

MORU Tropical Health Network 2021 Annual Report
Mahidol Oxford Tropical Medicine Research Unit (MORU)

2021 Annual Report



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MORU Tropical Health Network 2021 Annual Report

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Mahidol Oxford Tropical Medicine Research Unit (MORU)

Table Of Contents

MORU Tropical Health Network 2021 Annual Report

Mahidol Oxford Tropical Medicine Research Unit (MORU)

Executive Summary	2
Map of MORU Tropical Health Network	4
MORU Financial Strategy and 2021 Annual Review	6
Organisation Chart MORU Tropical Health Network	8
Equity, diversity and inclusion	10
MORU Bangkok-based Departments	12
Malaria & Critical Illness	14
Microbiology	24
Epidemiology	34
Clinical Pharmacology	42
Bioethics & Engagement	50
Mathematical and Economic Modelling (MAEMOD)	58
Clinical Therapeutics Unit (CTU)	66
Clinical Trials Support Group (CTSG)	72
Operations & Administration	76
MORU Units	80
Shoklo Malaria Research Unit (SMRU)	82
Lao-Oxford-Mahosot Hospital-Wellcome Trust Research Unit (LOMWRU)	92
Cambodia-Oxford Medical Research Unit (COMRU)	100
Myanmar-Oxford Clinical Research Unit (MOCRU)	106
Medicine Quality Research Group	112
KIMORU Study Site, DR Congo	118
Annex A: MORU Tropical Health Network Staff	122
Annex B: MORU Tropical Health Network Publications 2021	135
Annex C: Collaborators 2021	173
Annex D: Postgraduate Students, Active or Graduated in 2021	188



A group of MORU Bangkok staff who joined during the COVID-19 pandemic – at their first in-person staff meeting. © MORU 2022. Photographer: Gerhard Jøren.

Executive summary 2021

If 2020 was a difficult year, regionally and globally, 2021 saw Southeast Asia and the MORU Tropical Health Network having to face and tackle even more significant challenges. In 2020 the COVID-19 pandemic led to lockdowns and travel restrictions across the world, including in Southeast Asia. The MORU Network pivoted quickly to tackling the pandemic, working from home, making sure our colleagues were safe, and conducting a range of clinical trials and studies on SARS-CoV-2. However, Thailand, Lao PDR, Cambodia, Myanmar and other Southeast Asian countries were relatively spared from the high infection and death rates seen elsewhere in 2020.

2021, though, was a very different story.

Whereas the original Wuhan and Alpha variants of the virus appeared challenged by the transmission environment in Southeast Asia, the Delta variant caused devastating epidemics across the Indian sub-continent and in multiple, previously lightly affected Southeast Asian countries. Myanmar, already suffering from civil unrest following the political events of 1 February 2021 and with a relatively unvaccinated population, was particularly hard hit by an ‘unopposed’ wave of Delta infection. MOCRU and MAM responded rapidly, setting up 18 COVID-19 treatment centres equipped with oxygen concentrators across the country, and treating several thousand severely-ill COVID patients. Other countries in the region were also badly hit, though the impact was mitigated by expanding vaccine rollouts. MORU units helped governments with their virological and epidemiological response, setting up with Wellcome support SARS-CoV-2 sequencing to identify new variants, and conducting community engagement on the disease in underserved areas.

With lockdowns back in place, the MORU Network’s research response to the pandemic ramped up to a new level. Our COPCOV COVID-19 prevention study accelerated recruitment and enrolled by the end of 2021 over 4,000 participants across 11 countries in Asia, Africa, and Europe. The PRIORITISE study in India identified factors that predicted disease progression in moderately ill COVID patients. In sites in Thailand and Brazil the new PLATCOV pharmacodynamic study began characterising, by variant, antiviral efficacy of treatments for early SARS-CoV-2 infection. Our Asian ICU network continued to contribute individual patient information on severe disease, define the best care for COVID-19 in resource-limited ICU settings, and recruit patients into international treatment trials such as REMAP-CAP. Overall, in 2021 the MORU Network published over 70 papers on COVID-19, to add to the 31 published in 2020.

As the Delta wave waned and lockdowns and other restrictions were slowly lifted, we began to re-open non-COVID clinical research. While many of our clinical studies had been interrupted or their start delayed by the pandemic, by the end of 2021 all our major clinical trials, studies and projects on other infectious diseases, such as malaria, melioidosis and scrub typhus, and on drug-resistant infections, had restarted. This clinical research involved patient recruitment in around 50 clinical study sites across 22 countries in Asia, Africa and South America. The ambitious SEACTN rural fever flagship study, working in remote areas with village healthcare workers and small clinics, could finally begin recruiting. Of course, the pandemic was not over, but with mitigations in place and high vaccination levels in most areas, the rise of Omicron at the end of 2021 was not as disruptive or as harmful to our staff, their research, or to the populations we work amongst.

I have been incredibly impressed by how over the last two years our teams have managed to adapt to the dramatically changing and often difficult situation. As elsewhere, many have been unable to travel throughout this period, and have continued their work in relatively isolated areas without the respite of visits to see family and friends. Working from home has been isolating and stressful for some, and supporting colleagues has been a priority for all. Welcoming and integrating the 100 or so employees who joined us since the pandemic began has also been a challenge, particularly when for many of them the main interaction with their new colleagues has been on MS Teams calls. The response to the extraordinary circumstances of the last two years is a real tribute to the flexibility, spirit and dedication of the MORU Tropical Health Network’s staff.

Flexibility has always been and will continue to be MORU’s core strength. Despite the curtailing of much non-COVID clinical research, and having so many staff working from home, we have maintained or increased productivity and impact in many areas. The many achievements during 2021 of the units and departments that make up the MORU Network are outlined in this Annual Report, along with our research visions for the coming years. With most of us now back regularly in the lab, the office and the field, and with the pandemic and its lessons hopefully mainly in the rear-view mirror, we are excited about the challenges ahead.

Nicholas Day
Director
MORU Tropical Health Network

MORU Tropical Health Network

MORU Units

1 Mahidol Oxford Tropical Medicine Research Unit (MORU)
Mahidol University, Bangkok



2 Shoklo Malaria Research Unit (SMRU)
Mae Sot, Thailand



3 Lao-Oxford-Mahosot Hospital Wellcome Trust Research Unit (LOMWRU)
Vientiane, Lao PDR



4 Cambodia-Oxford Medical Research Unit (COMRU)
Siem Reap, Cambodia



5 Myanmar Oxford Clinical Research Unit (MOCRU)
Yangon, Myanmar



MORU Study Sites

Thailand

a Chiangrai Clinical Research Unit (CCRU)
Chiangrai, Thailand



b Ubon Ratchathani Sappasithiprasong Hospital



Cambodia

c Pursat Province, Kravanh District Hospital



d Siem Pang Siem Pang Health Centre



Bangladesh

e Chittagong Chittagong Medical College Hospital



f Ramu Ramu Upazilla Health Complex, Cox's Bazar



DR Congo

g Kinshasa KIMORU Kinshasa School of Public Health



MORU Financial Strategy and 2021 Annual Review

MORU's overarching financial strategy is to use the Wellcome CORE grant as a platform to effectively increase the scale and impact of our research activities. MORU continues to focus on a diverse portfolio of income streams and projects to ensure that the MORU Tropical Health Network remains flexible enough to achieve its stated strategic objectives.

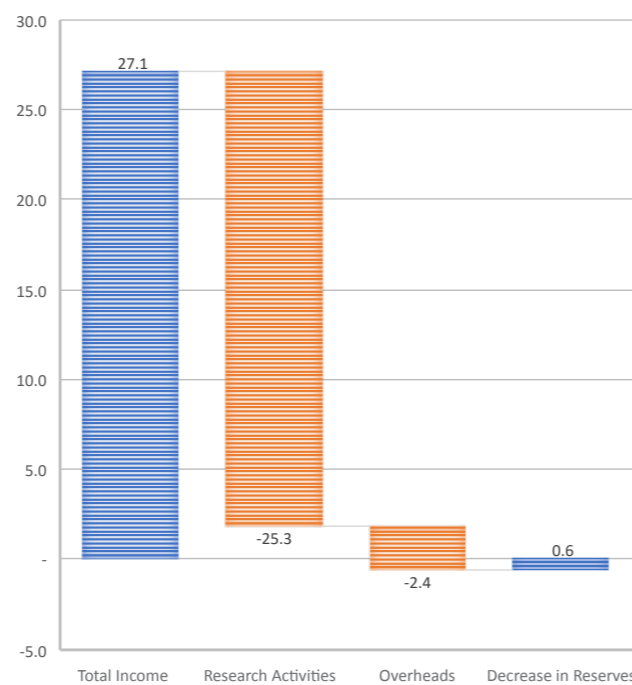
Where does our money come from?

In 2020/21 MORU external recognisable income increased by 3.8m GBP to 27.1m GBP. Despite the impact of COVID-19 with the cessation or slowing down of many projects, there was a significant increase in large multi-centre research programmes on malaria and COVID.

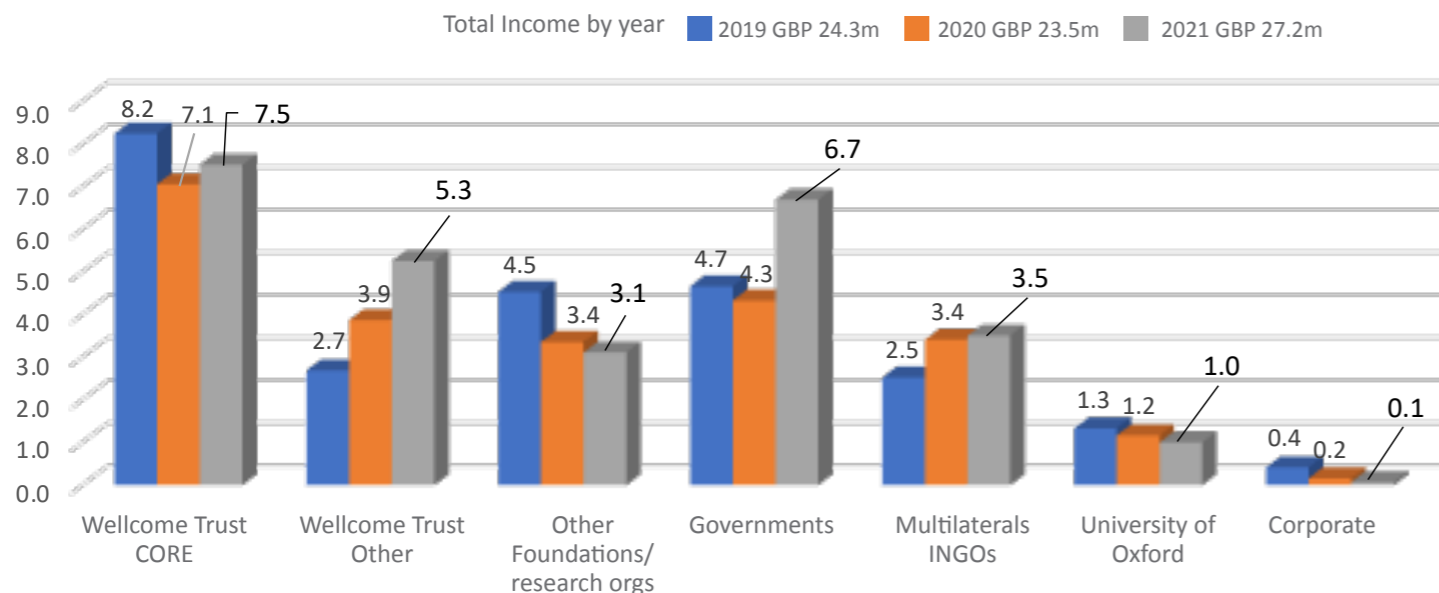
The largest individual donor was Wellcome Trust who provide around 47% of our funding. The rest of the income is predominantly donor contracted funding from organisations across the research, educational and government sectors.

In 2020/21 expenditure exceeded income by GBP 0.6m leading to a reduction in overall unrestricted operational reserves to GBP 0.6m

Income less expenditure in 2020/2021 (GBP m)



2021 Income by funding source (GBP m)



Where was the money spent?

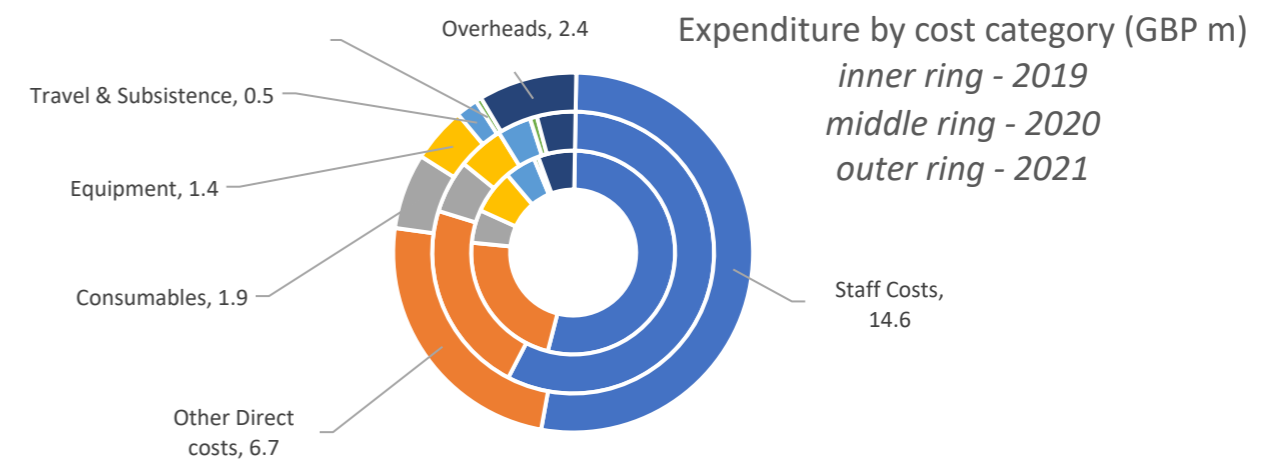
The MORU Tropical Health Network consists of a number of integrated departments and sites. Expenditure reported has been incurred at our main units in MORU Bangkok, SMRU, LOMWRU, COMRU and MOCRU, for activities in our multiple global study sites as well as Oxford specific support costs.

How was the money spent?

Salaries continue to account for more than half of MORU expenditure. Expenditure levels on different cost categories remained relatively constant, although the initial reduction in travel costs because of COVID-19 continued in 2021.

(Overheads represent contributions to host organisations and external services provided.)

Expenditure by cost category (GBP m)	2019			2020			2021		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
Staff Costs	13.6	13.8	14.6	54%	57%	53%			
Other Direct Costs	5.7	5.4	6.7	23%	22%	24%			
Consumables	1.3	1.5	1.9	5%	6%	7%			
Equipment	1.8	1.3	1.4	7%	5%	5%			
Travel & Subsistence	1.3	1.9	0.5	5%	4%	2%			
Premises	0.2	0.2	0.1	1%	1%	1%			
Overheads	1.5	1.1	2.4	6%	4%	9%			
Total Expenditure	25.3	24.1	27.7						
Efficiencies on project grants and other gains	0.4	0.1	0.1	1%	1%	0%			



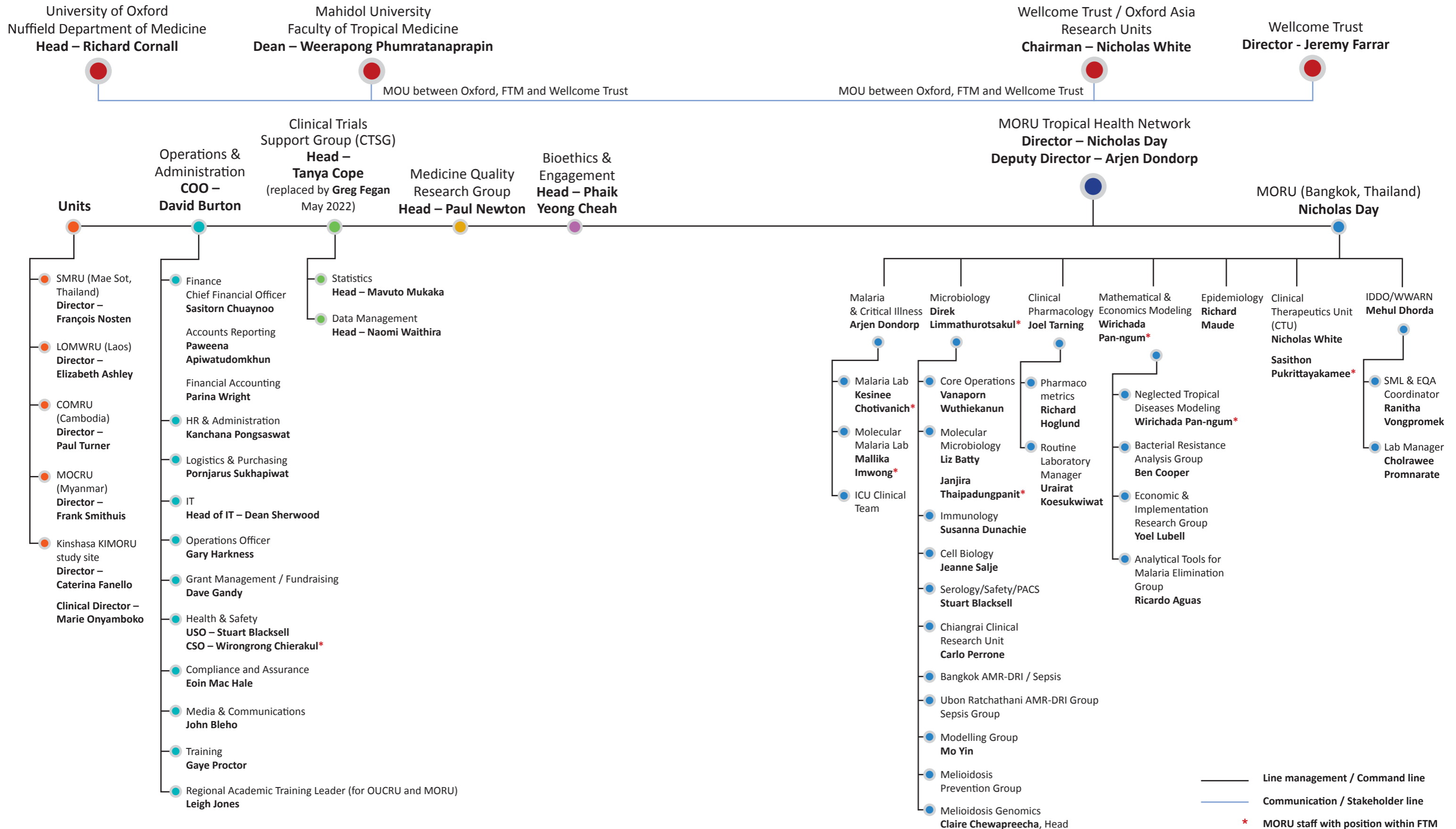
Assumptions

MORU is not a distinct organisation but a consolidation of activities across the University of Oxford and Mahidol University under common leadership. The financial figures represent a combination of independently audited financial statements of Thailand managed donor contracts and an extract of University of Oxford administered contracts. Annualised expenditure is based on 1 October-30 September accounting periods, held in multiple accounting systems, and subject to disparate accounting principles.

As such, there may be reporting discrepancies and MORU advise further consultation should these figures be used for whatever purpose.

Organisation Chart

MORU Tropical Health Network





Bangkok-based MORU Tropical Health Network colleagues. © MORU 2022. Photographer: Gerhard Jøren.

Equity, diversity and inclusion

The MORU Tropical Health Network restates its commitment to fostering an inclusive culture that promotes equality, values diversity, and maintains a working, learning and social environment that respects the rights and dignity of all of its staff and students. During 2021, in partnership with the MORU Equality & Diversity Committee (EDC) there was good progress towards removing and minimising disadvantages suffered by MORU employees because of protected characteristics (as classified under the Equality Act 2010). For 2022 there are further plans and actions in place to consolidate this work.

In 2019, based on the University of Oxford's equality objectives, discussions with the MORU Equality & Diversity Committee, and the results from the 2018 staff survey, MORU senior management committed to undertaking activities and measuring progress to the specific attainment of three MORU specific equity objectives, namely to:

1. **Reduce inequity of remuneration** of staff regardless of ethnicity, contractual status and nationality;
2. **Improve career development**, networking opportunities and access to resources for all staff;
3. **Advance gender equality**, e.g. representation of women in senior roles.

The activities and actions since then have not been limited to these three objectives but focused on creating and fostering a culture with increased participation, inclusivity and development opportunities for all employees so they can fulfil their potential.

1. Reduce inequity of remuneration

In 2019 an external review with an industry leading non-profit salary benchmarking organization

concluded and a new salary grade and step structure was introduced for all MORU employees. The design focused on the fair and transparent remuneration of employees with the creation of job families and clarity around the criteria around grading to enable career progression. The MORU EDC were involved in these discussions and decisions. In 2020 and 2021 after we received benchmarking reports from The Birches Group, a specialised human resource consultancy focused on labour market data in over 150 emerging and developing countries, we made adjustments to the scale. Further work will be undertaken to continue to benchmark and review these grades and also to communicate the requirements to managers and employees.

2. Improve career development

As well as the new grading structure, a full review of the PDR process was completed. There is now a process in place to better record and monitor development opportunities and training. A leadership programme aimed at locally contracted employees was established. The first cadre finished the six-module course and two new groups were selected in 2021 and started in 2022. A new online training system (Bridge) has been rolled out providing content for all Thai staff not previously accessible. A local training manager was recruited and completed a unit wide training needs analysis review to inform the annual training plan.

There is a focus on increasing networking opportunities and providing funding opportunity updates to all employees as well as harmonisation of inductions for Oxford and locally contracted employees. Other activities include the setting up of a training fund as part of the Wellcome CORE application targeting staff members who do not have access to their own funds. All these elements will fall under a formal career development strategy for MORU staff.

3. Advance Gender Equality

MORU continues to implement and follow the recommendations of the Athena Swan framework to recognise and celebrate good practices in MORU that contribute towards the advancement of gender equality: representation, progression and success.

Further related actions and plans

- A 2nd EDC staff survey was circulated to all staff, with findings presented to MORU's Core Management committee (CMC).
- In 2021 MORU contracted an external agency to carry out an equality, diversity, and inclusion review. In early 2022 an independent staff survey was sent out, management interviews undertaken and a series of focus group discussions were facilitated. At the end of this process in July 2022 MORU will receive a full report and work with the contractor to produce a roadmap to implementing actions based on the findings.
- MORU have implemented mandatory training courses to raise awareness of equality and diversity issues.

The Equality and Diversity Committee is an advisory committee established within MORU in consultation with the Nuffield Department of Medicine (NDM), University of Oxford, Athena Swan Committee and the Mahidol Oxford Tropical Medicine Research Unit (MORU).

The Equality and Diversity Unit (EDU), who prepared the Annual Equality Report for the University of Oxford, work in partnership across the collegiate University to support Oxford's commitment to fostering an inclusive culture that promotes equality, values diversity and maintains a working, learning and social environment that respects the rights and dignity of all its staff and students.

The Unit's work is overseen by the Equality and Diversity Panel, which reports to the Personnel and Education Committees of Council, and is chaired by Dr Rebecca Surender, the Pro-Vice-Chancellor and Advocate for Equality and Diversity. Further information on their work can be found at www.admin.ox.ac.uk/eop/aboutus.



