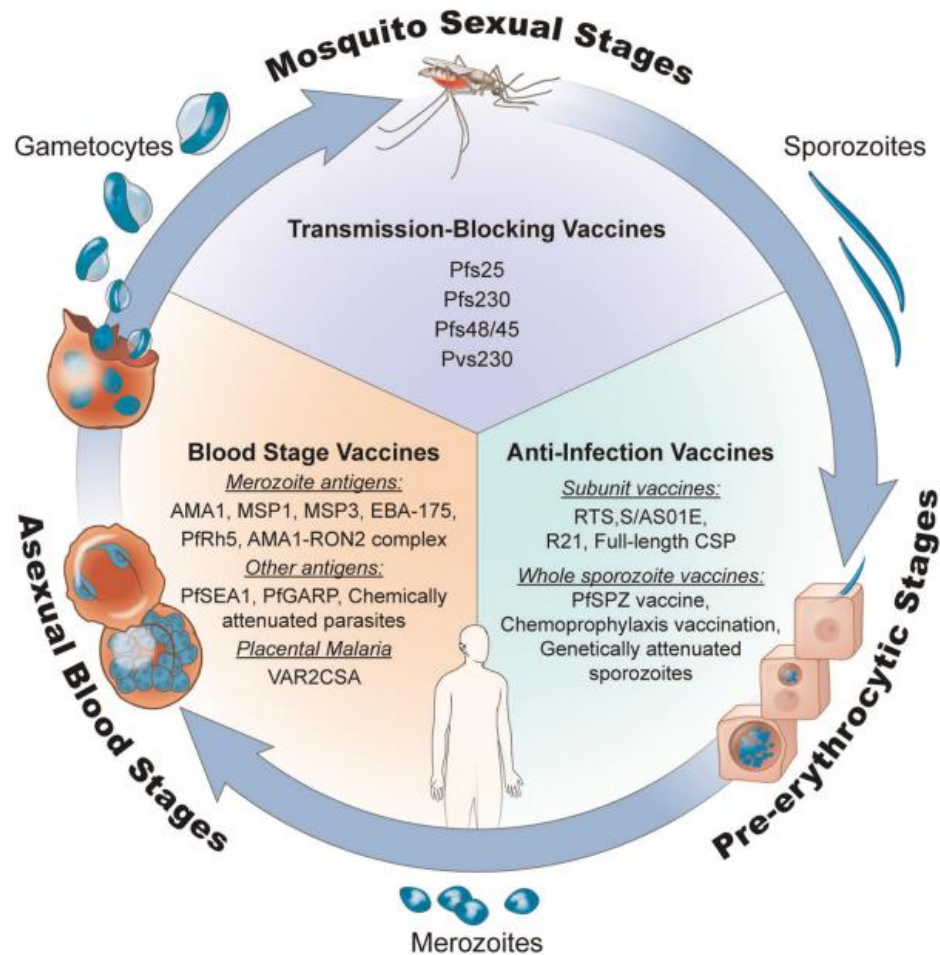
scientific reports

OPEN [Check for updates](#)

**Immunogenicity of a *Plasmodium vivax* vaccine based on the duffy binding protein formulated using adjuvants compatible for use in humans**

Francisco J. Martinez<sup>1</sup>, Micheline Guillotte-Blisnick<sup>1</sup>, Christèle Huon<sup>1</sup>, Patrick England<sup>2</sup>, Jean Popovici<sup>3</sup>, Héléne Laude<sup>4</sup>, Laurence Arowas<sup>4</sup>, Marie-Noëlle Ungeheuer<sup>4</sup>, Jenny M. Reimer<sup>5</sup>, Darrick Carter<sup>6,7</sup>, Steve Reed<sup>8</sup>, Steve Reed<sup>8</sup>, Paushali Mukherjee<sup>9</sup>, Virander S. Chauhan<sup>9</sup> & Chetan E. Chitnis<sup>1-3</sup>





**Fig. 1** Life cycle stages of *Plasmodium* and vaccine candidates that target each stage. This figure was adapted from a previously published illustration<sup>105</sup> that has been updated to include more recent malaria vaccine candidates. Illustration by Alan Hoofring, Medical Arts Design Section, NIH.



# Tack!



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