MORU BKK-based Departments





Led by Professor Arjen Dondorp (*back, centre*), the Malaria & Critical Illness Department focusses on research on the epidemiology diagnosis, pathophysiology, prevention, elimination and treatment of malaria, including drug resistance, and improving health for patients with critical illness in resource-limited settings. © MORU 2022. Photographer: Gerhard Jørén.

Malaria & Critical Illness

I. Overview

The Malaria & Critical Illness Department seeks to improve health for the many people who live in malaria endemic countries and for patients with critical illness in resource-limited settings.

Our research focuses on the epidemiology diagnosis, pathophysiology, prevention, elimination and treatment of malaria, including the raising issue of drug resistance. Research on critical illness focuses on epidemiological aspects, assessment and improvement in the quality of care, and trials of practical interventions to improve ICU care in LMICs. Headed by Prof. Arjen Dondorp, MORU's Malaria & Critical Illness Department consists of closely interacting teams that:

- Conduct treatment studies in severe and uncomplicated falciparum malaria;
- Improve the treatment of vivax malaria;
- Investigate the growing problem of antimalarial drug resistance;
- Develop approaches to malaria elimination;
- Research the pathophysiology of severe malaria;
- Perform quantitative and qualitative assessments of ICU care in the region, linked to locally led quality improvement projects; and
- Trial novel interventions to improve critical care in resource-limited settings.

The clinical team is responsible for community- and hospital-based malaria and critical illness studies within our network of study sites, where we work closely with our local collaborators.

The malaria laboratory in Bangkok, headed by Professor Kesinee Chotivanich, supports clinical research through a wide range of laboratory studies on pathobiological mechanisms and antimalarial drug action in *Plasmodium falciparum* and *P. vivax*.

The molecular malaria laboratory, directed by Professor Mallika Imwong, focuses on molecular genetic correlates of antimalarial drug resistance and supports our large clinical and epidemiological malaria studies with sensitive qPCR detection methods and molecular epidemiological tools.

Research carried out by MORU Malaria and other units of the MORU Tropical Health Network have contributed importantly to the current WHO guidelines for the treatment of severe malaria, uncomplicated falciparum and vivax malaria, and of malaria in pregnancy.



Professor Mallika Imwong (*seated, 2nd from right*) and the Molecular Malaria Laboratory team. © MORU 2022. Photographer: Gerhard Jørén.

Since 2020, the Malaria & Critical illness Department has coordinated DeTACT (Developing and evaluating triple artemisinin-based combination therapies (TACTs)), a large project funded by FCDO (former DFID) for improving the treatment of multidrug resistant falciparum malaria. A large randomised clinical trial (RCT) in 8 African and 3 Asian countries, DeTACT evaluates the safety and efficacy of 2 TACTs: artemether-lumefantrine-amodiaquine, and artesunate-mefloquine-piperazine. The start of the trial was delayed because of the pandemic, but it is now running in 10 of the 11 planned sites and is aiming for recruitment of 4,000 patients. Evaluating TACTs in African children has become increasingly relevant because of the emergence and spread of artemisinin resistance in Rwanda, Uganda, and the Horn of Africa. The DeTACT project in addition evaluates the future market positioning of TACTs and the potential bioethical issues of their deployment in both the African and Southeast Asian contexts. The African market positioning evaluation was finalised in 2021 and recently published. Development of mathematical models on the impact of the introduction of TACTs on delaying the development and spread of antimalarial drug resistance are continuing, as well as cost and economic impact models. A commercial partner was found for the further development of artemether-lumefantrine-amodiaquine as a fixed-dose combination, which will be available for deployment by the end of the project in 2023.

In addition, a study in Cambodia and Viet Nam evaluating artemether-lumefantrine-amodiaquine in areas with multiple drug resistant falciparum malaria (acronym TACT-CV) was completed and published in 2021. A study on chemoprophylaxis in forest goers in Cambodia, organised together with MORU's Epidemiology Department, was completed in 2021. This will be followed by a study on expanding the role of village malaria workers beyond malaria-related activities in the context of malaria elimination.

The first study in the 'MIST' Controlled Human Infection Models of *P. vivax* programme (with CTU) was completed in 2021. Human volunteers were successfully infected with sporozoites via infected mosquito bite, and *P. vivax* infected blood was banked to use as inocula in subsequent blood stage vivax malaria infection studies which will be used to assess blood stage vaccine candidates.

A study on the efficacy of short course primaquine and single dose tafenoquine for radical cure for *P. vivax* (EFFORT) started in 2021 in collaboration with the Cambodian National Malaria Programme (CNMP) and the Menzies School of Health Research.

The Star Homes Project aims to assess the health benefits of improvements in housing in rural Africa, in particular the impact of screened windows on malaria transmission. The first phase of the project consisting of the construction of 110 novel design houses in Mtwara, Tanzania is reaching completion. The next phase of the project will consist of the surveillance of children living in novel

design houses compared to children living in traditional houses over a three-year period. Active and passive surveillance will be used to detect episodes of malaria, respiratory tract infections, and diarrhoeal diseases.

Delayed in 2021 because of COVID-19, work is now continuing on the MRC funded study, *Assessing the tolerability of a potentially safer radical curative regimen of primaquine in healthy volunteers with glucose 6 phosphate dehydrogenase deficiency*. This study is challenging healthy G6PD deficient Thai males with an escalating dose regimen (up to 45 mg) of primaquine to induce a slow burn haemolysis. The study also attempts to identify the illusive active metabolite of the pro-drug primaquine.

PAC ('Primaquine in African Children'), a large placebo-controlled randomised clinical trial in over 1,100 children with uncomplicated falciparum malaria in Uganda and DR Congo on the safety of single low dose primaquine as transmission blocking adjunct to ACTs completed recruitment in 2021 (and will be published in 2022). The PAC study showed a reassuring safety profile for single low dose primaquine, including an absence of severe anaemia in patients with A- Glucose-6-Phosphate-Dehydrogenase deficiency. Single low dose primaquine is likely to become an important tools for the containment of artemisinin resistant falciparum malaria which has recently emerged and expanding in Rwanda, Uganda, and the Horn of Africa.

Our work on severe malaria in Chattogram (formerly Chittagong) was postponed in 2021 because of the COVID-19 pandemic. Severe malaria studies continued in collaboration with KIMORU in Kinshasa, DR Congo. These studies focus on the management of severe malaria, including fluid management and adjunctive treatments. The studies identified haem mediated oxidative stress as an important contributor to renal failure in severe malaria. Paracetamol was shown to mitigate this important pathway in adult severe malaria and will now be trialled in African children with severe malaria in collaboration with KIMORU. Also, in collaboration with KIMORU, an observational study on pulmonary pathology in children with severe malaria using lung ultrasound (LUSISM) was completed in 2021, and is now being analysed.

Studies evaluating ivermectin as an endectocide for the Anopheles mosquito malaria vector are continuing. A study identified the three primary metabolites of ivermectin from human liver microsomes, hepatocytes, and clinical trial samples, and these results were published. Detection of these three ivermectin metabolites will now be included in future clinical trial pharmacokinetic analyses, and evaluation of mosquito-lethal effect of these metabolites is ongoing.

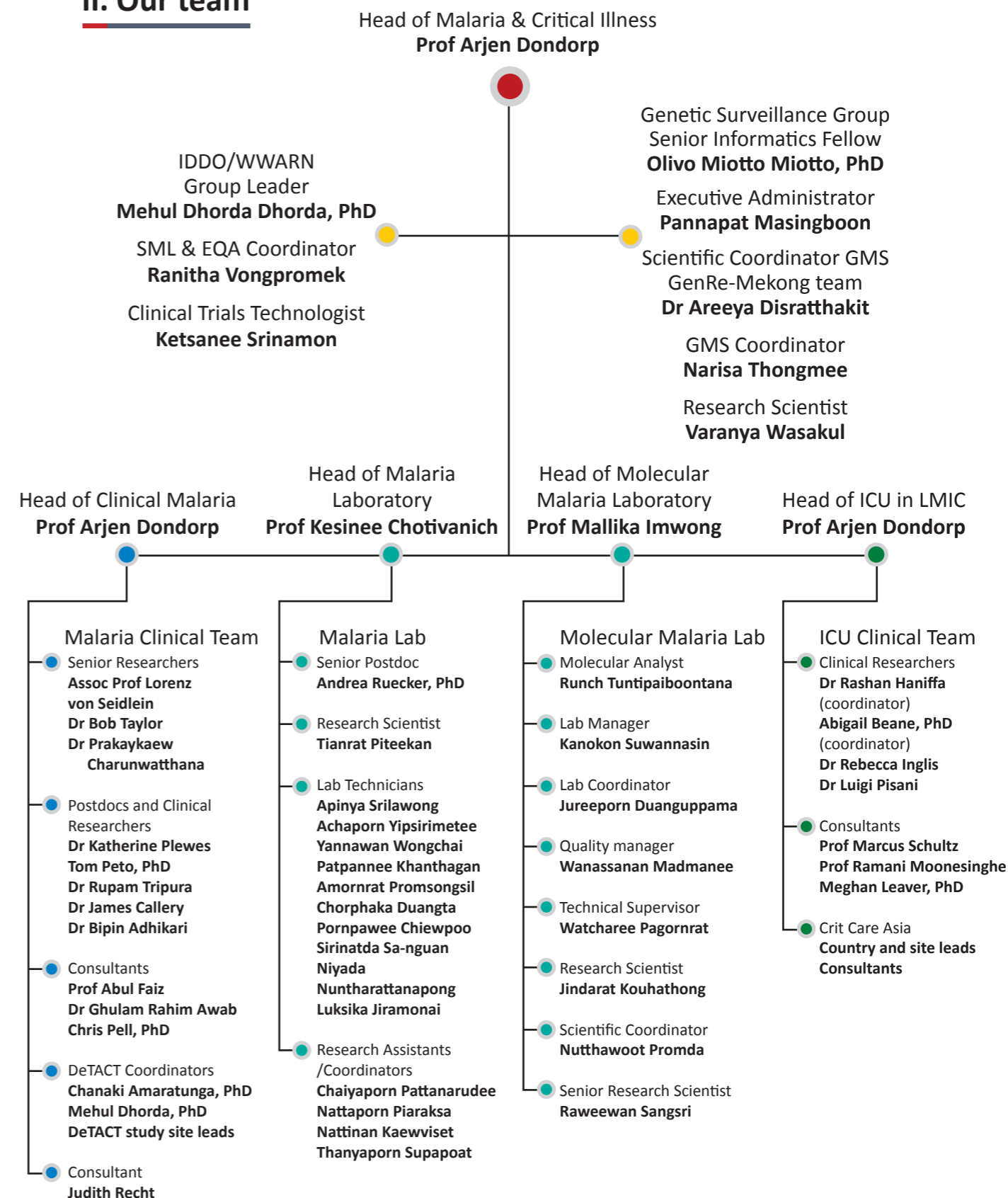
The work on critical illness has further expanded in 2021. The Critical Care Asia network is well-established, with an ICU registry implemented in 42 ICUs in 9 Asian countries. The electronic registry was also implemented beyond the 42 planned ICUs, and has expanded to 7 African countries, contributing to a rapidly expanding dataset comprising epidemiological and quality of care parameters. In addition to the quantitative analysis using the registry, qualitative evaluations of the quality of care in ICUs started in Bangladesh and India. These will feed into locally led quality improvement activities. Registry embedded clinical trials in the network continue, including the REMAP-CAP trial evaluating interventions in severe pneumonia caused by COVID-19 as well as other pathogens.

Ranitha Vongprommek (right) and the Bangkok-based IDDO/WWARN laboratory team. © MORU 2022. Photographer: Gerhard Jøren.

Our existing research infrastructure afforded us an opportunity to contribute to the response to the

COVID-19 pandemic. This included adaptation of the Crit Care Asia ICU registry to capture data related to the COVID-19 pandemic (by early 2022 contributing data of over 20,000 COVID-19 cases from 285 ICU's to ISARIC's international observational cohort). The Indian branch of the network is currently leading a WHO trial to evaluate the benefits of nursing patients with severe COVID-19 in the prone position ("awake proning"). In addition, a series of 10 articles on LMIC-adapted guidelines for the management of severe COVID-19 was written together with a global group of experts (published in the *Am J Trop Med Hyg* in Feb 2021).

II. Our team



III. Scientific achievements in 2021

The Malaria & Critical Illness team published more than 60 papers in 2021, many in leading journals.

The Malaria & Critical Illness Department has made significant achievements in recent years in: malaria elimination; antimalarial drug resistance; treatment of falciparum malaria; vivax malaria; severe malaria; malaria laboratory studies; and intensive care in resource limited settings.

Malaria elimination

- In the eastern Greater Mekong sub-region (GMS) malaria transmission is now almost entirely confined to the forest. A randomised study on the efficacy of artemether-lumefantrine as chemoprophylactic treatment in forest goers in Cambodia was completed in 2021 and will be published soon.



Dr Rupam Tripura (*right*) with members of the EFFORT study team at Kravanh District Hospital in Cambodia. A study on the efficacy of short course primaquine and single dose tafenoquine for radical cure for *P. vivax* (EFFORT) started in 2021 in collaboration with the Cambodian National Malaria Programme (CNMP) and the Menzies School of Health Research. © MORU 2022.

- A systematic review and meta-analysis on the safety of ivermectin in children weighing less than 15 kg was published. This preliminary evidence helps justify the launch of the Ivermectin Safety in Small Children (ISSC) trial in 2022. The ISSC trial will evaluate the safety, pharmacokinetics, and efficacy of ivermectin in children weighing less than 15 kg with partners in Bangladesh, Brazil, Kenya, and The Gambia.

Antimalarial drug resistance

- A large laboratory transcriptomic and cell biological study was published, using parasites and data from the TRAC studies describe the underlying mechanisms of artemisinin resistance in *P. falciparum*.
- The large DeTACT clinical trial evaluating two different Triple Artemisinin-based Therapies (TACTs) started recruitment in 2021 after

being delayed because of the COVID-19 pandemic. Studies on the potential marketing positioning and bioethical issues of TACTs were published.

Treatment of falciparum malaria

- Following the publication of the large multinational trial testing triple artemisinin combination therapies (TACTs) for the treatment of drug resistant falciparum malaria (TRAC II), a follow-up randomised clinical trial on an alternative TACT, arterolane-piperaquine-mefloquine, was evaluated in Kenyan children with uncomplicated falciparum malaria and published in 2021. A randomised controlled trial on the triple ACT artemether-lumefantrine-amodiaquine in areas with high ACT failure in Cambodia and Viet Nam was completed and published.
- A large study on the safety of single low dose primaquine for African children with uncomplicated falciparum malaria, either G6PD normal and deficient, was completed in Kinshasa (KIMORU) and Uganda (KEMRI-Wellcome) and was submitted for publication.

Vivax malaria

- A landmark study in Afghanistan showed for the first time the clear protective effect of Mediterranean type G6PD deficiency against *Plasmodium vivax* malaria and was published in e-Life.
- In collaboration with Menzies School of Public Health and the Cambodia malaria control programme, a study on tafenoquine and primaquine dosing for radical cure in vivax malaria has started successfully.

- An age-based and allometrically scaled, weight-based regimen of primaquine for radical cure for high frequency relapsing *P. vivax* has been developed and published. This will help control programmes in our region make evidenced-based decisions on dosing.



Senior Informatics Fellow Olivo Miotto (*centre*) and the Genetics Surveillance Group work with national malaria control programmes to set up molecular surveillance of antimalarial drug resistance in the GMS. © MORU 2022. Photographer: Gerhard Jøren.

Severe malaria

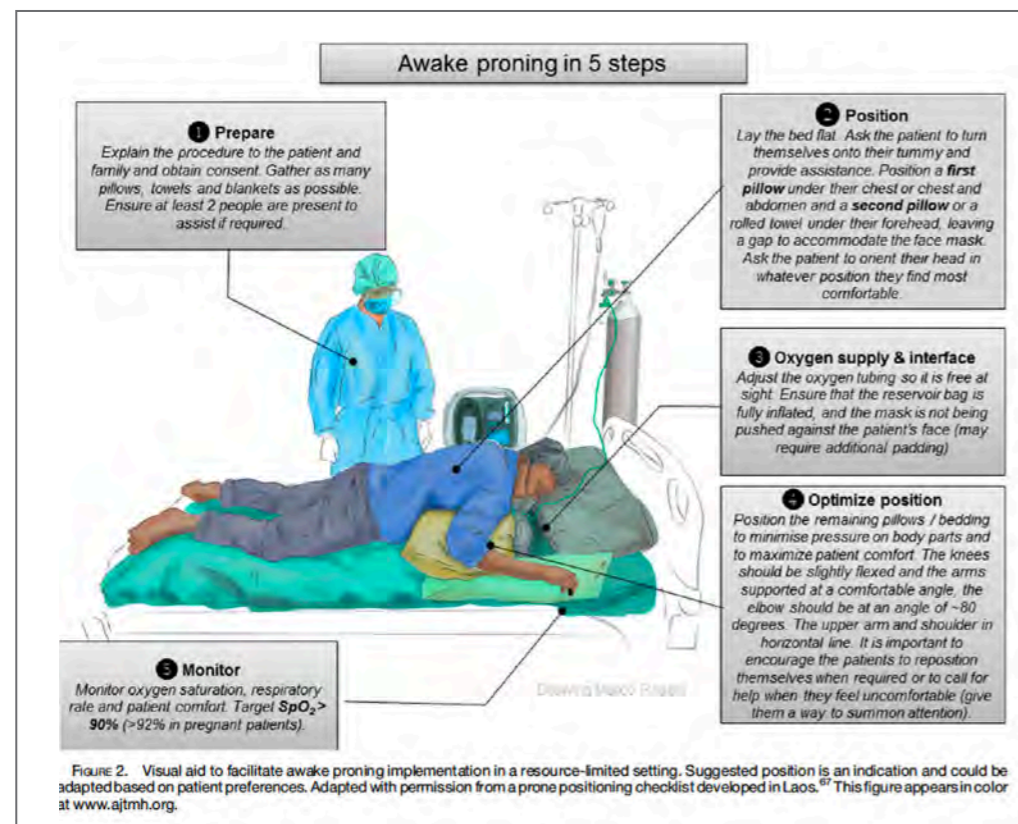
- As part of the SMAART consortium, an observational study on the clinical course of severe malaria compared between 5 African countries was started. This study will now also address specifically the impact of artemisinin resistance on the efficacy of parenteral artesunate for the treatment of severe malaria.
- A study on the reno-protective effect of IV paracetamol in children with severe malaria started in DRC.
- A study evaluating intrapulmonary changes, in particular pulmonary oedema, in children with severe malaria using lung ultrasound was completed in DRC. Results are now being analysed.

Malaria laboratory studies

- Large molecular surveillance studies of antimalarial drug resistance in the GMS were continued and shared on publicly accessible maps.
- The GenRe-Mekong project is continuing successfully, aiming to set up in-country capacity for molecular surveillance of antimalarial drug resistance in the GMS, and providing national malaria programmes with actionable report cards on the genetic epidemiology of malaria using a genetic barcode.
- A study was published showing that artemisinin resistance in falciparum malaria extends to the sexual stages of the parasite and studies on the gametocytocidal effect of primaquine on the sexual stages of artemisinin resistant *P. falciparum* are ongoing.

Intensive care in resource limited settings

- An electronic registry was implemented in >40 ICUs in 9 countries of the Crit Care Asia network, and is currently rolled out further in other Asian and African countries.
- Ongoing and published outputs of the network include descriptions of basic epidemiological aspects of intensive care in the region, evaluation of prognostic scoring tools, evaluation of the quality of care, and quality improvement through audit and feedback loops.
- Development of the network as a clinical trial platform is ongoing, and the network is already participating in a number of multinational trials (see above).



Visual aid to facilitate awake proning implementation in a resource-limited setting, developed by Dr Rebecca Inglis, member of the ICU Clinical team and DPhil student (University of Oxford), as part of a training course to improve the care of critically ill adults. © MORU 2022.

COVID-19

- Contribution of over 20,000 SARI cases to ISARIC's international observational cohort enabled by the Crit Care Asia ICU registry; data collection is now expanding to 7 African countries.
- Participation of 12 ICUs in 3 countries of the Crit Care Asia network in the REMAP-CAP trial on the management of severe COVID-19.
- Coordination of a series of 10 articles on LMIC-adapted guidelines to manage severe COVID-19 (published as open access supplement of the *Am J Trop Med Hyg* in Feb 2021).

IV. Top 10 publications in 2021

1. Mass drug administration for the acceleration of malaria elimination in a region of Myanmar with artemisinin-resistant falciparum malaria: a cluster-randomised trial. McLean ARD, Indrasuta C, Khant ZS, Phyo AK, Maung SM ... Kyaw TT, Dondorp AM, Imwong M, White NJ, Smithuis FM. *Lancet Infect Dis*. 2021 Nov;21(11):1579-1589. doi: 10.1016/S1473-3099(20)30997-X. Epub 2021 Jun 18. PMID: 34147154.
2. Arterolane-piperaquine-mefloquine versus arterolane-piperaquine and artemether-lumefantrine in the treatment of uncomplicated Plasmodium falciparum malaria in Kenyan children: a single-centre, open-label, randomised, non-inferiority trial. Hamaluba M, van der Pluijm RW, Weya J, Njuguna P, Ngama M ... Tarning J, Day NPJ, White NJ, Bejon P, Dondorp AM. *Lancet Infect Dis*. 2021 Oct;21(10):1395-1406. doi: 10.1016/S1473-3099(20)30929-4. Epub 2021 Jun 7. PMID: 34111412; PMCID: PMC8461080.
3. To what extent are the antimalarial markets in African countries ready for a transition to triple artemisinin-based combination therapies? de Haan F, Bolarinwa OA, Guissou R, Tou F, Tindana P ... Dhorda M, Dondorp AM, Ouedraogo JB, Mokuolu OA, Amaratunga C. *PLoS One*. 2021 Aug 31;16(8):e0256567. doi: 10.1371/journal.pone.0256567. PMID: 34464398; PMCID: PMC8407563.



Highly trained local expertise is key to the Malaria & Critical Illness Department's significant achievements in recent years in malaria elimination, antimalarial drug resistance, treatment of falciparum malaria, vivax and severe malaria, malaria laboratory studies, and intensive care in resource limited settings. © MORU 2022. Photographer: Gerhard Jøren.

4. Genetic surveillance in the Greater Mekong subregion and South Asia to support malaria control and elimination. Jacob CG, Thuy-Nhien N, Mayxay M, Maude RJ, Quang HH ... Rockett K, Day NP, Dondorp AM, Kwiatkowski DP, Miotto O. *Elife*. 2021 Aug 10;10:e62997. doi: 10.7554/eLife.62997. PMID: 34372970; PMCID: PMC8354633.
5. A scoping review of registry captured indicators for evaluating quality of critical care in ICU. Jawad I, Rashan S, Sigera C, Salluh J, Dondorp AM, Haniffa R, Beane A. *J Intensive Care*. 2021 Aug 5;9(1):48. doi: 10.1186/s40560-021-00556-6. PMID: 34353360; PMCID: PMC8339165.
6. Improving statistical power in severe malaria genetic association studies by augmenting phenotypic precision. Watson JA, Ndila CM, Uyoga S, Macharia A, Nyutu G ... Dondorp AM, Bejon P, Williams TN, Holmes CC, White NJ. *Elife*. 2021 Jul 6;10:e69698. doi: 10.7554/eLife.69698. PMID: 34225842; PMCID: PMC8315799.
7. Rolling out the radical cure for vivax malaria in Asia: a qualitative study among policy makers and stakeholders. Adhikari B, Awab GR, von Seidlein L. *Malar J*. 2021 Mar 23;20(1):164. doi: 10.1186/s12936-021-03702-5. PMID: 33757538; PMCID: PMC7987122.
8. Protective effect of Mediterranean-type glucose-6-phosphate dehydrogenase deficiency against Plasmodium vivax malaria. Awab GR, Aaram F, Jamornthanyawat N, Suwannasin K, Pa-gornrat W, Watson JA, Woodrow CJ, Dondorp AM, Day NP, Imwong M, White NJ. *Elife*. 2021 Feb 5;10:e62448. doi: 10.7554/eLife.62448. PMID: 33543710; PMCID: PMC7884069.
9. Molecular epidemiology of resistance to antimalarial drugs in the Greater Mekong subregion: an observational study. Imwong M, Dhorda M, Myo Tun K, Thu AM, Phyo AP ... Day NPJ, Dondorp AM, Smithuis FM, Nosten FH, White NJ. *Lancet Infect Dis*. 2020 Dec;20(12):1470-1480. doi: 10.1016/S1473-3099(20)30228-0. Epub 2020 Jul 14. PMID: 32679084; PMCID: PMC7689289.
10. Falciparum malaria mortality in sub-Saharan Africa in the pretreatment era. Watson JA, White NJ, Dondorp AM. *Trends Parasitol*. 2022 Jan;38(1):11-14. doi: 10.1016/j.pt.2021.10.005. Epub 2021 Dec 1. PMID: 34862145.

V. Capacity building achievements in 2021

The Malaria Department has an active, successful postgraduate student programme, with 11 students working on a DPhil or PhD in 2021.

One of the central goals of the Crit Care Asia Flagship programme is to build in-country and in-hospital capacity for data collection, evaluation of the quality of care, quality improvement and clinical research. In its first year of its existence, a number of locally led initiatives in these areas shows the Crit Care Asia network's initial success in achieving this.

Our longstanding collaborators in Chattogram, Bangladesh have now developed successful independent research lines on toxicology and snake bites.

VI. Future Vision

This has not changed essentially from last year's report. The Malaria & Critical Illness Department's future vision includes work to:

Antimalarial drug resistance in *P. falciparum*

- Develop triple ACTs (TACT) for treating multidrug resistant falciparum malaria and preventing emergence and spread of antimalarial drug resistance.
- Understand the biology of artemisinin and partner drug resistant falciparum malaria.



Shown at an DeTACT investigators virtual meeting in February 2021, clockwise from top left, DeTACT study members Chanaki Amaratunga, Arjen Dondorp, Akshaya Kumar Mohanty and Nick White. © MORU 2022.

- Study the effects of drug resistance on gametocyte production and transmissibility.
- Evaluate transcriptomic changes and biological correlates in multidrug resistant *P. falciparum*.
- Study the spread and genetic epidemiology of multidrug resistant *P. falciparum* and develop field adapted methods facilitating molecular surveillance; determine the genetic basis

for increased resistance of *P. falciparum* to artemisinin and partner drugs and validate molecular markers of antimalarial drug resistance.

- Test new antimalarial compounds.

Malaria elimination

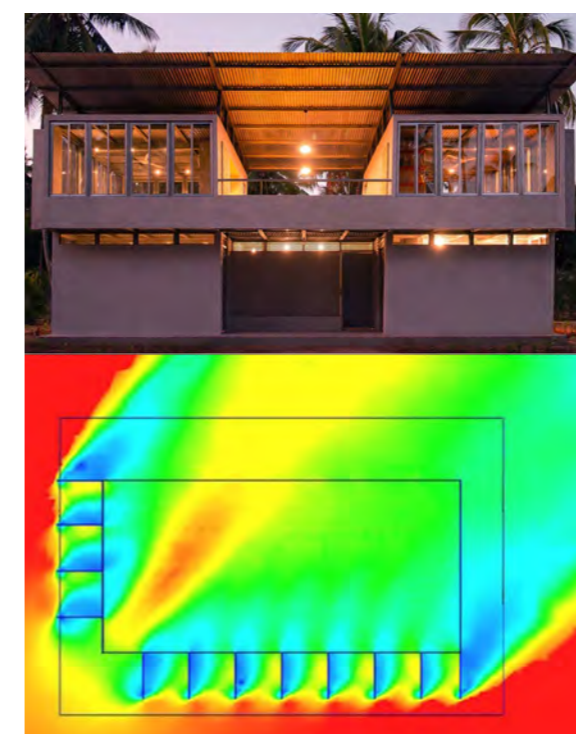
- Study the role of ivermectin in malaria elimination.
- Understand forest worker antimalarial chemoprophylaxis.
- Improve housing in hot humid regions to reduce vector entry and prevent malaria.
- Study the molecular epidemiology and phenotypes of PfHRP2/3 and PfLDH deleted *P. falciparum* in relation to their detection with rapid diagnostic tests.

Severe malaria

- Test paracetamol as reno-protective therapy in African children with severe falciparum malaria.
- Study the free haemoglobin-oxidative stress-AKI pathway in severe malaria.
- Evaluate lung ultrasound as guidance for fluid management in severe falciparum malaria and other paediatric illness.

Vivax malaria

- Optimise radical treatment of vivax malaria with primaquine or tafenoquine.
- Develop innovative primaquine regimens for different regions to obviate the need to test for G6PD deficiency.
- Study CYP2D6 genetic variants and their impact on primaquine efficacy.



A passively cooled research lab in Tanzania, developed by Assoc Prof Lorenz von Seidlein and the Star Homes Project team, who aim to assess the health benefits of improvements in housing in rural Africa. Photo courtesy of ingvartsen architects.

- Run *Plasmodium vivax* Controlled Human Infection Models (with CTU) to speed up vaccine development.
- Perform studies on the roll out of the radical cure for *P. vivax* at village and health post level.

Critical Illness

- Develop and implement setting adapted ICU registries in LMICs and establish a global ICU registry network.
- Understand the contributors to intensive care performance in LMICs.
- Develop sustainable quality improvement models to improve ICU care in LMICs.
- Evaluate the role of lung ultrasound in ICUs in LMICs.
- Optimise mechanical ventilation strategies in LMICs.
- Improve LMIC setting-adapted ICU guidelines.
- Develop an ICU regional clinical trials network.

COVID-19

- Collaborate in COVID-19 treatment trials in the Crit Care Asia ICU network.
- Contribute epidemiological data on patients hospitalised with COVID-19.



Head of Microbiology, Assoc Prof Direk Limmathurotsal (*back, centre*), with Bangkok-based members of MORU Microbiology. © MORU 2022. Photographer: Gerhard Jøren.

Microbiology

I. Overview

Established in 1986, the MORU Bangkok Microbiology Department conducts research on melioidosis, scrub typhus and other rickettsial infections; leptospirosis, the epidemiology of infectious diseases, sepsis, drug-resistant infections, the evaluation of diagnostic tests, and the immunology and cell biology of infectious diseases.

Led by Associate Professor Direk Limmathurotsakul, a Wellcome Trust Intermediate Fellow with expertise in melioidosis, sepsis, antimicrobial resistance (AMR) / drug-resistant infections (DRI) and medical statistics, MORU Microbiology conducts research into clinical and laboratory aspects of bacterial and viral illnesses in Thailand, Bangladesh and Sri Lanka.

In Bangkok, MORU Microbiology operates a US Select Agent Program certified BSL3 laboratory, and BSL2, molecular and serology laboratories. In Thailand, we have clinical research lab facilities and units in Ubon Ratchathani province (Sunpasitthiprasong Hospital) and Chiangrai province (Chiangrai Clinical Research Unit (CCRU) in Chiangrai Prachanukroh Hospital). Microbiology works closely with the microbiology labs of MORU Units SMRU (Thailand), LOMWRU (Lao PDR) and COMRU (Cambodia), with other Wellcome Africa and Asia Programmes (particularly OUCRU in Viet Nam), and collaborates with research organisations across Thailand and Southeast Asia.

The Department continuously conducts training at its various laboratories in clinical microbiology, molecular biology, cell biology, and laboratory safety. In 2018, we set up a sequencing unit in Bangkok with short-read Illumina MiSeq sequencing and bioinformatics analysis capacity.

Microbiology has 14 senior researchers with multiple areas of expertise, 28 middle-level or junior staff in Bangkok, 20 in Ubon Ratchathani and 5 in Chiangrai. The current team includes:

- Yazid Abdad: expertise in fever diagnostics and rickettsial pathogens.



Some of Microbiology's 14 senior researchers, clockwise from left: Yazid Abdad, Elizabeth Batty, Jeanne Salje, Piengchan Sonthayanon, Tri Wangrangsimakul and Vanaporn Wuthiekanun. © MORU 2022. All photos except Yazid Abdad by Gerhard Jøren.

- Elizabeth Batty: expertise in bioinformatics and genomics.
- Stuart Blacksell: expertise in serology, rickettsial diagnostics, and safety, including biosafety, biosecurity and biocontainment.
- Narisara Chantratita: expertise in immunology, host genetics and melioidosis.
- Wirongrong Chierakul: expertise in melioidosis, leptospirosis and scrub typhus.
- Christiane Dolecek: expertise in AMR/DRI and enteric fever.
- Susanna Dunachie: expertise in cellular immunology, COVID-19, scrub typhus and melioidosis.
- Direk Limmathurotsakul: expertise in melioidosis, sepsis, AMR/DRI and medical statistics.
- Jeanne Salje (Royal Society Dorothy Hodgkin Research Fellow): expertise in cell biology and scrub typhus.
- Carlo Perrone: research clinician investigating scrub typhus infections.
- Piengchan Sonthayanon: expertise in molecular microbiology and scrub typhus.
- Janjira Thaipadungpanit: expertise in molecular microbiology, leptospirosis and melioidosis.
- Tri Wangrangsimakul: research clinician leading studies of scrub typhus pathophysiology and treatment. Recently completed an Oxford DPhil.
- Vanaporn Wuthiekanun: expertise in basic microbiology, leptospirosis and melioidosis.

Microbiology also has teams at study sites in Thailand in Ubon Ratchathani and Chiangrai.

Ubon Ratchathani

Sunpasitthiprasong Hospital in Ubon Ratchathani hosts microbiology clinical research lab facilities headed by Gumphol Wongsuvan. These include a BSL2 Laboratory and its AMR/DRI, Sepsis and Melioidosis Prevention Groups. MORU has undertaken many collaborative studies here since 1986, including a landmark randomised controlled trial on the treatment of melioidosis (1989) that reduced the mortality of melioidosis in Thailand by half. Registered clinical studies at Ubon Ratchathani include:

- *Causes and Factors Associated With Outcomes in Community-acquired Sepsis and Severe Sepsis in Northeast Thailand.*
- *An Observational Study of the Causes, Management, and Outcomes of Community-acquired Sepsis and Severe Sepsis in Southeast Asia.*
- *A Single-blind Stepped Wedge Cluster Randomized Controlled Behaviour Change Trial to Determine Effectiveness of Prevention Programme of Melioidosis in Diabetics in Ubon Ratchathani, Northeast Thailand (PREMEL).*
- *Co-trimoxazole as Maintenance Therapy for Melioidosis; Mortality Related to AMR in Patients with Hospital-acquired Infection (HAMR).*
- *Defining Antibiotic Treatment Duration for Ventilator-Associated Lung Infection (REGARD_VAP)*
- *Dissecting the Genetic basis of melioidosis infection (BurkHostGEN).*

Chiangrai Clinical Research Unit (CCRU)

Headed by Carlo Perrone, with a focus on improving health, treatment and prevention, CCRU carries out hospital and community-based research on acute febrile illness, scrub typhus, AMR/DRI, and the ethics of research in vulnerable populations, and also conducts public engagement activities at primary care units (PCUs) in areas of high scrub typhus risk in Chiangrai province. Ongoing registered clinical studies at CCRU include:

- *Defining Causes of Deaths in South and SE Asia (SEACTN-VA).*



Dr Carlo Perrone (*centre*) and the Chiangrai Clinical Research Unit conduct community-based research and public engagement on acute febrile illness, scrub typhus, AMR/DRI,. © MORU 2022. Photographer: Gerhard Jøren.

- Causes and Outcomes of Febrile Illness in Health Facilities in Rural South and SE Asia (SEACTN-WP-B).
- Incidences, Causes, and Outcomes of Febrile Illness in Rural South and SE Asia (SEACTN WP-A).
- Scrub Typhus Antibiotic Resistance Trial (START).

Students and training

Microbiology has an active, successful postgraduate student programme, with 18 DPhil/PhD students in 2021.

III. Scientific achievements in 2021

Microbiology's achievements in 2021 reflect our continued research focus on: melioidosis, sepsis, antimicrobial resistance/drug-resistant infections (AMR/DRI), acute febrile illness, rickettsial infections, clinical studies, and COVID-19.



Shown with Oxford-based Senior Immunologist Barbara Kronsteiner (*left*) and Research Assistant Priyanka Abrahams (*right*), Prof Susanna Dunachie and her Immunology team aim to hold clinical trials in Thailand for a melioidosis vaccine. © MORU 2022. Photographer: Samuel Allard.

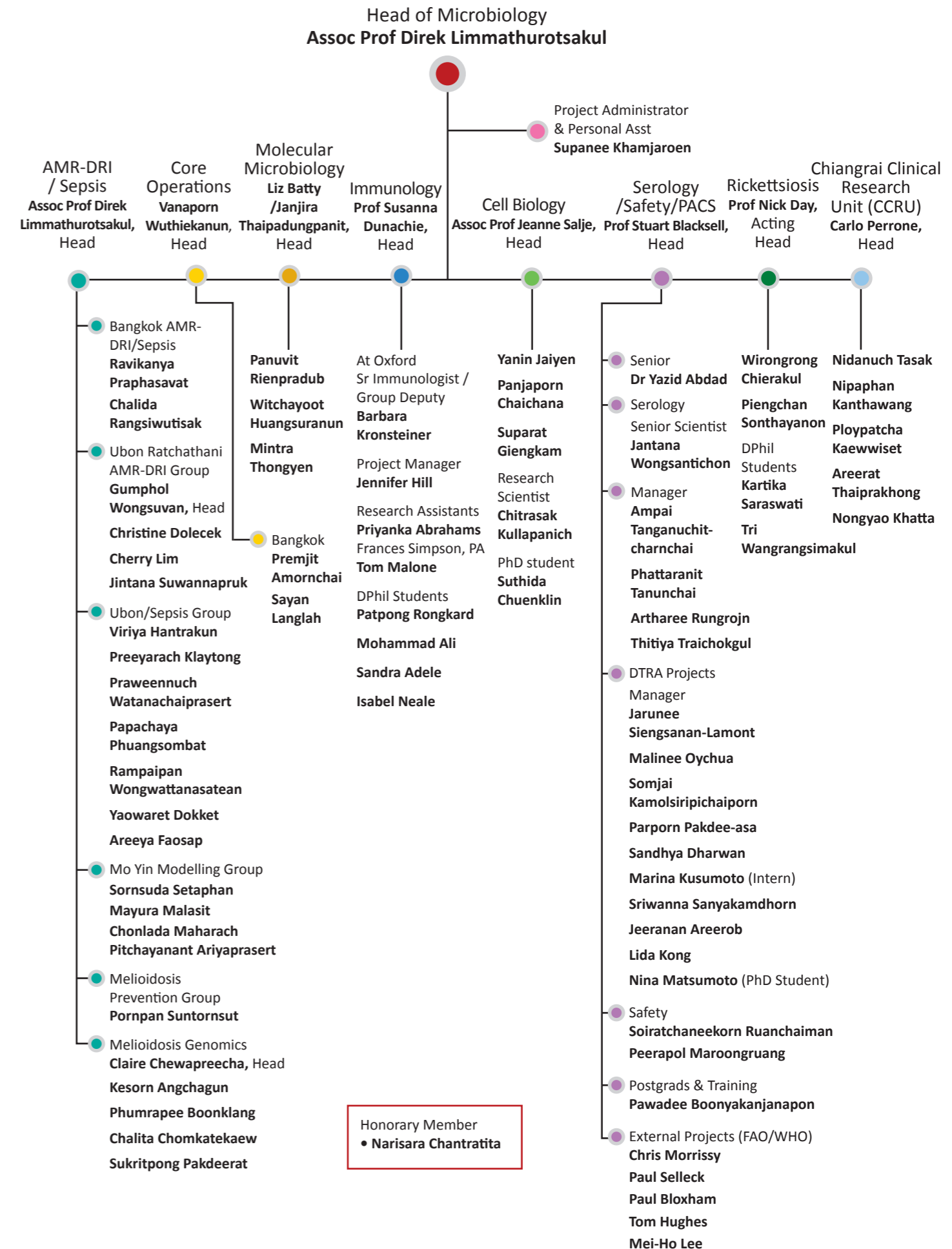
Melioidosis

- Led and supported a large series of publications describing the burden and challenges of melioidosis in countries across our active international melioidosis network (21 publications).
- Developed a rapid immunochromatography test (ICT) for POC detection of IgG antibodies to *B. pseudomallei* Hcp1.
- Showed correlation of IgG2 antibodies and survival from melioidosis; that sera from recovered melioidosis patients could restrict *B. pseudomallei* growth in macrophages; and the cross-reactivity of immune responses to avirulent *B. species* with responses to *B. pseudomallei*.
- Demonstrated genomic loss in environmental and isogenic morphotype isolates of *B.*

pseudomallei and that this mechanism is associated with intracellular survival and plaque-forming efficiency.

- Showed that host tetraspanins are involved in *B. pseudomallei*-induced cell-to-cell fusion of phagocytic and non-phagocytic cells.
- Highlighted that *B. pseudomallei* has been evolutionarily selected to survive nutrient depletion through a combination of genome-wide scan for co-selection signatures across 2,011 genomes, condition-wide transcriptome analyses, and gene knocked-out assays.
- Identified genetic markers associated with environmental or clinical *B. pseudomallei* isolates using genome-wide association studies performed on 1,010 genomes. One of the strongest hits for clinical isolates is Hcp1, which confirms current choice of vaccine target and POC detection.
- Completed a randomized controlled trial, comparing between a 12-week regimen and a 20-week regimen of oral trimethoprim-sulfamethoxazole for an oral eradication treatment, and recommended the 12-week regimen of TMP-SMX for oral eradication treatment of melioidosis.

II. Our team



- Completed a stepped-wedge cluster-randomised controlled trial, evaluating effectiveness of a multifaceted prevention programme for melioidosis in diabetics (PREMEL).
- Collaborated with the Epidemiology Division, Thailand Ministry of Public Health (MoPH), and showed that there were 7,126 culture-confirmed melioidosis patients (2,805 of whom died) identified from 2012 to 2015 in 60 hospitals countrywide.
- Susanna Dunachie secured funding from MRC DPFS, DTRA and NIHR for a clinical trial in Oxford of a University of Nevada developed candidate melioidosis vaccine, aiming to rapidly transition to clinical trials in Thailand.

Sepsis

- Led a large study defining the clinical epidemiology and outcomes of sepsis in northeast Thailand and contributed to the Sepsis Assessment and Identification in Low Resource Settings Collaboration (Ubon-sepsis).
- Showed that some limited critical care resources are commonly managed on general medical wards despite high rates of respiratory failure and shock. Enhancing sepsis care in emergency departments and general wards, and improving access to ICUs, may reduce mortality.
- Demonstrated that sTREM-1 can predict mortality from infection in a tropical, middle-income country comparably to a model derived from clinical variables.
- Showed that a two-biomarker model, including interleukin-6 and interleukin-8, can predict 28-day mortality in melioidosis.

Antimicrobial resistance/drug resistant infections (AMR/DRI)

- Promoted 'Antibiotic footprint' concept as a tool to communicate to the public the magnitude of antibiotic use in humans, animals and industry, and how it could support the reduction of overuse and misuse of antibiotics worldwide (www.antibioticfootprint.net).
- Developed the AutoMated tool for Antimicrobial resistance Surveillance System (AMASS; www.amass.website) to support clinical microbiology laboratories to analyse their microbiology and hospital data files (in CSV or Excel format) onsite, and promptly generate AMR surveillance reports (in PDF and CSV formats).
- Showed that previously estimated global burdens of AMR are not comparable because of their different methodological approaches, assumptions, and data used to generate the estimates. We defined key actions required and called for innovative thinking and solutions to address these problems.
- Demonstrated that impacts of low blood culture utilization rate on the estimated proportions and incidence rates of AMR infections could be high. We recommended that AMR surveillance reports should additionally include blood culture utilization rate and stratification by exposure to a parenteral antibiotic at the hospital.
- Continued to build data to estimate the global burden of AMR as part of the GRAM project, and published an opinion piece on the challenges of estimating the global burden of AMR.

Acute febrile illness

- Reported on 'causes of fever' in Chiangrai, northern Thailand. Scrub typhus and dengue were the major aetiologies seen, and biomarkers (particularly CRP) were found to have a role in differentiating viral from bacterial infections.
- Completed social science studies and described local conceptions of illness, medicine, and the role of point of care CRP testing.
- Demonstrated a modest reduction in antibiotic prescribing with the use of standalone CRT testing in the community in acutely febrile patients in SE Asia – results of the CRP RCT in Thailand and Myanmar.

Rickettsial infections

- Completed a genome-wide siRNA screen to identify host factors involved in early stages of bacterial entry.
- Performed a detailed reannotation of the complex mobile genetic elements and repetitive genes in the reference genomes of *Orientia tsutsugamushi*.



Co-Head of Molecular Microbiology, Janjira Thaipadungpanit (right). © MORU 2022. Photographer: Gerhard Jøren.

- Expanded the rickettsial cell biology group to include a second research site at Rutgers University, USA.
- Championed a risk-based approach to lab safety when working with rickettsial pathogens.
- Clinically characterised paediatric scrub typhus in Chiangrai, northern Thailand, and explored the factors contributing to high complication and treatment failure rates.
- Performed and published a large-scale validation study for scrub typhus ELISAs, including geographically appropriate diagnostic cut-off.
- Coordinated the Rickettsia Threat Reduction Network and developed and managed the website/database for mapping rickettsial cases worldwide (www.Rickettsia.net).
- Provided rickettsial diagnostic support for the LSHTM Febrile Illness Evaluation in a Broad Range of Endemicities (FIEBRE) study.

COVID-19

- Worked with the Department of Disease Control, MoPH Thailand to evaluate effectiveness of personal protective measures against severe acute respiratory disease coronavirus 2 (SARS-CoV-2) infection. Our findings support consistent wearing of masks, handwashing, and social distancing to protect against COVID-19.
- Collaborated on continued genomic surveillance of SARS-CoV-2 in Thailand. Showed that the SARS-CoV-2 A.6/Thai-1 lineage contains a frame-shift deletion at ORF7a, encoding a putative host antagonizing factor of the virus.
- Stuart Blacksell, a member of the WHO International Health Regulations COVID-19 expert committee, participated in the development and updates of WHO COVID-19 biosafety guidance including global and regional implementation webinars.
- Provided COVID-19 specific biosafety training using e-learning modules via existing regional FAO projects to assist global support efforts.
- Susanna Dunachie led a research team of 5 principal investigators in Oxford characterising the T cell response to SARS-CoV-2, published in *Nature Communication*, and established a UK national study of healthcare workers' response to natural infection and vaccination.
- Undertaking a cross sectional study of antibody and T cell immune response to SARS-CoV-2 in Bangladesh inpatients and healthcare workers.
- Stuart Blacksell is a member of the WHO special advisory group on the origins of novel pathogens (SAGO) investigating COVID-19's origins.



Prof Stuart Blacksell (back, 2nd left) and members of the MORU Safety team. © MORU 2022. Photographer: Gerhard Jøren.

Ongoing

- Eschar investigations in scrub typhus study (CCRU, Chiangrai).
- Scrub typhus antibiotic resistance trial (CCRU, Chiangrai).
- Sepsis-3 study (Ubon Ratchathani Unit).

MORU Bangkok-based Departments

- Expanded the rickettsial cell biology group to include a second research site at Rutgers University, USA.
 - Championed a risk-based approach to lab safety when working with rickettsial pathogens.
 - Clinically characterised paediatric scrub typhus in Chiangrai, northern Thailand, and explored the factors contributing to high complication and treatment failure rates.
 - Performed and published a large-scale validation study for scrub typhus ELISAs, including geographically appropriate diagnostic cut-off.
 - Coordinated the Rickettsia Threat Reduction Network and developed and managed the website/database for mapping rickettsial cases worldwide (www.Rickettsia.net).
 - Provided rickettsial diagnostic support for the LSHTM Febrile Illness Evaluation in a Broad Range of Endemicities (FIEBRE) study.
- ### Global/Regional Biosafety
- Stuart Blacksell was a member of the WHO Laboratory biosafety manual 4th edition editorial team and lead author of the associated monographs, Laboratory design and maintenance and Biosafety cabinet and primary containment devices.
 - Participated in the European Union project 81 developing e-learning modules to support SE Asia and countries in developing surge capacity for pandemic threats such as COVID-19.

- Hospital-acquired antibiotic-resistant infection (Ubon Ratchathani Unit).
- Multicentre trial on the antibiotic treatment of scrub typhus (INTREST study) in India.
- Barriers and facilitators to the adoption of blood culture sampling recommendations.
- Utility of the AutoMated tool for Antimicrobial resistance Surveillance System plus National Notifiable Disease Surveillance System (AMASS+), a pilot implementation study in Health Area 10 in five provinces in northeast Thailand.
- BurkHostGEN to identify genetic markers in both *B. pseudomallei* and human hosts that result in poorer infection outcome (Ubon Ratchathani Unit).

IV. Top 10 publications in 2021



Claire Chewapreecha heads Microbiology's Melioidosis Genomics Group. © MORU 2022. Photographer: Gerhard Jøren.

Melioidosis

1. Effectiveness of a multifaceted prevention programme for melioidosis in diabetics (PREMEL): A stepped-wedge cluster-randomised controlled trial. Suntornsut P, Teparrukkul P, Wongsuvan G, Chaowagul W, Michie S, Day NPJ, Limmathurotsakul D. *PLoS Negl Trop Dis*. 2021;15(6):e0009060. doi: 10.1371/journal.pntd.0009060. PMID: 34170931; PMCID: PMC8266097.
2. Co-evolutionary signals identify *Burkholderia pseudomallei* survival strategies in a hostile environment. Chewapreecha C, Pensar J, Chattagul S, Pesonen M, Sangphukieo A ... Day NPJ, Parkhill J, Thomson NR, Sermswan RW, Corander J. *Mol Biol Evol*. 2021. doi: 10.1093/molbev/msab306. PMID: 34662416; PMCID: PMC8760936.

Rickettsial infections

3. Discovery of a diverse set of bacteria that build their cell walls without the canonical peptidoglycan polymerase aPBP. Atwal S, Chuenklin S, Bonder EM, Flores J, Gillespie JJ, Driscoll TP, Salje J. *mBio*. 2021;12(4):e0134221. PMID: 34311584; PMCID: PMC8406291.
4. *Orientia tsutsugamushi* dynamics in vectors and hosts: ecology and risk factors for foci of scrub typhus transmission in northern Thailand. Elliott I, Thangnimitchok N, Chaisiri K, Wangrangsimakul T, Jaiboon P, Day NPJ, Paris DH, Newton PN, Morand S. *Parasit Vectors*. 2021;14(1):540. PMID: 34663445; PMCID: PMC8524837.

Sepsis

5. Effectiveness of a sepsis programme in a resource-limited setting: a retrospective analysis of data of a prospective observational study (Ubon-sepsis). Booraphun S, Hantrakun V, Siriboon S, Boonsri C, Poomthong P ... Day NPJ, Dondorp AM, Teparrukkul P, West TE, Limmathurotsakul D. *BMJ Open*. 2028;11(2):e041022. PMID: 33602702; PMCID: PMC7896572.
6. Comparative clinical characteristics and outcomes of patients with community acquired bacteremia caused by *Escherichia coli*, *Burkholderia pseudomallei* and *Staphylococcus aureus*: A prospective observational study (Ubon-sepsis). Somayaji R, Hantrakun V, Teparrukkul P, Wongsuvan G, Rudd KE, Day NPJ, West TE, Limmathurotsakul D. *PLoS Negl Trop Dis*. 2021;15(9):e0009704. PMID: 34478439; PMCID: PMC8415581.

AMR/DRI

7. Impact of low blood culture usage on rates of antimicrobial resistance. Lim C, Hantrakun V, Teerawattanasook N, Srisamang P, Teparrukkul P, Sumpradit N, Turner P, Day NP, Cooper BS, Peacock SJ, Limmathurotsakul D. *J Infect*. 2021;82(3):355-362. PMID: 33278401; PMCID: PMC7994019.
8. Effect of delays in concordant antibiotic treatment on mortality in patients with hospital-acquired *Acinetobacter* species bacteremia: Emulating a target randomized trial with a 13-year

retrospective cohort. Lim C, Mo Y, Teparrukkul P, Hongsuwan M, Day NPJ, Limmathurotsakul D, Cooper BS. *Am J Epidemiol*. 2021;190(11):2395-2404. PMID: 34048554; PMCID: PMC8561124.

COVID-19

9. Case-Control Study of Use of Personal Protective Measures and Risk for SARS-CoV 2 Infection, Thailand. Doung-Ngern P, Suphanchaimat R, Panjangampathana A, Janekrongtham C, Ruampoom D ... Kripattanapong S, Chantian T, Bloss E, Namwat C, Limmathurotsakul D. *Emerg Infect Dis*. 2020;26(11):2607-2616. PMID: 32931726; PMCID: PMC7588529.
10. Genomic surveillance of SARS-CoV-2 in Thailand reveals mixed imported populations, a local lineage expansion and a virus with truncated ORF7a. Joonlasak K, Batty EM, Kochakarn T, Panthan B, Kümpornsin K ... Sungkanuparph S, Pasomsab E, Klungthong C, Chookajorn T, Chantratita W. *Virus Res*. 2021 Jan 15;292:198233. PMID: 33227343; PMCID: PMC7679658.

V. Capacity building achievements in 2021

- Developed a strong collaboration and the capacity to conduct epidemiological studies with the Department of Disease Control, MoPH, Thailand as shown by the published study of effectiveness of mask wearing against COVID-19 in Thailand.
- Created a strong collaboration and the capacity to conduct genetic epidemiology with the emerging infectious disease network in Thailand as shown in the published study of genetic epidemiology of SARS-CoV-2 in Thailand.
- Provided biosafety and biosecurity training and advice to WHO headquarters and SE Asian regional office (SEARO) and SEARO member states.
- Gave biosafety and biosecurity training and advice to SEA regional FAO emergency centre for transboundary animal disease programme.
- Provided biosafety and biosecurity support to the US government Defence Threat Reduction Agency's Biological Threat Reduction Program in SEA.

VI. Future Vision



Senior researcher Narisara Chantratita has developed a rapid diagnostic test for melioidosis. © MORU 2022. Photographer: John Bleho.

MORU Microbiology aims to be a leader in developing and deploying prospective AMR surveillance systems for LMICs, and a global leader in melioidosis and rickettsiosis research. We will engage policymakers, healthcare providers, and the public to achieve policy changes for better surveillance, diagnosis, treatment and prevention for these diseases.

The MORU Microbiology Department will focus its research efforts on these areas and will:

Antimicrobial resistance/drug resistant infections (AMR/DRI)

- Develop and deploy prospective AMR surveillance systems for LMICs. By leading the A Clinically Oriented Antimicrobial Resistance Network (ACORN) study, the MORU Network aims to improve and evaluate a comprehensive data capture system in study sites in Lao PDR and Viet Nam.
- Lead on the development of methods to utilise readily available routine data for AMR surveillance. Collaborating with the MoPH, Thailand, we will enhance data sharing by using the 'AutoMated tool for Antimicrobial resistance Surveillance System' (AMASS) to share reports and anonymous summary data at Wellcome AAP sites and with new partners. We will also work closely with the GRAM project and with the new Singapore-based ADVANCE-ID Network.
- Take the lead in AMR data analysis and improving blood culture utilisation practice in LMICs.

- Research on how best to communicate and engage with policymakers and the public on AMR.

Melioidosis and diabetes mellitus

- Maintain our global leadership in melioidosis research, focussing on epidemiology, diagnosis, treatment and prevention.
- Continue to host and develop a hub for the research community to share information, maps, and data, and foster communication between researchers.
- Identify bacterial genetic factors that determine disease severity, identify host biomarkers associated with susceptibility to melioidosis and disease severity, and construct models scoring bacterial and host factors to predict disease outcome.
- Carry out clinical and laboratory research to improve our understanding of the association between melioidosis and diabetes mellitus, their immune regulation and dysfunction.
- Prepare for a clinical trial of a candidate vaccine for melioidosis in Thailand, following a phase I trial in Oxford in 2023.
- Improve our understanding of in-host responses during infection by conducting a series of studies on bacterial and host “-omics”. We will integrate clinical data with “-omics” data from regional and global partners, and carry out hypothesis-driven experimental work.
- Conduct community engagement study of melioidosis vaccine attitudes in Ubon Ratchathani (MeVa).



BSL Lab Manager Premjit Amornchai. In Bangkok, MORU Microbiology operates a US Select Agent Program certified BSL3 laboratory, and BSL2, molecular and serology laboratories. © MORU 2022. Photographer: Gerhard Jøren.

Rickettsioses

Become a global leader in tropical rickettsiosis research, studying epidemiology, diagnosis, treatment and prevention. We will:

- Develop a rickettsiosis research hub to promote sharing clinical and laboratory data within the research community and foster communication and collaboration between researchers.
- Finish 2 scrub typhus treatment clinical trials.
- Develop rationale for scrub typhus vaccination and conduct non-human primate studies of vaccine candidates. Create evidence base to develop and safely conduct a controlled human scrub typhus infection model, including investigating the significance of persistence and dormancy.
- Develop and improve technologies to study cell biology and host-pathogen interactions of fastidious, genetically-intractable bacterial organisms, especially the Rickettsiales.
- Study fundamental aspects of the host-pathogen cell biology of *Orientia tsutsugamushi* with focussing on the peptidoglycan cell wall and its interaction with host cells, the intracellular infection cycle of the bacterium, and the mechanisms of virulence in hosts.
- Initiate a comparative cell biology programme on obligate intracellular Rickettsiales bacteria including *R. typhi* and *Neorickettsia sennetsu*.

Bioinformatics

Provide leadership in Southeast Asia on integrating and analysing local, regional and global bioinformatics data with clinical data in neglected tropical infectious disease, leveraging our large melioidosis, rickettsiosis and AMR/DRI networks. We will:

- Develop and evaluate how sequencing could be used on-site in LMICs. MORU is introducing Oxford Nanopore sequencing into our research projects to enable on-site sequencing in sites outside Bangkok, and investigate its utility in diagnostics and AMR investigation in real-time;
- Build local bioinformatics and genomics capacity through training lectures and workshops;
- Study the genomes and the population genomics of *Orientia tsutsugamushi*, *B. pseudomallei*, SARS-CoV-2 and their genome dynamics over time.

Global/Regional Biosafety

Under the leadership of Stuart Blacksell, recently re-appointed to the WHO Technical Advisory Group for Biosafety (TAG-B), we will continue to strengthen MORU's reputation as a regional centre of excellence in biosafety and biosecurity. We will:

- Apply for WHO collaborating Centre in Biosafety and Biosecurity;
- Continue support to FAO, WHO, World Organisation for Animal Health (OIE) and other global agencies as a regional leader in Biosafety and Biosecurity methodologies and training.

COVID-19 and outbreak preparedness

- Develop expertise in live virus and pseudovirus neutralisation assays, ELISA and T cell studies to enable local study of immunity to current and emerging pathogens of concern.



Microbiology lab evaluated multiplex, quantitative RDTs that can diagnose a panel of common tropical infectious diseases with high sensitivity and specificity. © MORU 2022. Photographer: Gerhard Jøren.



A compact flow cytometer made to provide maximum speed and reliability in high-throughput screening used in Susanna Dunachie's Oxford lab. © MORU 2022. Photographer: Samuel Allard.



Professor Richard Maude (back, left), Head of Epidemiology, with Bangkok based members of the department. Partnering with policymakers in South and Southeast Asia to address the scientific questions most pertinent to their disease control and elimination agendas and to generate evidence to inform policy decisions, MORU Epidemiology has staff and students based in Bangladesh, Cambodia, Lao PDR, Malaysia, Myanmar, the People’s Republic of China, the Philippines, South Africa, Thailand, the United Kingdom and Viet Nam. © MORU 2022. Photographer: Gerhard Jøren.

Epidemiology

I. Overview

MORU Epidemiology studies the factors that contribute to the risk of different diseases and how to reduce those risks. The research portfolio includes clinical studies, descriptive epidemiology, social science, and statistical and mathematical modelling of human diseases, principally in South and Southeast Asia, with a current focus on malaria, dengue, scrub typhus, COVID-19, health facility and population mapping, and environmental health.

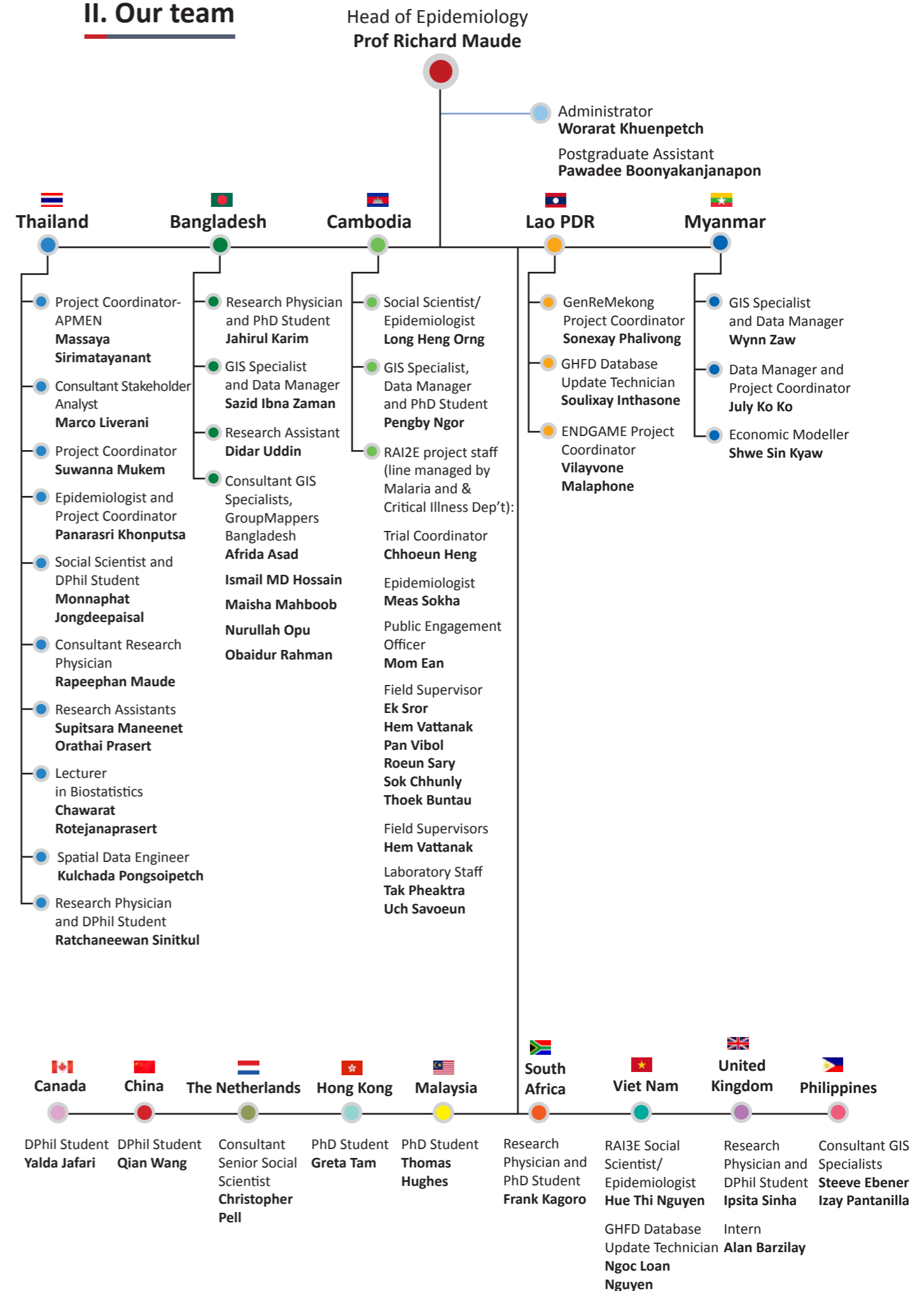
Headed by Prof. Richard Maude, the Epidemiology Department at MORU works in close collaboration with other departments and units across the MORU network, national disease control programmes and a broad range of other collaborators. In all projects, the Epidemiology Department works with policy-makers as partners to address the scientific questions most pertinent to the disease control and elimination agendas and generate evidence to inform policy decisions.

We have staff and students based in Bangladesh, Cambodia, Lao PDR, Malaysia, Myanmar, the People’s Republic of China, the Philippines, South Africa, Thailand, the United Kingdom and Viet Nam.



Head of Epidemiology, Prof Richard Maude. © MORU 2022. Photographer: Gerhard Jøren.

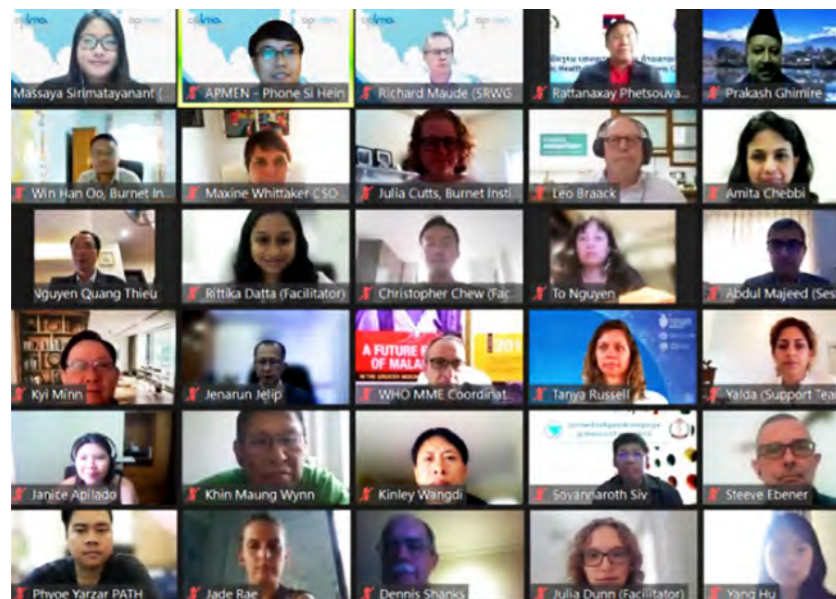
II. Our team



The Epidemiology Department's primary research aims to quantify the burden of malaria, dengue, scrub typhus and other communicable diseases in South and Southeast Asia over space and time and investigate their determinants to inform planning of disease control and elimination strategies. Core components include:

- Clinical and epidemiological field studies;
- Collation and analysis of secondary data from a wide range of partners;
- Disease trend and risk factor analysis;
- Mapping, spatial statistical analysis, and modelling;
- Stakeholder interviews and health policy analysis; and
- Building epidemiology, modelling and mapping capacity across the region.

III. Scientific achievements in 2021

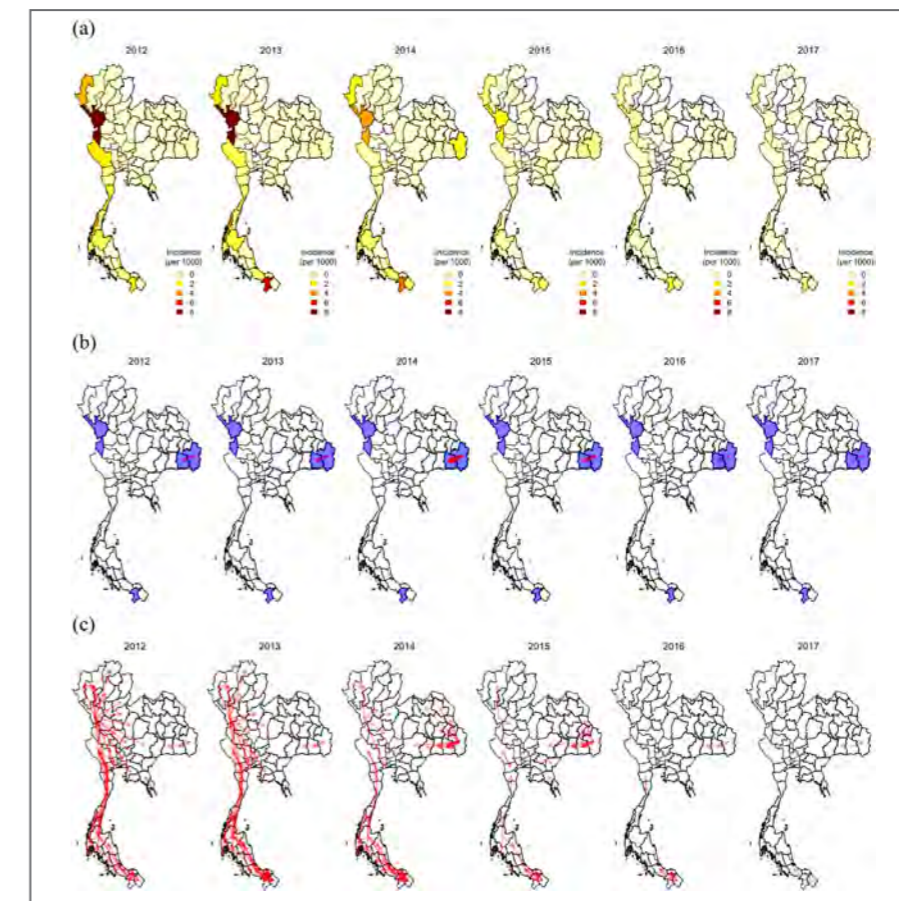


A screengrab of some of the 130 participants to the 1-3 Nov 2021 Asia Pacific Malaria Elimination Network (APMEN) Surveillance and Response Working Group (SRWG) AGM. Head of MORU Epidemiology Richard Maude (*top centre*) is SRWG and meeting co-chair. The meeting theme was Data to Elimination: Prioritizing Gaps in Research and Capacity Development for Surveillance and Response. © MORU 2022.

Malaria

- Completed a large randomised trial of malaria prophylaxis in forest goers in Cambodia (working with Malaria and Critical Care), and associated qualitative studies on the feasibility of prophylaxis and mapping travel patterns of forest goers in Cambodia, Lao PDR, and Thailand. These showed prophylaxis was highly effective in preventing malaria, was well tolerated by participants and was broadly acceptable to communities. Results were shared with a broad range of partners to inform ongoing discussions about implementing prophylaxis as an intervention in the Greater Mekong Subregion.
- Completed surveys on malaria prevention preferences and bed net usage Thailand, Cambodia and Lao PDR.
- Completed a systematic review in implementing organisation interviews on expanded roles to sustain village malaria workers in the Asia Pacific.
- Conducted stakeholder interviews and community surveys on expanded roles of community health workers beyond malaria in Cambodia, Thailand, and Viet Nam.
- Mapped travel patterns of forest goers in Cambodia, Lao PDR, and Thailand and developed new methods to analyse GPS tracking data to identify potential malaria transmission sites in the forest.
- Supported ongoing implementation of our standardised travel survey tool for quantifying population movement in people with malaria. This is continuing to be implemented in a range of collaborative studies across the Greater Mekong subregion and Africa. To date, working

- in partnership with national malaria control programmes (NMCPs), we have collected and analysed over 13,000 demographic and travel surveys from people with malaria.
- Continued to update our End-to-End data pipeline and interactive online application for Ministries of Health to share interactive analyses of demographic and travel surveys with national malaria control programmes.
- Completed a modelling study with the Thai government on the impact of population movement on malaria distribution in Thailand using cell phone data.
- Developed new statistical forecasting methods for sparse malaria incidence data in Thailand.
- Completed analysis of over 5,000 cell phone usage surveys among people with malaria in Lao PDR.
- Supported the Cambodian government to continue mapping and counting population in villages in malaria endemic Cambodia across the whole country.
- Continued to support the Cambodian government with stratification for malaria using new analytical methods first developed by us in 2019-20. The Cambodian government adopted and applied this nationwide. We have helped them to integrate it in their Malaria Information System and they used it to underpin their national elimination strategy and Global Fund applications for malaria elimination.
- Conducted ongoing analyses and mapping of routine malaria incidence data in Bangladesh, Cambodia, Lao PDR, Myanmar, Thailand, and Viet Nam to answer priority questions identified by their Ministries of Health (MOHs).
- Provided support to the GenReMekong malaria genetics project which has collected over 13,000 dried blood spots for genetic analysis.
- Developed and published a set of minimum reporting criteria for studies collecting genetic markers of antimalarial resistance.



A metapopulation model that used mobile phone call data to estimate malaria parasite flow between three main hotspots of malaria transmission in Thailand showed that parasite connectivity between them was limited, suggesting the need for separate malaria control and elimination policies for each area. © MORU 2022.

- Contributed to development of new international guidelines including the WHO and UN-Habitat Global Response Framework to Malaria and Mosquito-transmitted Diseases in Urban Areas 2021-30; the WHO/UNICEF Geo Enabled Digital Microplanning Handbook; and the CHAI/CHIC/GF/UNICEF Implementation Support Guide: Development of a National Georeferenced Community Health Worker Master List Hosted in a Registry.

COVID-19

- Provided regular population movement analysis, population distribution and Facebook distancing data to the Thai government to monitor the impact of COVID-19 lockdown measures. This was maintained and delivered as a dashboard for the Thai government COVID-19 Emergency Operations Center.
- Conducted an observational study on facemask usage in Thailand, Bangladesh, Lao PDR, Myanmar, PR China and Viet Nam with over 100,000 observations from March 2020 to date.
- Completed in-depth interviews to assess knowledge, attitudes and practice for personal protection against COVID-19 among healthcare workers in Thailand.
- Completed geospatial analysis of accessibility of healthcare services for COVID-19 in Bangladesh and Lao PDR and shared results with Ministries of Health.
- Used ongoing analysis of population movement, population distribution and distancing data from Facebook, Google and Apple to quantify the impact of measures against COVID-19 in Bangladesh, Cambodia, Lao PDR, Myanmar, Thailand, and Viet Nam.
- Provided extensive geospatial data collection and analysis support to the Ministry of Health and Family Welfare for COVID-19 response in Bangladesh. This included creating and maintaining COVID-19 situation dashboards, analysis for risk zoning of Dhaka city and updating and correcting map boundary files for the whole country.

Dengue

- Performed ongoing analyses of the dengue situation and factors driving spatiotemporal patterns in Thailand and Myanmar for the Ministries of Health.
- Completed a systematic review of sensitivity and specificity of WHO dengue clinical definitions and implications for surveillance.
- Provided ongoing support for the Ministry of Health and Sports in Myanmar to introduce serology for dengue surveillance in preparation for a large intervention trial.

Environmental health

- Completed follow-up for a cohort study of pregnant women and infants in Thailand in collaboration with the Faculty of Medicine, Mahidol University, Public Health England and the Pollution Control Department of the Thai Ministry of Public Health to study the impact of environmental pollution on health.

IV. Top 10 publications in 2021

- Bayesian spatio-temporal distributed lag modelling for delayed climatic effects on sparse malaria incidence data. Rotejanaprasert C, Ekapirat N, Sudathip P, Maude RJ. *BMC Med Res Methodol.* 2021;21(1):287. PMID: 34930128, PMCID: 8690908.
- Low parasite connectivity among three malaria hotspots in Thailand. Chang HH, Chang MC, Kiang M, Mahmud AS, Ekapirat N, Engø-Monsen K, Sudathip P, Buckee CO, Maude RJ. *Sci Rep.* 2021;11(1):23348. PMID: 34857842, PMCID: 8640040.
- Acceptability and feasibility of malaria prophylaxis for forest goers: findings from a qualitative study in Cambodia. Jongdeepaisal M, Ean M, Heng C, Buntan T, Tripura R, Callery JJ, Peto TJ, Conrads-Jansen F, von Seidlein L, Khonputsu P, Pongsoipetch K, Soviet O, Sovannarothe S, Pell C, Maude RJ. *Malar J.* 2021;20(1):446. PMID: 34823527, PMCID: 8613728

- Risk factors for malaria in high incidence areas of Viet Nam: a case-control study. Maude RJ, Ngo TD, Tran DT, Nguyen BTH, Dang DV, Tran LK, Gregory M, Maude RR, Sinha I, Pongsoipetch K, Martin NJ. *Malar J.* 2021;20(1):373. PMID: 34535140, PMCID: 8446736.
- Study protocol: an open-label individually randomised controlled trial to assess the efficacy of artemether-lumefantrine prophylaxis for malaria among forest goers in Cambodia. Maude RJ, Tripura R, Ean M, Sokha M, Peto TJ ... Mukaka M, Waithira N, Soviet O, von Seidlein L, Sovannarothe S. *BMJ Open.* 2021;11(7):e045900. PMID: 34233975, PMCID: 8264911.
- Analysing human population movement data for malaria control and elimination. Tam G, Cowling BJ, Maude RJ. *Malar J.* 2021;20(1):294. PMID: 34193167, PMCID: 8247220.
- Diagnostic accuracy of the WHO clinical definitions for dengue and implications for surveillance: A systematic review and meta-analysis. Raafat N, Loganathan S, Mukaka M, Blacksell SD, Maude RJ. *PLoS Negl Trop Dis.* 2021;15(4):e0009359. PMID: 33901191, PMCID: 8102005.
- Improving knowledge, attitudes and practice to prevent COVID-19 transmission in healthcare workers and the public in Thailand. Maude RR, Jongdeepaisal M, Skuntaniyom S, Muntajit T, Blacksell SD, Khuenpetch W, Pan-Ngum W, Taleangkaphan K, Malathum K, Maude RJ. *BMC Public Health.* 2021;21(1):749. PMID: 33865342, PMCID: 8053080.
- Spatiotemporal distributed lag modelling of multiple Plasmodium species in a malaria elimination setting. Rotejanaprasert C, Lee D, Ekapirat N, Sudathip P, Maude RJ. *Stat Methods Med Res.* 2021;30(1):22-34. PMID: 33595402.
- Incorporating human mobility data improves forecasts of dengue fever in Thailand. Kiang MV, Santillana M, Chen JT, Onnela JP, Krieger N, Engø-Monsen K, Ekapirat N, Areechokchai D, Prempeh P, Maude RJ, Buckee CO. *Sci Rep.* 2021;11(1):923. PMID: 33441598, PMCID: 7806770.

V. Capacity building achievements in 2021

During 2021, Epidemiology conducted a training needs assessment survey and training development workshop as well as a malaria research priority identification and ranking workshop of Asia-Pacific National Malaria Programmes and partners. In 2021, we ran workshops on surveillance of antimalarial drug resistance for the Asia-Pacific region, mathematical modelling in Lao PDR and GIS in Bangladesh. One-on-one support was also provided to National Malaria Programmes in the GMS and Bangladesh for collation and validation of routine surveillance data.



The MORU Epidemiology supported Group Mappers volunteer network in Bangladesh made Connecting GIS to Language the theme of their February 2021 newsletter, which used geospatial science to illustrate the importance of language and culture. © MORU 2022.

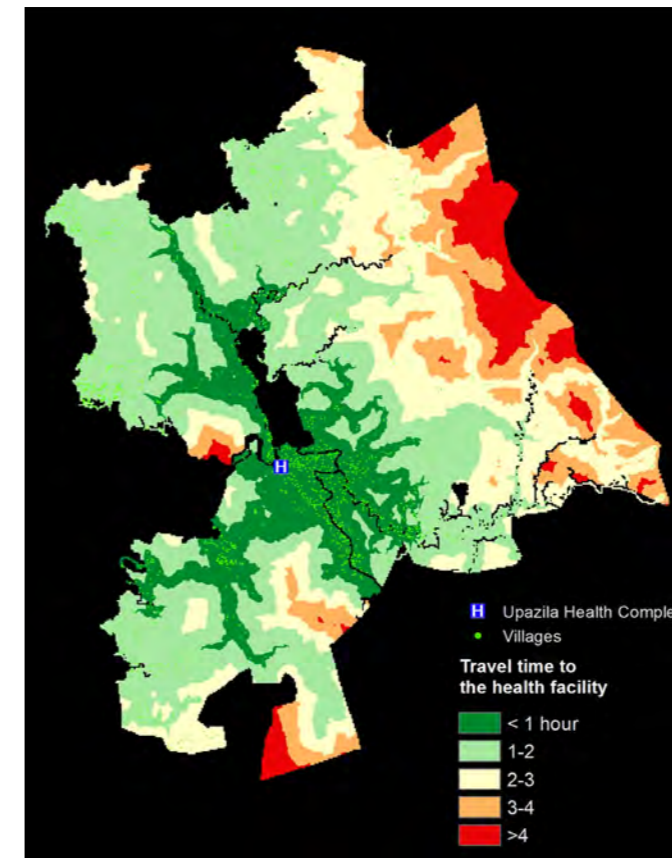
VI. Future vision

MORU Epidemiology plans to combine prospective data collection through field epidemiological studies, retrospective secondary data analysis and cutting-edge predictive modelling and big data analytics as well as development and application of new methods and context appropriate technological solutions to improve the quality and timeliness of data collection. There will be an ongoing prioritisation

of work that generates evidence that is relevant to health policy decision making with research focussing on how science can best influence this process and continuing to work in close partnership with Ministries of Health across the region. Areas of disease focus will extend to other communicable diseases with an agenda driven by public health priorities in the region. In the coming years, there will be an increasing focus on assessing and improving the quality of surveillance data and quantifying the impact of suboptimal data on measurement of health outcomes. Research priorities will remain those with most potential for direct impact on health outcomes as determined through ongoing interaction with Ministries of Health, the World Health Organization and other implementing partners.

Current Epidemiology projects include:

- Enhanced modelling for NMCP Decision-making in the GMS to Accelerate Malaria Elimination (ENDGAME). Led by MORU Epidemiology, working with MAEMOD, and funded by the Bill and Melinda Gates Foundation (BMGF), the ENDGAME project supports NMCPs in Cambodia, Lao PDR, Myanmar, Thailand, and Viet Nam with mathematical, statistical and economic modelling and data analysis to guide planning for malaria elimination. ENDGAME addresses priority research questions with direct policy relevance which are identified by NMCPs and their selected partner organisations to inform their decision making for national malaria strategy.
- Reducing the Risk of Forest Malaria in the GMS. Funded by the Regional Artemisinin-resistance Initiative 2 Elimination (RAI2E) of the Global Fund to Fight AIDS, Malaria and Tuberculosis, this project combines a clinical trial of antimalarial chemoprophylaxis, in-depth interviews and mapping among forest-goers at high risk of malaria in Cambodia, Lao PDR, and Thailand.
- Sustaining village health worker programmes with expanded roles in the GMS funded by the Regional Artemisinin-resistance Initiative 3 Elimination (RAI3E) of the Global Fund to Fight AIDS, Malaria and Tuberculosis, this project combines a clinical study in Cambodia with stakeholder, community and health worker interviews and surveys together with economic modelling and policy landscape analysis to health worker interviews how community health worker programmes for malaria can be sustained through expanding their roles to other health areas in Cambodia, Thailand and Viet Nam.
- Quantifying the impact of human mobility on *P. falciparum* malaria burden and spread of antimalarial resistance in the Greater Mekong Sub-region and Bangladesh. Combining patient travel surveys, analysis of cell phone records and parasite genetic data together with big data analytics and mathematical modelling this project includes collaborators from the Hong Kong University, Harvard TH Chan School of Public Health, and The Wellcome Trust Sanger Institute.
- Epidemiology of malaria in northeast Thailand: a case-control study.
- Development and optimisation of *Plasmodium falciparum* artemisinin and partner drugs resistance maps for communication to policymakers in Southern Africa and Southeast Asia.
- School and community-based student-driven dengue vector control and monitoring in Myanmar: a cluster randomized controlled trial. This large consortium project is led by the Norwegian University of Life Sciences and Myanmar Ministry of Health and Sports with components including health education with the Ministry of Education, entomology and a clinical trial of dengue control methods. MORU Epidemiology lead the clinical trial.
- Dengue spatiotemporal epidemiology in Myanmar and Thailand with the national dengue control programme in each country.
- Impact of population movement on dengue in Thailand with the national dengue control programme.
- Children's environmental health in Thailand: cohort study of pregnant women and children with the Faculty of Medicine, Mahidol University.
- Automated smartphone microscopy for malaria with the National Institutes of Health, USA.
- GroupMappers: crowdsource mapping of communities for communicable disease surveillance in Bangladesh. Funded by public donations.
- End-to-End Data Pipeline (E2): presenting pre-publication research to policymakers funded by Wellcome iTPA.



Map of modelled travel time to an Upazila Health Complex in Lama, Bangladesh. This was part of an analysis of accessibility of COVID-19 health services for the whole country.

- Improving Knowledge, Attitudes and Practice for COVID-19 Prevention: Science Engagement in Schools at the Golden Triangle Border.
- WHO Global Health Facilities Database. Funded by and run in close partnership with the WHO GIS Centre in Geneva, this project aims to support ministries of health to develop, assess and openly share their health facility master lists. We are leading the implementation in 8 countries.
- Assessing mobility data for guiding disaster response in the Greater Mekong Subregion and Bangladesh. Funded by Crisis Ready, this project aims to assess the representativeness of available population mobility datasets used during the COVID-19 pandemic.
- Assessment of the spatiotemporal distribution and global distribution of scrub typhus.

In all our projects, MORU Epidemiology works with policymakers as partners to address the scientific questions most pertinent to the disease control and elimination agendas.

We also provide support to a broad range of studies across the MORU network, including:

- South and Southeast Asian Community-based Trials Network (SEACTN) Wellcome Trust Flagship
- Malaria Elimination Task Force (METF)
- Genetic reconnaissance of malaria in the Greater Mekong Sub-region and Bangladesh (GenReMekong)
- Molecular and in vitro surveillance of ACT partner drug efficacy in the GMS (5% MIVS-ACT)
- Studying the impact of zoonotic disease surveillance in the Orang Asli (indigenous population) communities of Peninsular Malaysia on reducing the risk of zoonotic disease emergence

Future COVID-19 plans

- Complete the study of facemask usage once transmission decreases.
- Update and complete analyses of population movement, distribution and distancing and share results with government and regional partners.
- Update and refine healthcare accessibility analyses and further share with government and regional partners.
- Conduct geospatial analyses to support vaccine roll-out as part of the UNICEF and WHO CO- VAX GIS Working Group.
- COVAX to build a consortium to run a multicountry study on epidemiology of long-COVID in low- and middle-income countries (LMICs).



Clinical Pharmacology conducts its own research and supports the MORU Tropical Health Network and external research groups with study design, drug measurements, pharmacometric analysis, and interpretation of pharmacological results. © MORU 2022. Photographer: Gerhard Jøren.

Clinical Pharmacology

I. Overview

Established in 2003 to meet a need for accurate, sensitive antimalarial drug measurements in the biological fluids of clinical trials patients, MORU's Department of Clinical Pharmacology has become one of the world's leading laboratories for antimalarial drug pharmacology.

Led by Prof Joel Tarning, Clinical Pharmacology conducts its own research and supports the MORU Tropical Health Network and external research groups with study design, drug measurements, pharmacometric analysis and interpretation of pharmacological results. This research has already had a major influence on the currently recommended treatment regimens for malaria.

The Pharmacometric team, led by Dr Richard Hoglund, focusses on pharmacokinetic and pharmacodynamic modelling to further our understanding of infectious disease pharmacology. The pharmacometrics group conducts non-compartmental analysis, nonlinear mixed-effects modelling and simulation, and optimal study design evaluations.

The Bioanalysis team, led by Dr Urairat Koesukwiwat, perform accurate and sensitive LC-MS quantification of small molecules in clinical trial samples (such as plasma, whole blood and dried blood spots on filter paper). The laboratory is ISO-accredited for the quantification of drugs and operates to the highest standard to comply with regulatory guidelines. Between 10,000 and 15,000 clinical samples are commonly analysed each year.

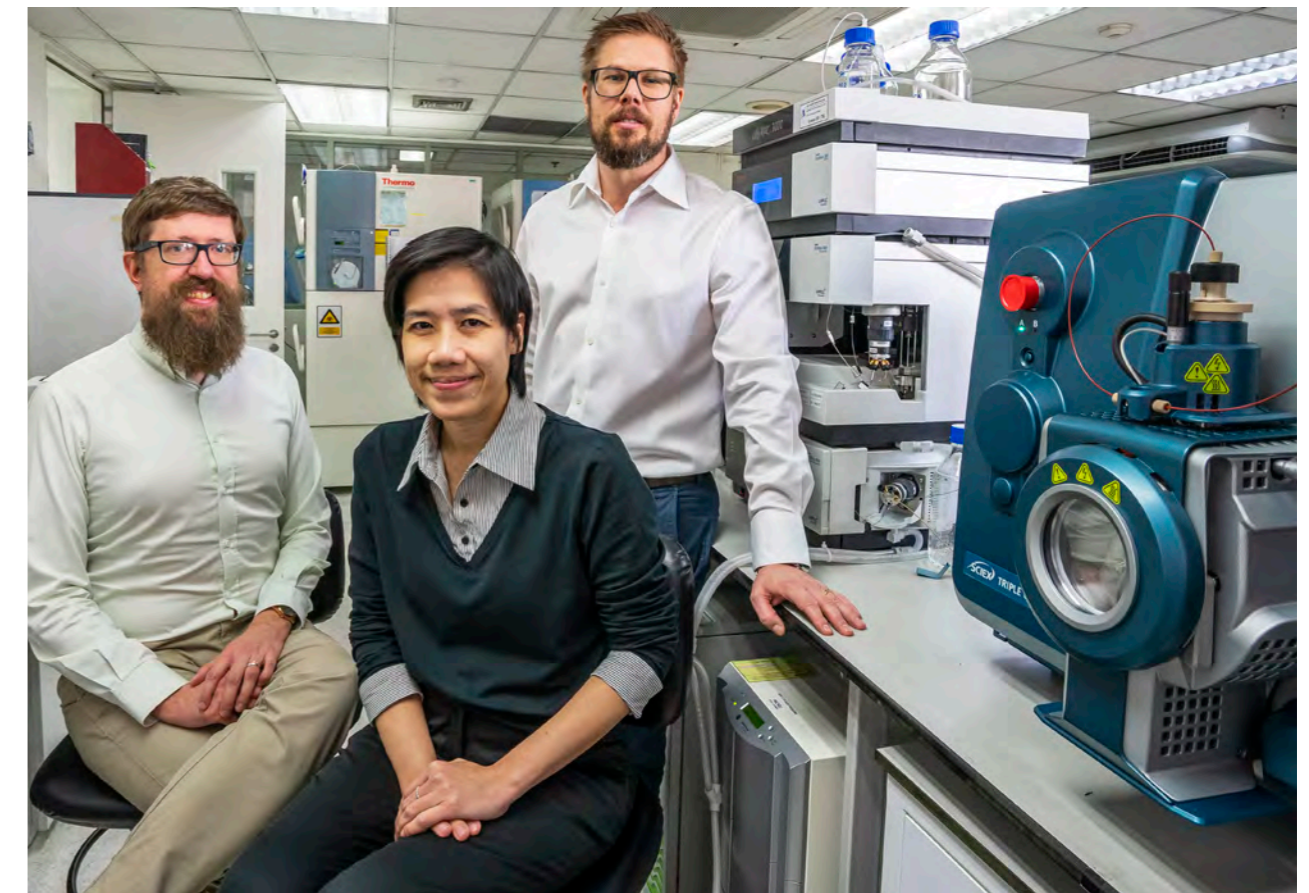
The Biochemistry & Discovery team, led by Prof Joel Tarning, focusses on omics-based research (metabolomics/ proteomics/ lipidomics), drug measurement methodology development and medicine

quality research. The team develop novel LC-MS methods to quantify drugs in biological samples, with a particular focus on filter paper methodologies to facilitate and enable pharmacokinetic field studies. The metabolomic, proteomic and lipidomic researchers use in vitro and clinical patient samples in combination with high-resolution/high-accuracy LC-MS measurements to characterise and identify unknown metabolites, develop improved diagnostics, understand pathophysiology, and describe mechanisms of drug action and resistance. The medicine quality researchers develop novel methodologies to detect substandard and falsified medicine.

In addition, the MORU Clinical Pharmacology Department has an active, successful postgraduate student programme.

Facilities

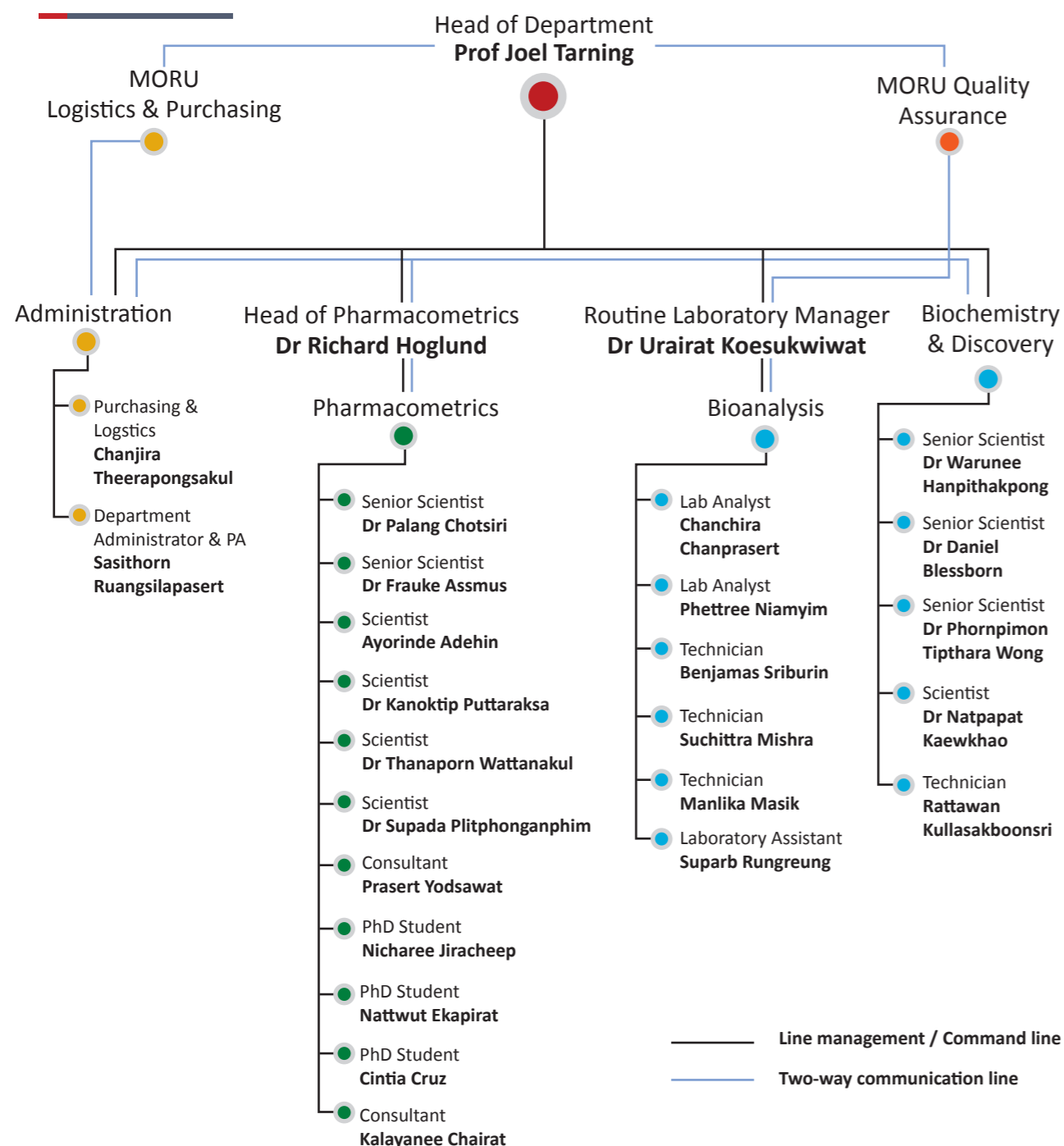
Based at MORU Bangkok, the Clinical Pharmacology Laboratory uses a variety of sample preparation techniques in combination with LC-MS to quantify drugs in biological samples. We operate a high-throughput system, consisting of two liquid handlers and three LC-MS Triple-Quadrupole systems,



Clinical Pharmacology is led by Prof. Joel Tarning (*right*). Dr Richard Hoglund (*left*) leads the Pharmacometric research team, focusing on pharmacokinetic and pharmacodynamic modelling to further our understanding of infectious disease pharmacology. The Routine Laboratory team, led by Dr Urairat Koesukwiwat (*centre*), perform accurate and sensitive LC-MS quantification of small molecules in clinical trial samples (such as plasma, blood and dried blood spots on filter paper). © MORU 2022. Photographer: Gerhard Jøren.

dedicated to the quantification of drugs in clinical trial samples. The laboratory has full ISO accreditation for competency (ISO 15189) and safety (ISO 15190) and all assays are developed and conducted to international regulatory guidelines. A particular focus of the drug measurement research is the development of high throughput field adapted filter paper methodologies. We operate one additional LC-MS Q-Trap system for exploratory research, including medicine quality and bioanalytical assay development, and one high-resolution/high-accuracy LC-MS Triple-TOF instrument for omics-based research.

II. Our team



III. Scientific achievements in 2021

Clinical Pharmacology conducts its own research and supports the MORU Tropical Health Network and external research groups with study design, drug measurements, pharmacometric analysis, and interpretation of pharmacological results. Some of our scientific achievements are highlighted below.

COVID-19 response

Clinical Pharmacology, has been active in the COVID-19 research field supporting MORU-led activities, such as safety and efficacy of hydroxychloroquine in the prevention of COVID-19 (COPCOV), as well as a trial of antiviral pharmacodynamics in patients with early symptomatic COVID-19 (PLATCOV). PLATCOV is a platform for quantitative assessment of antiviral effects in low-risk patients with high viral burden and uncomplicated COVID-19. We also provided modelling and simulation

support to Drugs for Neglected Diseases initiative (DNDi) in their evaluation of repurposed drugs in the fight against COVID-19, and developed a modelling and simulation framework to de-risk and prioritise repurposed drugs for COVID-19. Prof Joel Tarning and Dr Richard Hoglund were active members of the Bill & Melinda Gates-funded “Rapid Dose Optimization Team”, providing modelling and simulation support to academic and for-profit groups developing drugs for the treatment of COVID-19. Prof Joel Tarning chairs the Clinical Pharmacology Working Group, COVID-19 Clinical Research Coalition.



Mass spectrometry-based drug measurements in the bioanalysis laboratory. © MORU 2022. Photographer: Gerhard Jørn.

was a significant nonlinear relationship between age and primaquine concentrations. Children had primaquine trough concentrations that were 0.53-fold lower compared with adults, suggesting that young children may need higher weight-adjusted primaquine doses than adults. We then used population-based pharmacokinetic modelling and simulations to optimise weight-based and age-based primaquine regimens in the treatment of *vivax malaria*. The proposed weight-based regimen had 5 dosing bands and showed less variability around the optimal exposure within each dosing band compared to the age-based regimen. Both dosing regimens demonstrated a clear advantage compared to the currently recommended fixed mg/kg dose regimen.

Improving antimalarial treatment in malnourished children

Young children are especially vulnerable to malaria, particularly when malnourished. Altered physiological properties in malnourished children might change pharmacokinetic properties and result in under-dosing, as we demonstrated for artemether-lumefantrine. Using physio-



Schematic overview of the physiologically-based strategy for prediction of drug exposure in a malnourished pediatric population.

logically-based pharmacokinetic (PBPK) modelling, we developed a general physiologically-based translational framework for prediction of drug disposition in malnourished children. The model is readily applicable for dose recommendation strategies to address the urgent medical needs of this vulnerable population.

Improving antimalarial treatment in children with severe malaria

Parenteral artesunate is the first-line treatment against severe malaria. Unfortunately, many children with severe malaria die before or just after reaching a facility capable of administering parenteral drugs. A rectal formulation of artesunate has been developed as pre-referral treatment to reduce malaria mortality in children unable to tolerate oral medication. We evaluated the pharmacokinetic properties of artesunate after rectal and intravenous administration in 80 children with

malaria, and showed that even if rectal bioavailability of artesunate is low and variable, it could still be an effective pre-referral treatment and save lives. We also developed and validated an *in silico* decision tool to guide optimal dosing of parenteral artesunate in patients with artemisinin-sensitive and artemisinin-resistant severe malaria infections.

Improving antimalarial treatment in pregnant women

Malaria in pregnancy, including asymptomatic infections, has a detrimental impact on fetal development. WHO recommends that intermittent preventive treatment in pregnancy (IPTp) should be administered at every scheduled visit during the second and third trimesters of pregnancy, spaced at least one month apart, to prevent the adverse consequences of malaria in pregnancy. Dihydroartemisinin-piperaquine is a highly efficacious and well-tolerated antimalarial treatment. The long half-life of piperaquine provides extended malaria chemoprevention for up to six weeks. We have reported on the pharmacokinetic properties of piperaquine in IPTp in Kenya and Indonesia (n=467). Modelling and simulation showed that standard treatment doses of dihydroartemisinin-piperaquine, once a month, achieve sufficient drug exposure to prevent malaria infections.

Improving antimalarial treatment of multi-drug resistant malaria

We have continued our work on the treatment of multi-drug resistant malaria and triple combination therapies. A total of 217 children with uncomplicated *falciparum* malaria in Kenya were treated with artemether-lumefantrine, artemether-lumefantrine-piperaquine, or artemether-lumefantrine-mefloquine. This study showed that triple combination therapy is an efficacious and safe treatment for *falciparum* malaria and could potentially be used to prevent or delay the emergence of antimalarial resistance. We reported no drug-drug interactions between the individual drugs, and are evaluating this in more detail using a modelling and simulation approach.

Pharmacological properties of endectocides

Mass drug administration of ivermectin has been proposed as a possible malaria elimination tool. Ivermectin exhibits a mosquito-lethal effect well beyond its biological half-life, suggesting the presence of active slowly eliminated metabolites. Human liver microsomes, primary human hepatocytes, and whole blood from healthy volunteers given oral ivermectin were used to identify ivermectin metabolites by ultra-high-performance LC-MS. The molecular structures of identified metabolites were determined by LC-MS and verified by NMR. Pure cytochrome P450 enzyme isoforms were also used to elucidate the metabolic pathways of ivermectin. We identified three major metabolites, all predominantly formed by the CYP3A4 isoform. We are currently evaluating the pharmacokinetic properties and mosquito-lethal activity of these metabolites.

Mechanistic pharmacokinetic-pharmacodynamic modelling of antimalarial drugs

The induced blood-stage malaria model has been extensively used to investigate the activity of antimalarial drugs in humans. A mechanistic parasite dynamics model was developed to explain



Pharmacometrics Group members, from left, Palang Chotsiri, Supada Plitphongphanphim, Kanoktip Puttaraksaand Nicharee Jiracheep. © MORU 2022. Photographer: Gerhard Jørgen.

the maturation of parasites, sequestration of mature parasites, synchronicity of infections, and multiplication of parasites, as seen in natural clinical infections. Piperaquine-associated parasite killing was estimated using a maximum effect function. Treatment simulations (3-day oral dosing of dihydroartemisinin-piperaquine) indicated that to be able to combat multidrug-resistant infections, an additional drug in a new antimalarial triple-combination therapy should result in at least a 100-fold reduction in parasitemia per life cycle with a duration of action of ≥ 2 weeks. This tool can be used to assess and optimise current and future drug combinations.

Drug measurements in clinical trial samples

The drug measurement laboratory successfully maintained ISO-accreditation and expanded the scope of new methods for measurements of drugs and metabolites in biological samples. A high-throughput quantification method for amodiaquine and desethylamodiaquine in plasma was developed, as well as structure-switching aptamer sensors for the specific detection of piperaquine and mefloquine. A new LC-MS Triple-Quad system was acquired to address the increasing demand on method specifications. Overall, despite long periods of work-from-home lockdowns, we managed to process and report drug concentration measurements in a total of 9,962 clinical trial samples.

IV. Top 10 publications in 2021

1. Identification of the metabolites of ivermectin in humans. Tiphara P, Kobylinski KC, Godejohann M, Hanboonkunupakarn B, Roth A, Adams JH, White NJ, Jittamala P, Day NPJ, Tarning J. *Pharmacol Res Perspect*. 2021;9(1):e00712. PMID: 33497030; PMCID: PMC7836931.
2. Artemether-lumefantrine-mefloquine versus artemether-lumefantrine-piperaquine and artemether-lumefantrine in the treatment of uncomplicated *Plasmodium falciparum* malaria in Kenyan children: a single-centre, open-label, randomised, non-inferiority trial. Njuguna P, Ngama M, Kalume P, Mwambingu G, Ngetsu C, Wambua J, Boga M, Mturi N, Lal AA, Khuroo A, Taylor WRJ, Gonçalves S, Miotto O, Dhorda M, Mutinda B, Mukaka M, Waithira N, Hoglund RM, Imwong M, Tarning J, Day NPJ, White NJ, Bejon P, Dondorp AM. *Lancet Infect Dis*. 2021;21(10):1395-1406. PMID: 34111412; PMCID: PMC8461080.
3. Determinants of primaquine and carboxyprimaquine exposures in children and adults with *Plasmodium vivax* malaria. Chu CS, Watson JA, Phyo AP, Win HH, Yotyingaphiram W ... Tarning J, Proux S, Ling C, Nosten FH, White NJ. *Antimicrob Agents Chemother*. 2021;65(11):e0130221. PMID: 34398667; PMCID: PMC8522776.
4. A physiologically-based pharmacokinetic framework for prediction of drug exposure in malnourished children. Sjögren E, Tarning J, Barnes KI, Jonsson EN. *Pharmaceutics*. 2021 Feb 2;13(2):204. PMID: 33540928; PMCID: PMC7913226.
5. Semi-mechanistic pharmacokinetic and pharmacodynamic modelling of piperaquine in a volunteer infection study with *Plasmodium falciparum* blood-stage malaria. Wattanakul T, Baker M, Mohrle J, McWhinney B, Hoglund RM, McCarthy JS, Tarning J. *Antimicrob Agents Chemother*. 2021:AAC.01583-20. PMID: 33468477; PMCID: PMC8097471.
6. Development and validation of an *in silico* decision-tool to guide optimisation of intravenous artesunate dosing regimens for severe *falciparum* malaria patients. Zaloumis SG, Whyte JM, Tarning J, Krishna S, McCaw JM ... Kreamsner P, Dondorp A, Price RN, White NJ, Simpson JA. *Antimicrob Agents Chemother*. 2021:AAC.02346-20. PMID: 33685888; PMCID: PMC8316083.
7. Structure-switching aptamer sensors for the specific detection of piperaquine and mefloquine. Coonahan ES, Yang KA, Pecic S, De Vos M, Wellem TE, Fay MP, Andersen JF, Tarning J, Long CA. *Sci Transl Med*. 2021 Mar 17;13(585):eabe1535. PMID: 33731432.

8. Pharmacokinetic study of rectal artesunate in children with severe malaria in Africa. Fanello C, Høglund RM, Lee SJ, Kayembe D, Ndjowo P, Kabedi C, Badjanga BB, Niemyim P, Tarning J, Woodrow C, Gomes M, Day NP, White NJ, Onyamboko MA. *Antimicrob Agents Chemother.* 2021 Feb 1;AAC.02223-20. PMID: 33526485; PMCID: PMC8097454.
9. Development of weight and age-based dosing of daily primaquine for radical cure of vivax malaria. Taylor WR, Høglund RM, Peerawaranun P, Nguyen TN, Hien TT ... Buchy P, Menard D, White NJ, Tarning J, Mukaka M. *Malar J.* 2021;20(1):366. PMID: 34503519; PMCID: PMC8427859.
10. Piperaquine pharmacokinetics during intermittent preventive treatment for malaria in pregnancy. *Antimicrob Agents Chemother.* Hughes E, Wallender E, Kajubi R, Jagannathan P, Ochieng T ... Clark TD, Rosenthal PJ, Dorsey G, Aweeka F, Savic RM. *Antimicrob Agents Chemother.* 2021;65(3):e01150-20. Epub ahead of print. PMID: 34864925.

V. Capacity building achievements in 2021

During 2021, Cintia Cruz and James Callery were registered for a DPhil at University of Oxford. The pharmacometric group has recruited two new post-docs (Dr Ayorinde Adehin and Dr Supada Plitphongaphim).

VI. Future vision

Highly integrated with MORU Tropical Health Network activities across the globe, Clinical Pharmacology's strengths are in scientific output, our laboratories, and access to clinical trials and samples. We anticipate working on new trials and disease areas including TB, hepatitis C and filariasis, medicine quality and pharmacology-based basic science (omics).

Specifically, Clinical Pharmacology plans to work on:



Sample processing and extraction using an automated liquid handler. © MORU 2022. Photographer: Gerhard Jøren.

COVID-19

PLATCOV will enable quantitative assessments of antiviral effects in low-risk patients with high viral burdens and uncomplicated COVID-19. In this randomised open label, controlled, group sequential adaptive platform trial, we will assess the performance of three distinct types of intervention relative to control (no treatment); (A) potentially effective repurposed antiviral drugs; (B) positive control using monoclonal antibody cocktail (REGN-COV2); and (C) any future small molecule drugs that pass

phase 1 testing. We are also working actively on using modelling and simulation techniques to advance the development of new and repurposed drugs in the treatment of COVID-19.

Antimalarial dose optimisation

We will continue to optimise antimalarial dose regimens in young children and pregnant women. Drug exposure does not commonly scale linearly with body weight, and small children often need a higher dosage (mg/kg) compared to adults to achieve equivalent exposures. Drug exposure is often different in pregnant women compared to non-pregnant adults due to physiological alterations during pregnancy. Individual clinical trial analyses and large-scale meta-analysis on the pharmacokinetic properties of antimalarial drugs will be conducted and reported.

Treatment of multi-drug resistant malaria

Several projects are ongoing investigating efficacy, safety, and potential drug-drug interactions of



Preparation of quality control samples used in routine bioanalytical drug measurements. © MORU 2022. Photographer: Gerhard Jøren.

antimalarial drugs when used in novel combination treatments. Particular focus will be on triple combination therapy with or without other transmission and/or vector control agents such as primaquine and/or ivermectin. Pharmacokinetic and pharmacodynamic modelling of these combinations aims to inform treatment policy of multi-drug resistant malaria and provide treatment options in malarial elimination campaigns.

Malnutrition and malaria treatment

Working with the MSF site in Niger we will continue to evaluate the pharmacokinetic and pharmacodynamic properties of antimalarial drugs in malnourished children, and use modelling and simulation to suggest revised dose regimens.

Pharmacokinetic and pharmacodynamic properties of Hepatitis C agents

Two ongoing clinical trials in Viet Nam and Myanmar are investigating the efficacy and safety of sofosbuvir and daclatasvir in the treatment of hepatitis C. Bioanalytical assays will be developed to quantify these drugs in plasma and whole blood. Pharmacokinetic and pharmacodynamic samples will be collected in these studies so that the pharmacokinetic properties can be evaluated, and linked to their pharmacodynamic effect (viral elimination).

Pharmacokinetic and pharmacodynamic properties of anti-infective agents

A collaboration between MORU and DNDi has begun to provide pharmacokinetic and pharmacodynamic modelling support to inform the development of novel drugs for neglected tropical diseases (e.g. leishmaniasis, Chagas disease and filariasis). The initial focus will be on filariasis with the aim to provide a rational modelling framework for in vitro to in vivo scaling, animal to human scaling, healthy volunteer to patient scaling, and to perform phase I-IV clinical trial evaluations of novel drugs under development.

Physiologically-based pharmacokinetic (PBPK) modelling

We will initiate more projects using a PBPK methodology. These analyses will be carried out using the software SimCYP, which has been developed specifically for PBPK modelling. Initially, we will investigate the impact of pregnancy and lactation on the pharmacokinetic properties of antimalarial drugs.

Medicine Quality

The Department will continue research in medicine quality, in order to determine the amount of active drug content present in marketed products and medicines used in clinical trials. We also aim to evaluate the abilities of handheld analytical devices alone, or in combination, to detect substandard and falsified medicine. We aim to establish a novel laboratory dedicated to medicine quality as part of the Department in the coming years.

Improved diagnostic tools for neglected tropical diseases

The challenge for the management of tropical diseases is often not the treatment, but the diagnosis. Patients report to hospitals with nonspecific symptoms, which can have various origins. Although the symptoms are similar, treatment differs between pathogens. Using a proteomics approach, we aim to identify novel diagnostic markers for neglected tropical diseases like melioidosis and scrub typhus. Such biomarkers could be used to develop non-invasive, field-based rapid tests, allowing for early and reliable identification of pathogens in patients.



Prof Phaik Yeong Cheah (*centre*) and the MORU's Bioethics & Engagement team engage with MORU stakeholders and conduct ethics research to ensure that MORU research is ethical, trustworthy, and maximised its potential health impact. © MORU 2022. Photographer: Gerhard Jøren.

Bioethics & Engagement

I. Overview

Led by Professor Phaik Yeong Cheah, Bioethics & Engagement provides support for MORU's central objective of improving the health of people living in the resource-poor tropics. We do this by engaging with our stakeholders and conducting ethics research to ensure that our research is ethical and trustworthy, and that its potential health impact is maximised.

Based in Bangkok, Bioethics & Engagement has teams operating in Mae Sot and Chiangrai in Thailand, Siem Pang and Siem Reap in Cambodia, and Oxford, UK.

COVID-19

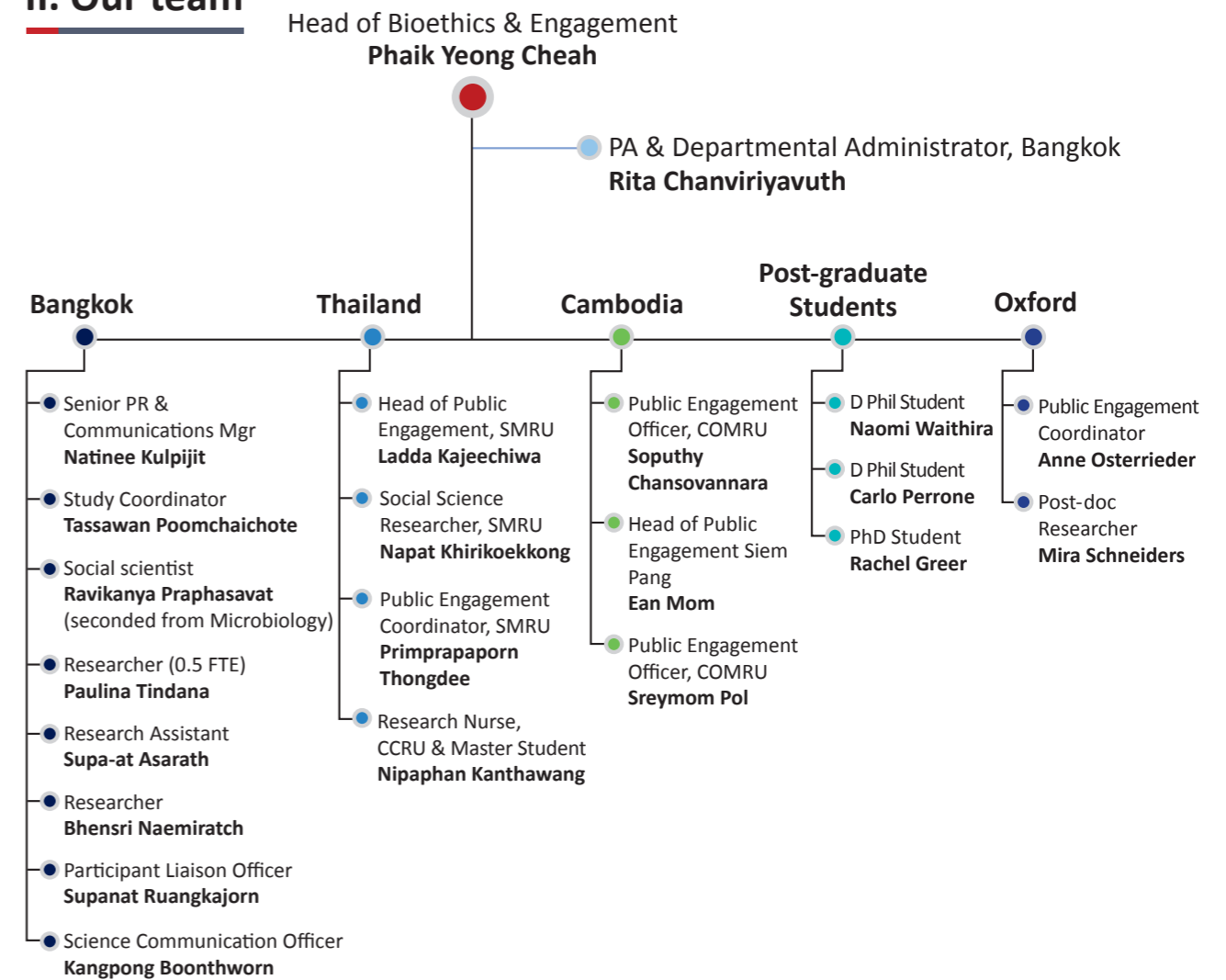
Despite COVID-19 related restrictions, the Bioethics & Engagement team remained very active in 2021. Some field engagement activities were paused or reduced, while others moved to online platforms.

In memoriam: In 2021 we lost two important persons to COVID-19. Saw Aung Than Wai, from the Karen community on the Thai-Myanmar border, was one of the founding members of the Tak Province Community Ethics Advisory Board (T-CAB). He was a healthcare worker and active member of the T-CAB for many years. Pakkapong Thangchaipinyokul (Act) was a member of the Bangkok Health Research Ethics Interest Group (HREIG). He had many good ideas and contributed actively during our discussions. We are very sad and will miss them both greatly.



Professor Phaik Yeong Cheah, head of Bioethics & Engagement. © MORU 2022. Photographer: Gerhard Jøren.

II. Our team



III. Scientific achievements in 2021

In 2021, Bioethics & Engagement led and supported many bioethics and engagement initiatives:

A. Bioethics (and related social science projects)

COVID-19

Before the arrival of widely available and effective COVID-19 vaccines and treatments, governments relied primarily on non-pharmaceutical interventions to mitigate the pandemic's impacts. Authorities and policy makers rarely considered how these restrictions might impact different social groups, particularly vulnerable groups. To address this gap in evidence, Bioethics & Engagement conducted **SEBCOV** (Social, ethical and behavioural aspects of COVID-19'), a mixed-methods study in five countries (Thailand, Malaysia, United Kingdom (UK), Italy and Slovenia). We analysed the data collected in 2020 and published several papers. The full list of outputs is available here: <https://www.tropmedres.ac/covid-19/sebcov>.



The Bioethics & Engagement SEBCOV study sought evidence on the impact of non-pharmaceutical interventions like social distancing to mitigate COVID-19's impact on vulnerable groups. © MORU 2022. Photographer: Supa-at Asarath.

Phaik Yeong Cheah is involved in various COVID-19 committees as:

- Chair of the [Data Sharing Working Group](#), and member of the Ethics Working Group of the COVID-19 Clinical Research Coalition.
- Member of the World Health Organization (WHO) COVID-19 Research Roadmap Committee.
- Member of the WHO COVID-19 Task Force on Good Participatory Practices (Engagement).
- Member and ethicist for the Data & Safety Monitoring Board of DisCoVeRy (Multi-centre, adaptive, randomized trial of the safety and efficacy of treatments of COVID-19 in hospitalized adults, Inserm C20-15), the sister trial of the WHO SOLIDARITY trial.



Poster for a COVID-19 Research Coalition webinar organised by Bioethics & Engagement. © MORU 2022.

Health Research) in Mae Sot and Chiangrai has been completed and we continue to write up papers. See photo gallery, [Life at the Thai-Myanmar border through the eyes of a frontline researcher](#), and [In our voices](#), a film co-created with Tak Province Community Ethics Advisory Board (T-CAB) members. In the short video, [On the frontline](#), frontline researchers discuss their role as a critical bridge between communities and research institutions.

DeTACT

The Bioethics & Engagement team completed the data collection and analyses of the empirical ethics study *Ethical, Social, Regulatory and Market related aspects of Deploying Triple Artemisinin-Based Combination Therapies for Malaria treatment in Burkina Faso and Nigeria, Africa*. Led by Phaik Yeong, with consultant Paulina Tindana, this empirical ethics study is part of the MORU-led DeTACT (Development of Triple Combination Artemisinin Therapy) study.

REUSE Study

This study on data sharing is led by Naomi Waithira as part of her DPhil project. The project involves an international survey and qualitative study on the enablers and barriers of data reuse. Phaik Yeong Cheah is the supervisor. Data collection is under way.

Melioidosis Vaccine (MeVA) study

We are leading the bioethics component of a large study led by Prof Susie Dunachie (MORU, Oxford) that will involve a melioidosis vaccine trial. We will study vaccine hesitancy and acceptance among patients at risk of melioidosis (led by Supa-at Asarath and Napat Khirikoekkong).

B. Engagement

Community/public advisory groups

Bioethics & Engagement currently lead or support several advisory groups:

- The Tak Province Community Ethics Advisory Board (T-CAB): Due to COVID-19 restrictions, the T-CAB met only twice in 2021 and discussed *Medical English for borderline health staff* and *Rural febrile illness Flagship Project*.
- Young Persons' Advisory Group (YPAG), Siem Reap, Cambodia: Unable to meet in 2021.

MISTE

An embedded ethics project within the Malaria Infection Study Thailand (MIST), the MISTE project aims to engage with all involved to gain knowledge, understand, and to identify the social and ethical aspects of issues arising from vivax human challenge studies. Begun in Nov 2020 and conducted by Bhensri Naemiratch and Supanat Ruangajorn, interviews continued in 2021.

REACH

Data collection for REACH (Resilience, Empowerment & Advocacy in Women's and Children's



In 2021, Bioethics & Engagement partnered with Bangkok's Foreign Correspondents Club of Thailand to hold its online Pint of Science panel. © MORU 2022. Photographer: Supa-at Asarath.

- *Dissecting the genetic basis of melioidosis infection*, by Dr Claire Chewapreecha.
- *Use of facemasks in Bangkok during the COVID-19 pandemic*, by Professor Richard Maude.
- *"Smoky Season" The haze crisis in Chiang Mai: Why now?* by Dr Olivier Evraud.
- *Science in the view of patent attorney*, by Peeyakorn Suparugbundit.
- *If at first you do succeed, trial, trial again!* by Professor Yoel Lubell.

Youth Against Antimicrobial Resistance

We were involved in coordinating [Youth Against Antimicrobial Resistance](#), an international project that brought together young people from Viet Nam, Kenya, Nepal, and Thailand to help combat the challenge of antimicrobial resistance (AMR). They also helped develop short films in [Thai](#) and [English](#) to promote appropriate antimicrobial usage and understanding of AMR. Other YAAR videos can be seen at <https://www.youthagainstamr.com/yaar-films>.

A significant output of the project was [An AMR learning framework for children and youth](#) published on 16 Nov 2021 during AMR week 2021.

AMR Dialogues

The AMR Dialogues project (coordinator: Tassawan Poomchaichote) brings together adult audiences, non-governmental organisation representatives, AMR researchers and national policy makers to co-create an AMR stakeholder map, an engagement strategy, and context-specific solutions to reduce the AMR burden in Thailand. The AMR Dialogues project will inform the Thailand National Strategic Action Plan on Antimicrobial Resistance 2023-2027.

Antibiotic Footprint Calculator

Team members supported the launch of the [Antibiotic Footprint Calculator](#) (main coordinator: Ravikanya Prapharsavat), an interactive guide to help people understand the total amount of antibiotics consumed around the world. The calculator also shows how antibiotics affect lifestyle, including through food intake.

Antibiotic Footprint

Members of our team supported the launch of the [Antibiotic Footprint](#), an interactive guide to help you understand the total amount of antibiotics consumed around the world.

Thailand Antimicrobial Awareness Week

MORU was a co-organiser in Thailand's World Antibiotic Awareness Week <https://eventdee.com/amr/>.

- The Bangkok Health Research Ethics Interest Group (HREIG) met three times in 2021 and discussed: AMR Dialogues, the AMR footprint calculator, and COVID-19 vaccines. Formal evaluation of HREIG is underway.
- New YPAGs have been established in Mae Sot and in Siem Pang.

Pint of Science events

In May 2017, MORU coordinated the first Pint of Science festival in Asia. Pint of Science Thailand is directed by Matt Robinson and Phaik Yeong Cheah with Rita Chanviriyavuth as the event manager.

In 2021, Pint of Science Thailand was held online on 13 May – a first in Thailand. [Pint of Science Thailand 2021](#) consisted of these talks:



INDOORS Exhibition: Experiences of older people during lockdown

An online photography exhibition that first launched on 12 November 2020 as part of the *Being Human Festival 2020*, “[INDOORS](#)” brought to life how older Londoners struggled with and adapted to life under the spring 2020 lockdown, through striking portraits and interviews.

The exhibition showcased the images and stories of older Londoners and their neighbours during lockdown in spring 2020. Their stories are interwoven with insights from research in social science, ethics and history and the wider impacts of isolation on our society’s fabric. Specifically, two of four thematic panels, namely on ‘connect- edness’ and ‘coping’ were informed by research conducted as part of the SEBCOV UK qualitative study.

On 21-26 March 2021, the “[INDOORS](#)” exhibition was presented by Mira Schneiders as part of the Oxford based [Festival of Arguments](#), an online public festival of practical ethics to explore critical thinking about life. “[INDOORS](#)” is available online indefinitely (co-curated by Mira Schneiders and Anne Osterrieder).

In March 2021, Mira Schneiders presented the Bioethics & Engagement supported INDOORS photo exhibit at the *Festival of Arguments*, an online festival of practical ethics.
© MORU 2022. Photographer: Mira Schneiders.

Following the easing of COVID-19 restrictions in the UK, an ‘in-person’ exhibition also took place in September 2021 at Toynbee Hall in London.

Scrub typhus engagement

In phase 1, the CCRU team (led by Nipaphan Kanthawang and Carlo Perrone) conducted training sessions with community health volunteers (CHVs) and healthcare workers in Mueang Chiang Rai district (141 participants) to spread knowledge about scrub typhus diseases. Participants were provided with flip charts, videos and brochures. All participants have been recruited, engagement sessions have been done, and the 3-6 month follow-up has been completed.

In phase 2, the team conducted the same training sessions in primary care units (PCU) in districts of Chiangrai province with a high incidence of scrub typhus. They also engaged with the Mae Suai district hospital primary care department, new partners for the second round of public engagement activities.

The training session engaged CHVs and healthcare workers. Additional sessions were conducted by CHVs with villagers (10-15 healthcare workers and 100-150 CHVs) and observed by CCRU staff to compare the effectiveness of different means of knowledge transmission.

COVID engagement on the Thai-Myanmar border

A COVID-19 vaccine information campaign targeting undocumented Myanmar migrant workers living and working in five border districts along Thai-Myanmar Border was conducted in 2021.

Lack of access to accurate and reliable information on COVID-19 vaccine among migrant workers causes high rate of vaccine hesitancy. To ensure that migrant workers living and working along

Thai-Myanmar border have access to correct information, the public engagement (PE) team planned for risk communication and community engagement.

The PE team worked in five districts along Thai-Myanmar border and liaised with community health workers, local key contact persons (village chiefs, elders, well respected community members) to identify migrant communities and clusters and to plan an information campaign. In all, 91 information campaign sessions delivered to over 10,000 migrants.

Co-creating information materials with communities to improve the Informed Consent process (CIMIC)

Led by Nipaphan Kanthawang, CIMIC uses community participation methods and works with community members, especially hill tribes, the elderly and/or illiterate, and women of childbearing age. Through workshops, we will assess the understanding of informed consent forms and participant information sheets of passed, current or planned clinical studies, and identify critical aspects. We then will explore with local interpreters and graphic designers the use of various media (video, audio, graphic) to produce improved materials, that can be used as templates by future research projects.

Engagement related Malaria Infection Studies Thailand (MIST)

The team led by Natinee Kulpijit supported the recruitment efforts of MIST 2nd phase by producing information animation in a short video (<https://youtu.be/ISML4akaPtI>). This video is being played during participants’ information sessions and put up on the MIST website and social media to inform and engage with the wider community. We continued to maintain the MIST website (<https://mist.in.th/>).

Miscellaneous

- Supa-at Asarath supported the SEACTN project to produce Thai language training materials for site launches in Thailand. Link to materials [SEACTN Materials in Thai](#)
- Phaik Yeong Cheah and Anne Osterrieder attended Sharing learning from seed funding schemes” (MESH, 5 May 2021); the output of this workshop was the following guide: <https://mesh.tghn.org/articles/guide-supporting-engagement-through-seed-funding-schemes/>

C. Public Engagement bursaries

In 2021, we awarded five bursaries. After a bursary subcommittee led by Anne Osterrieder reviewed applications, MORU’s Science & Strategy Committee approved project awards to:

- Three Minute Thesis (3MT) competition and lab tour 2021
- Teenage pregnancy: Making Changes Through Dialogue Drama
- Antibiotic Footprint – Individual Calculator
- Understanding local beliefs and cultural imperatives surrounding death in south and southeast Asia: public engagement on verbal autopsy methods
- Improving Knowledge, Attitudes and Practice for COVID-19 Prevention: Science Engagement in Schools at the Golden Triangle Border

D. SONAR-GLOBAL 3rd AMR Hub Meeting – Social Dimensions of Antibiotic Resistance in Asia: a One Health Perspective

On 14-15 September 2021, the [AMR regional hub](#) in Bangkok in collaboration with MORU and OUCRU, hosted a [two-day online workshop](#) so researchers working in social sciences, ethics, public engagement, and epidemiology related to AMR in Asia could share their research findings and plans. At its peak, it had 80 participants from all over the world. Report: <https://www.sonar-global.eu/sonar-global-3rd-amr-hub-meeting/>

E. Data sharing

Rita Chanviriyavuth and Phaik Yeong Cheah continue to coordinate the MORU Data Access Committee. In 2021, we received and approved five requests.

IV. Top 10 publications in 2021

1. Economic and social impacts of COVID-19 and public health measures: results from an anonymous online survey in Thailand, Malaysia, the UK, Italy and Slovenia. Osterrieder A, Cuman G, Pan-Ngum W, Cheah PK, Cheah PK ... Mackworth-Young CRS, Ongkili D, Chanviriyavuth R, Mukaka M, Cheah PY. *BMJ Open*. 2021 Jul 20;11(7):e046863. PMID: 34285007; PMCID: PMC8295020.
2. Ethical, regulatory and market related aspects of deploying triple artemisinin-based combination therapies for malaria treatment in Africa: A study protocol. Tindana P, de Haan F, Mokuolu OA, Guissou R, Bolarinwa OA ... Moors EHM, Dondorp AM, Dhorda M, Amaratunga C, Cheah PY. *Wellcome Open Res*. 2021 Apr 7;6:75. 16065.1. PMID: 34458588; PMCID: 8378406.
3. Solutions to COVID-19 data sharing. Fegan G, Cheah PY; Data Sharing Working Group. *Lancet Digit Health*. 2021 Jan;3(1):e6. PMID: 33735070; PMCID: 7832223.
4. Grandparent caregiving in Cambodian skip-generation households: Roles and impact on child nutrition. Schneiders ML, Phou M, Tun V, Kelley M, Parker M, Turner C. *Matern Child Nutr*. 2021 Jul;17 Suppl 1(Suppl 1):e13169. PMID: 34241960; PMCID: 8269139.
5. Theory of change: Drama and arts-based community engagement for malaria research and elimination in Cambodia. Ean M, Sanann N, Callery JJ, Pell C, Peto TJ, Tripura R, Cheah PY. *Wellcome Open Res*. 2021 May 12;6:46. doi: 10.12688/wellcomeopenres.16574.2. PMID: 34041367; PMCID: 8127021.
6. Deploying triple artemisinin-based combination therapy (TACT) for malaria treatment in Africa: ethical and practical considerations. Tindana P, de Haan F, Amaratunga C, Dhorda M, van der Pluijm RW, Dondorp AM, Cheah PY. *Malar J*. 2021 Feb 27;20(1):119. PMID: 33639946; PMCID: 7910789.
7. Vaccine hesitancy in the COVID-19 era. Adhikari B, Cheah PY. *Lancet Infect Dis*. 2021 Aug;21(8):1086. PMID: 34217431; PMCID: 8248943.
8. "AMR Dialogues": a public engagement initiative to shape policies and solutions on antimicrobial resistance (AMR) in Thailand. Poomchaichote T, Osterrieder A, Prapharsavat R, Naemiratch B, Ruangajorn S, Thiarapantu C, Skurung K, Kiatying-Angsulee N, Sumpradit N, Punnin S, Limmathurotsakul D, Cheah PY. *Wellcome Open Res* 2021, 6:188.
9. Deploying triple artemisinin-based combination therapy for malaria treatment in Africa: ethical and practical considerations. Tindana P, de Haan F, Amaratunga C, Dhorda M, van der Pluijm RW, Dondorp AM, Cheah PY. *Malar J*. 2021 Feb 27;20(1):119. doi: 10.1186/s12936-021-03649-7. PMID: 33639946; PMCID: PMC7910789.
10. Good participatory practice for coronavirus disease 2019 (COVID-19) research: the case of a COVID-19 prevention study. Perrone C, Schilling W, Callery JJ, Ashley EA, Chamber M ... Uranw S, Vannachione S, Woodrow CJ, White NJ, Cheah EA. *Wellcome Open Res* 2021, 6:216.

V. Capacity building achievements in 2021



Participants in the Youth Against Antimicrobial Resistance (YAAR) Thailand project, which worked with its young collaborators to produce short videos and AMR messaging for young audiences. © MORU 2022. Photographer: Supa-at Asarath.

Supa-at Asarath completed the Mental Health First Aid England-organised Mental Health First Aid Adult course in 2021.

Pakanun Luppayaporn, Faculty of Architecture, Chulalongkorn University, Thailand, interned from 6 May-5 August 2022.

Current students (2021)

Rachel Greer, PhD (Allied Health & Chemical Sciences), Open University. Thesis title: *Can C-Reactive Protein Testing Improve Antibiotic Prescribing?*

Naomi Waithira, DPhil (Clinical Medicine), University of Oxford. Thesis title: *Promoting the reuse of clinical research data*.

Nipaphan Kanthawang, MPH, Major Border Health Management. Mae Fah Luang University, Thailand.

Carlo Perrone, PhD (Clinical Tropical Medicine, Open University, UK). Provisional title: *Scrub typhus and other neglected zoonoses in rural northern Thailand*.

Training offered

- Anne Osterrieder helped organise the joint Wellcome Centre for Ethics and Humanity (WEH)/OUCRU/ MORU training workshop, *Impact through engagement*, delivered by external consultant Dr Jamie Gallagher 12-13 May 2021.
- Anne Osterrieder developed and ran an online science communication training workshop together with Dr Caroline Wood for MSc students, Germany, at the MolBio Symposium 2021 *Science Outside the Box*, 30 September 2021.
- Phaik Yeong Cheah and Anne Osterrieder delivered *Introduction to Public Engagement* to MORU PhD students and researchers (5 Oct 2021).

Training completed by team (selected):

- The Bioethics & Engagement team attended two facilitator training sessions: *Inclusion and multi-stakeholder engagement (7 April 2021)* and *Facilitation skills for online engagement (20 April 2021)*.
- The team co-organised and attended *Social dimensions of AMR*, a bespoke training.

VI. Future vision

Bioethics & Engagement will continue to conduct ethics research especially on issues involving research in low- resource settings. We continue to lead the ethics/engagement component for various studies.

We will continue to lead/support engagement around research studies at all our study sites. We will provide and organise training on community and public engagement to all MORU network staff.



MORU's MAEMOD uses modelling approaches to explore the impact and cost-effectiveness of interventions to control and eliminate tropical diseases. MAEMOD aims to build capacity within the group and in the institutions and programmes of their collaborators by training new mathematical modellers, health economists and data analysts. © MORU 2022. Photographer: Gerhard Jøren.

Mathematical & Economic Modelling (MAEMOD)

I. Overview

Led by Assoc Prof Wirichada Pan-ngum, MAEMOD uses a range of modelling approaches to explore the impact and cost-effectiveness of interventions for the control and elimination of tropical diseases in Greater Mekong Sub-Region (GMS). Our focus areas include neglected tropical diseases, drug resistant bacterial infections, malaria elimination and optimise usage of diagnostic and prognostic tools to improve the care of non-malarial febrile illness.

MAEMOD's active policy engagement with governments, stakeholders and communities helps identify the right research questions, design and simulate pragmatic, data-driven solutions, and evaluate them in the field for impact and cost-effectiveness.

A key aim of MAEMOD is to build capacity within the group and in the institutions and programmes of their collaborators by training new mathematical modellers, health economists and data analysts. A long-term goal of MAEMOD is to create a productive and sustainable collaborative modelling network in Southeast Asia (SEA) which links with and supports the discipline in all tropical settings.



Assoc Prof Wirichada Pan-ngum, Head of MAEMOD. © MORU 2022. Photographer: Gerhard Jøren.

Key MAEMOD activities and objectives include:

- Maintaining a comprehensive independent research agenda using mathematical and economic modelling to understand better the burden of infectious diseases and AMR at the patient and societal levels, and to evaluate the utility and cost-effectiveness of vaccines, diagnostics, therapeutics and other interventions aiming to lessen their impact.
- Supporting projects led by other MORU Departments and Units with modelling and health economic analyses.
- Bridging MORU research and health policy, making MAEMOD a nexus of MORU research activities that feed into policy guidance.
- Working with policymakers (national and international), notably guiding malaria elimination activities of National Malaria Control Programmes (NMCPs) around the world.
- Training future modellers and policymakers in interpreting and engaging with modelling outputs.
- Networking with the international modelling research community with a focus on south-south collaborations.

There are four groups within MAEMOD:

Neglected Tropical Diseases Modelling (NTDM) Group

Led by Assoc Prof Wirichada Pan-ngum, NTDM focuses on regional health problems, mostly neglected tropical diseases such as leptospirosis, rabies, dengue, and tuberculosis.

The NTDM team explores specific issues that may become relevant to infectious diseases including aging populations, health attitudes and practices, chronic infections such as diabetes, climate change, life style and urbanisation. The team combines modelling with community health research, population surveys and qualitative studies. They use surveys to refine their research questions and plan for effective implementation of new interventions.

Drug-Resistant Infection and Disease Dynamics Group (DRiADD)

Prof Ben Cooper heads the DRiADD group, which aims to contribute to the basic scientific understanding of the processes driving the spread of bacterial drug resistance, develop methods to better quantify the burden of disease due to drug-resistant infections, and create and evaluate innovative solutions to the problem. While DRiADD's main focus is resource-limited settings in Southeast Asia, its work has considerable relevance beyond this region. In addition to work on drug-resistant infections, DRiADD applies its expertise in infectious disease modelling to other pathogens including influenza, SARS-CoV-2, Ebola, and Hepatitis E Virus.

Economics & Implementation Research Group (EIRG)

Headed by Assoc Prof Yoel Lubell, EIRG explores the cost-effectiveness of diagnostics, treatments and vaccines for infectious diseases. The multidisciplinary group reflects its broad focus, going beyond clinical efficacy to encompass how interventions can achieve high impact in routine care environments, considering contextual barriers to their implementation.

A key area of EIRG research in recent years has been evaluating and implementing diagnostic and prognostic tools to help guide the management of febrile illness in South and Southeast Asia. EIRG members lead on multi-site projects across SEA to identify relevant biomarkers of bacterial infection and severity of illness. They use the findings to develop and evaluate point-of-care tests (POCTs) applicable for use by relatively unskilled community healthcare workers in remote areas. Supported by a Wellcome Innovations Flagship programme, EIRG has implemented the South and Southeast Asia Community-based Trials Network (SEACTN), developing a network of ~750 villages across SEA where village health workers and peripheral health facilities will be supplied and trained with mobile devices and sample collection tools to ascertain the incidence, causes and outcomes of febrile illness. In addition, EIRG oversees the management of the Wellcome/MORU Institutional Translational Partnership Award (ITPA), facilitating the funding and progression of translational research projects in MORU.



Assoc Prof Yoel Lubell (*left*) and the Economics & Implementation Research Group (EIRG) explore the cost-effectiveness of diagnostics, treatments and vaccines for infectious diseases. In addition, EIRG and Maneerat Ekkapongpisit (*seated back*) oversee the management of the Wellcome/MORU Institutional Translational Partnership Award (iTPA). © MORU 2022. Photographer: Gerhard Jøren.

Analytical Tools for Malaria Elimination (AToME) Group

Led by University Research Lecturer Ricardo Aguas, the AToME Group is currently entirely dedicated to the BMGF-funded Enhanced modelling for NMCP Decision-making to Accelerate Malaria Elimination (ENDGAME) project. Engaging with national malaria control programmes (NMCPs) in the GMS, ENDGAME calibrates malaria transmission models using epidemiological data and records from previous intervention deployments to predict the impact and cost efficiency of different elimination-driven strategies.

III. Scientific achievements in 2021

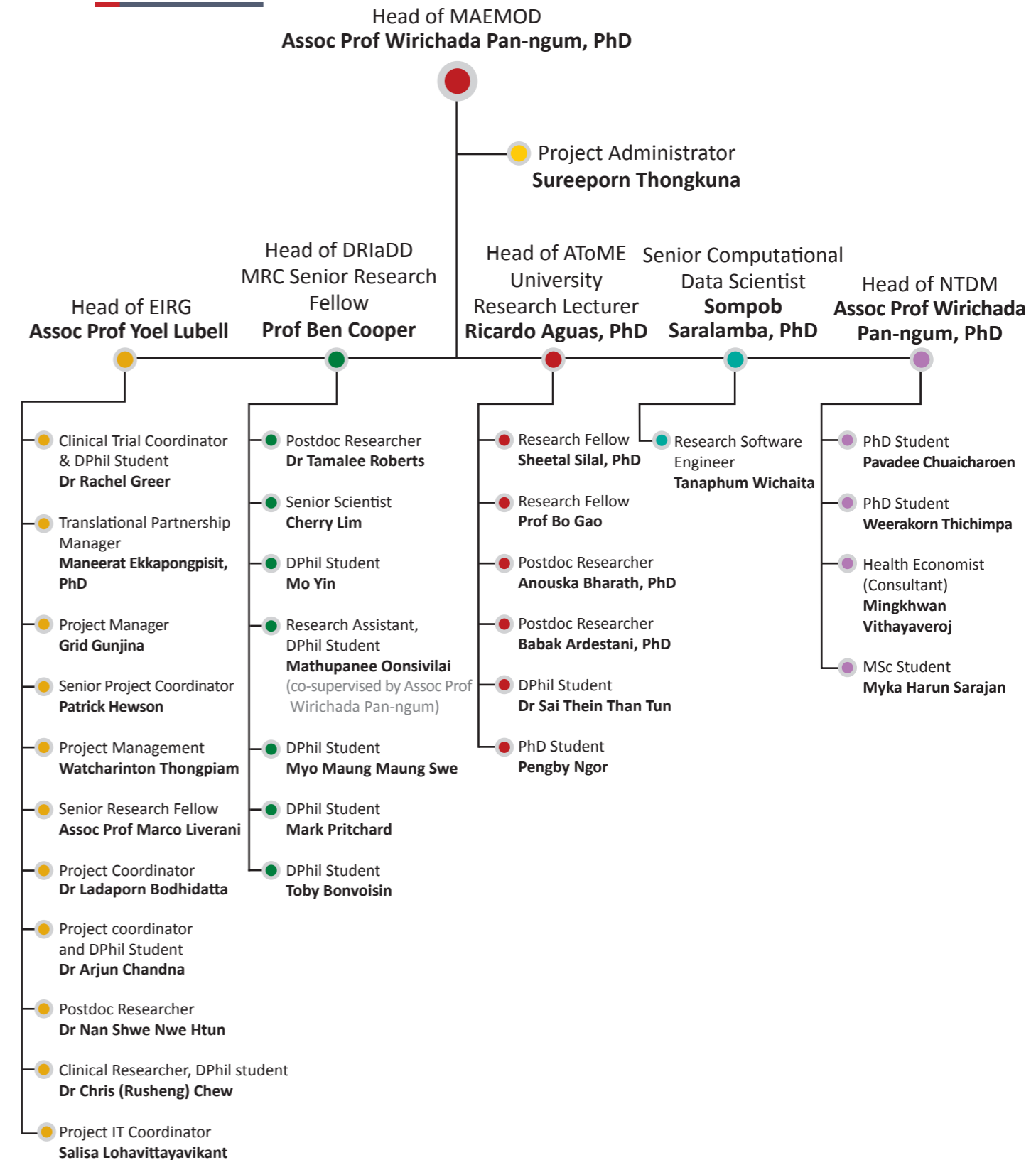
Since 2015, MAEMOD has led, supported or contributed to a number of teaching, training and capacity building initiatives, research projects, public engagement activities, and scientific publications, many of them ongoing and with a significant impact on the transmission, control and elimination of tropical diseases. MAEMOD currently has 12 PhD/DPhil students from various universities. The team have offered placement projects within MAEMOD to students enrolled in the MSc in International Health and Tropical Medicine, University of Oxford, as well as research trainees from several Thai universities.

MAEMOD members make a major curriculum development and teaching contribution to various teaching programmes including at the University of Oxford and Mahidol University:

Given the COVID-19 situation in 2021, MAEMOD:

- Represented Mahidol as the training partner of the Strengthening Preparedness in the Asia Pacific Region through Knowledge (SPARK), Australia’s Department of Foreign Affairs and Trade (DFAT)-supported modelling network.
- Developed innovative methodologies to quantify the nosocomial spread of SARS-CoV-2 and to identify routes of intra-hospital transmission.
- Contributed through modelling work and a meta regression of RCTs to understanding hand hygiene interventions’ potential to reduce the spread of acute respiratory infections.

II. Our team



- iTPA launched an accelerated funding call for COVID-19 related projects, subsequently supporting 3 such projects across the MORU network. EIRG and Médecins sans Frontières (MSF) launched a multi-site prospective study looking at biomarkers of severity in Covid-19.
- AToME continued to lead technical development, user support and capacity building for the University of Oxford based CoMo Consortium, which includes partners from 40+ countries across Africa, Asia, and South and North America and provides decision-making support to policymakers using evidence from epidemiological and economic models adapted to each country’s context.



MAEMOD holds regular weekly Journal Clubs and currently has 13 PhD/DPhil students from various Thai and overseas universities, including Mahidol and the University of Oxford. © MORU 2022.

Photographer: Gerhard Jørén.

- Worked with the Thai Health Intervention and Technology Assessment Program (HiTAP) and CoMo on optimal COVID-19 vaccine design strategies for low- and middle-income (LMIC) settings.
- EIRG directed leveraged funding and research infrastructure to identify biomarkers of severity in febrile illness to a similar study focussed on Covid-19, resulting in the identification of new prognostication models for oxygen need in patients with moderate illness.

MAEMOD's most recent significant achievements include work in:

Malaria research

- Developed, in collaboration with University of California San Francisco (UCSF), a multi-species spatially explicit economic-epidemiological model to support an investment case for malaria elimination in the Asia-Pacific region.
- Drawing on extensive costing data collected during the IMPROV and OPRA studies, we produced the most extensive findings to date on the costs of vivax malaria to households and facilities, the global costs of vivax malaria, and cost-benefit analyses of radical cure.
- Developed a simple deterministic model whose built-in front-end design allows policymakers to compare the predicted impact of competing strategies for malaria elimination within minutes.
- Created a spatially explicit, individual-based simulation model, with detailed intervention logistics that can reproduce any intervention at any scale given enough data. Its within-host component is also being developed further to account for intricate PK/PD dynamics of new triple antimalarial therapies.
- Created a forest malaria simulation platform with detailed mosquito and human movement that evaluates the impact of travel restrictions and forest kits on malaria transmission.
- Developed a within host model with detail PK/PD to look at the evolutionary dynamics of drug resistance emergence.
- Started a malaria modelling working group to communicate research work and share update findings related to malaria and modelling among the members of MORU network

Microbiology and non-malaria research

- The first SEACTN site began recruiting in July 2021.
- Conducted interim analysis of an ongoing regional multicentre RCT of reducing antibiotic treatment duration for ventilated-associated pneumonia.
- Contributed to COVID-19 research in nosocomial transmission and hand hygiene.
- Developed and published new methodology to help quantify the burden of disease due to drug-resistant bacterial infections and the impact of delays to concordant antibiotic treatment.
- Performed model-based analysis of the potential impact of reduced duration of antibiotic treatment on antimicrobial resistance.
- Published the innovative protocol for an ongoing REGARD-VAP multicentre trial we are running in South and Southeast Asia to evaluate reduced antibiotic treatment duration for ventilator-associated pneumonia.

Neglected tropical diseases

- Studied contacts in human-animal environment and the epidemiology of leptospirosis in high-risk settings to inform improved Thai disease prevention and outbreak control.
- Surveyed and modelled dog population dynamics for sterilization programme to control and eliminate rabies.
- Modelled mass drug administration for soil-transmitted-helminth infections in Thailand.

- Studied vitamin A supplementation to prevent and reduce severity of hand-foot-mouth disease in young children and modelled an approach to understand its transmission in school settings.
- Used mathematical modelling to assess the impacts of shorter-course regimens for multi-drug-resistant tuberculosis (TB) in SEA.
- Did a cost-effectiveness analysis of rotavirus vaccine and transmission dynamic modelling to quantify the indirect benefit (herd immunity) In Thailand's population.

IV. Top 10 publications in 2021

1. Evaluating the impact of intervention strategies on the first wave and predicting the second wave of COVID-19 in Thailand: A mathematical modeling study. Mahikul W, Chotsiri P, Ploddi K, Pan-Ngum W. *Biology (Basel)*. 2021;10(2):80. PMID: 33499138; PMCID: 7911628.



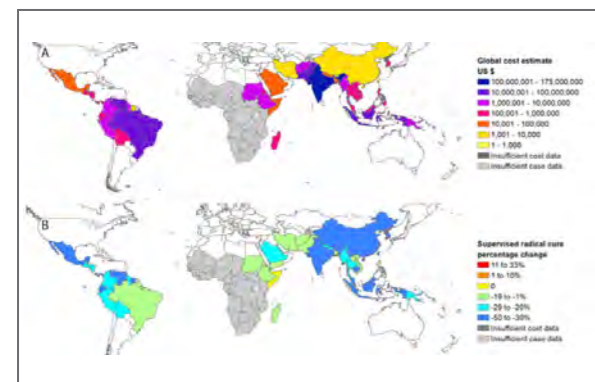
While working on her DPhil thesis supervised by Prof Ben Cooper in Oxford, Mo Yin conducted a multinational clinical trial on optimising treatment duration for ventilator-associated pneumonia. During the pandemic, she worked with Public Health England and the WHO mainly focusing on hospital-acquired COVID-19 amongst patients and healthcare workers. © MORU 2022.

2. Human, animal, water source interactions and leptospirosis in Thailand. Narkkul U, Thaipadungpanit J, Srisawat N, Rudge JW, Thongdee M, Pawarana R, Pan-Ngum W. *Sci Rep*. 2021;11(1):3215.. PMID: 33547388; PMCID: 7864926.
3. Effect of delays in concordant antibiotic treatment on mortality in patients with hospital-acquired *Acinetobacter* species bacteremia: Emulating a target randomized trial with a 13-year retrospective cohort. Lim C, Mo Y, Teparrukkul P, Hongsuwan M, Day NPJ, Limmathurotsakul D, Cooper BS. *Am J Epidemiol*. 2021;190(11):2395-2404. PMID: 34048554; PMCID: 8561124.
4. Transmission of community- and hospital-acquired SARS-CoV-2 in hospital settings in the UK: A cohort study. Mo Y, Eyre DW, Lumley SF, Walker TM, Shaw RH, O'Donnell D, Butcher L, Jeffery K, Donnelly CA; Oxford COVID infection review team, Cooper BS. *PLoS Med*. 2021;18(10):e1003816. PMID: 34637439; PMCID: 8509983.
5. Potential health and economic impacts of dexamethasone treatment for patients with COVID-19. Águas R, Mahdi A, Shretta R, Horby P, Landray M, White L; CoMo Consortium. *Nat Commun*. 2021;12(1):915. PMID: 33568665; PMCID: 7875992.
6. Levels of SARS-CoV-2 population exposure are considerably higher than suggested by seroprevalence surveys. Chen S, Flegg JA, White LJ, Aguas R. *PLoS Comput Biol*. 2021;17(9):e1009436. PMID: 34543264; PMCID: 8483393.
7. Potential global impacts of alternative dosing regimen and rollout options for the ChAdOx1 nCoV-19 vaccine. Aguas R, Bharath A, White LJ, Gao B, Pollard AJ, Voysey M, Shretta R. *Nat Commun*. 2021;12(1):6370. PMID: 34737262; PMCID: 8569205.
8. Estimating the programmatic cost of targeted mass drug administration for malaria in Myanmar. Kyaw SS, Delmas G, Drake TL, Celhay O, Pan-Ngum W, Pukrittayakamee S, Lubell Y, Aguas RJ, Maude RJ, White LJ, Nosten F. *BMC Public Health*. 2021;21(1):826. PMID: 33926399; PMCID: 8082869.

9. Global economic costs due to vivax malaria and the potential impact of its radical cure: A modelling study. Devine A, Battle KE, Meagher N, Howes RE, Dini S, Gething PW, Simpson JA, Price RN, Lubell Y. *PLoS Med.* 2021;18(6):e1003614. PMID: 34061843; PMCID: 8168905.
10. Implementation of field detection devices for antimalarial quality screening in Lao PDR-A cost-effectiveness analysis. Luangsanatip N, Khonputsu P, Caillet C, Vickers S, Zambrzycki S, Fernández FM, Newton PN, Lubell Y. *PLoS Negl Trop Dis.* 2021;15(9):e0009539. 34591842; PMCID: 8483304.

V. Capacity building achievements in 2021

- Secured funding from the University of Oxford to support the CoMo platform in delivering policy support to dozens of LMIC countries struggling with the Covid-19 pandemic.
- Received SPARK funding to build modelling capacity in the Asia Pacific Region, both for research and teaching.
- Funding secured as part of a consortium to inform country antibiotic guidance and local action in LMICs (ADILA).
- Started RHUBARB, a new Wellcome Trust supported project to improve methodologies to quantify the burden of drug-resistant bacterial infections.
- Funding secured as part of an international consortium to develop and evaluate one health interventions to reduce the spread of AMR in DRC and Burkina Faso (CABU-EICO).



A modelling study by Angela Devine and MAEMOD's Yoel Lubell highlights a substantial global economic burden of vivax malaria that could be reduced through investment in safe and effective radical cure achieved by routine screening for G6PD deficiency and supervision of treatment.

capacity building programme abroad and in Thailand, where it has resulted in increased engagement with Thai government partners.

The AToME group will:

- Offer analytical support to GMS countries to best inform their national strategic plans (NSP) targeting malaria elimination.
- Model the potential benefits and cost effectiveness of triple artemisinin combination therapies (TACTs). AToME is part of a large global team in the UKAid-funded DeTACT project trialling two different TACTs in 11 countries. We will investigate which combinations of drugs are expected to slow down the spread of ACT resistance in SE Asia will prevent ACT emergence in Africa. A strong health economics component will aim to build a business case for first line therapy replacement.
- Provide within-host insights of *P. falciparum de novo* resistance emergence, particularly understanding how drug/parasite phenotype combinations modulate the evolutionary pressure of drug resistance emergence.

VI. Future vision

MAEMOD's vision remains to provide pragmatic, innovative solutions to global health challenges in resource-limited settings. We will expand our

- Continue to assess the cost-effectiveness of different malaria intervention packages.
- Model cost-effective unified treatment strategies for multiple malaria species.

DRiADD aims to:

- Continue enrolling patients into an RCT trial to reduce the duration of antibiotic treatment for ventilator acquired pneumonia (VAP) in SEA.
- Analyse data from a whole genome sequencing study of *Acinetobacter spp.* transmission in a neonatal intensive care unit in Thailand.
- Continue to work on analytical approaches to developing and evaluating antibiotic stewardship interventions in LMIC settings, including work on a new cluster randomised trial to improve antibiotic use in sub-Saharan Africa.
- Develop a dynamic spatial one health model of AMR spread in Thailand informed by high resolution genomic data.
- Extend work on the nosocomial transmission of SARS-CoV-2 using both modelling approaches and clinical trials.
- Develop new modelling approaches that aim to help improve empirical antibiotic prescribing in community and hospital settings, with a global focus.

EIRG will:

- Complete the Spot Sepsis study looking at biomarkers of severity in febrile children and work with industry and other partners to validate appropriate POCTs for a follow-on intervention trial.
- Complete the roll out of the SEACTN programme, collecting data on >100,000 febrile episodes in hundreds of villages across SEA. We will use these data and the outcomes of Spot Sepsis to design optimal packages to extend the role of village malaria workers to village health workers (VHWs). We will later run cluster RCTs for new diagnostics and other interventions to improve the care of non-malarial febrile illness in the region.
- Continue our collaboration with HiTAP on developing regional health technology assessment capacities by training early career researchers, and conducting workshops for policymakers in economic evaluation, decision modelling and other relevant skills.
- Expand the iTPA support to researchers in MORU and FTM seeking pathways to translate their research into global health impact.

The NTDM Group aim to:

- Continue focusing our modelling work around public health issues in Thailand and SE Asia where neglected tropical diseases (NTDs) may cause low mortality but a high disease burden and economic loss.
- Take a participatory modelling approach to engage with communities as well as policymakers. Participation will be sought at all stages of model development and analysis, enabling stakeholders to play an active, influential role in stating research problems, study design, and making health decisions.
- Continue capacity building and research collaborations to build a strong research network involving Thai universities, the Thai Ministry of Public Health (MoPH), and other national organisations.
- Provide modelling support and work collaboratively with other MAEMOD departments.
- Initial stage of developing platform for model code and data sharing together with designing optimal workflow process among nodes in preparedness for future disease emergency.
- Work on rabies surveillance and dog population control with the Thai Government Livestock Department, the Thai MoPH, and the Veterinary Science Department at Mahidol University.



Overseen by Co-Head Professor Sasithon Pukrittayakamee (*centre*), the Clinical Therapeutics Unit (CTU) is staffed by experienced doctors and nurses familiar with Good Clinical Practice guidelines and research methodologies. Dr Podjane Jittamala, Dr Borimas Hanboonkunupakarn (*3rd from left*) and Dr Kittiyod Poovorawan (*3rd from right*) lead the various clinical and pharmacometric studies. © MORU 2022. Photographer: Gerhard Jørgén.

Clinical Therapeutics Unit (CTU)

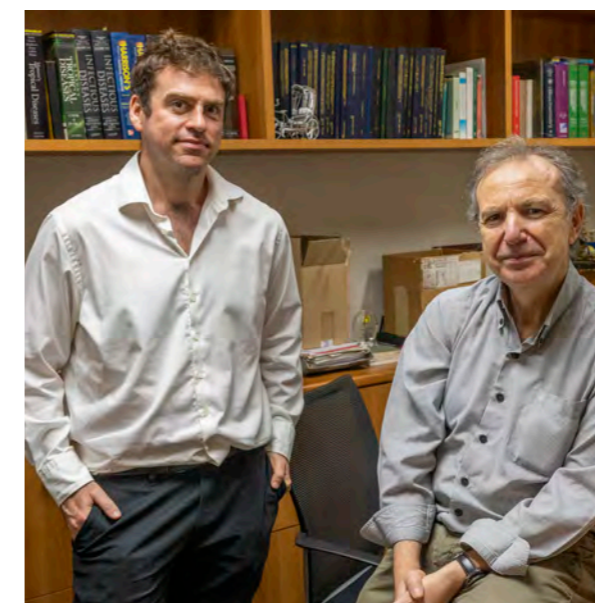
I. Overview

The Clinical Therapeutics Unit (CTU) conducts clinical studies on the treatment of uncomplicated malaria and COVID-19, and pharmacometric studies of new anti-infective drugs. CTU investigates, analyses and models pathological and pharmacological responses in malaria, G6PD deficiency, *Plasmodium vivax* relapse, COVID-19 and Chagas disease.

Located in a ward of the Hospital for Tropical Diseases, part of Mahidol University's Faculty of Tropical Medicine (FTM), and overseen by Prof. Sasithon Pukrittayakamee, CTU is staffed by experienced doctors and nurses familiar with Good Clinical Practice guidelines and research methodologies. Dr Podjane Jittamala, Dr Borimas Hanboonkunupakarn and Dr Kittiyod Poovorawan lead the various clinical and pharmacometric studies.

The clinical team conducts studies on the treatment of uncomplicated malaria in the hospital inpatient wards and healthy volunteer clinical pharmacology and vaccinology studies. The CTU has initiated a major new project in collaboration with the Mahidol Vaccine Research Unit (MVRU) – volunteer controlled human *Plasmodium vivax* malaria challenge studies. The aim is to develop sporozoite and blood stage infection models in Thailand to accelerate *P. vivax* vaccine development. The first volunteers have been safely infected with sporozoites and studied, and then treated, and blood was banked for future blood stage infection models.

Since early 2020 CTU has led multinational studies on the prevention and treatment of COVID-19. The COPCOV study, a double-blind placebo-controlled evaluation of chloroquine or hydroxychloroquine chemoprophylaxis in the prevention of COVID-19, is led by Dr Will Schilling. COPCOV was conducted first in FTM, but then extended to UK, Pakistan, Indonesia, Kenya, Zambia, Niger, Côte d'Ivoire, and Benin and eventually enrolled 4,646 subjects. The PLATCOV study is an open randomised adaptive platform pharmacometric comparison of different antiviral drugs in acute uncomplicated COVID-19. Most recruitment has been in FTM (led by Dr Podjane Jittamala), but the study has also started in Minas Gerais in Brazil, and will soon start in the Aga Khan University Hospital in Karachi, Pakistan and Mahosot hospital, Vientiane, Lao PDR. The study uses a new methodology for assessing antiviral pharmacodynamics *in-vivo*.



Dr Will Schilling (*left*) is co-PI for the global COPCOV study and a University of Oxford DPhil student based in Bangkok. Dr Bob Taylor studies the optimal use of primaquine – leading multinational randomised controlled trials, developing new dose regimens and addressing the neglected problem of primaquine formulations and dosing in children. © MORU 2022. Photographer: Gerhard Jørgén.

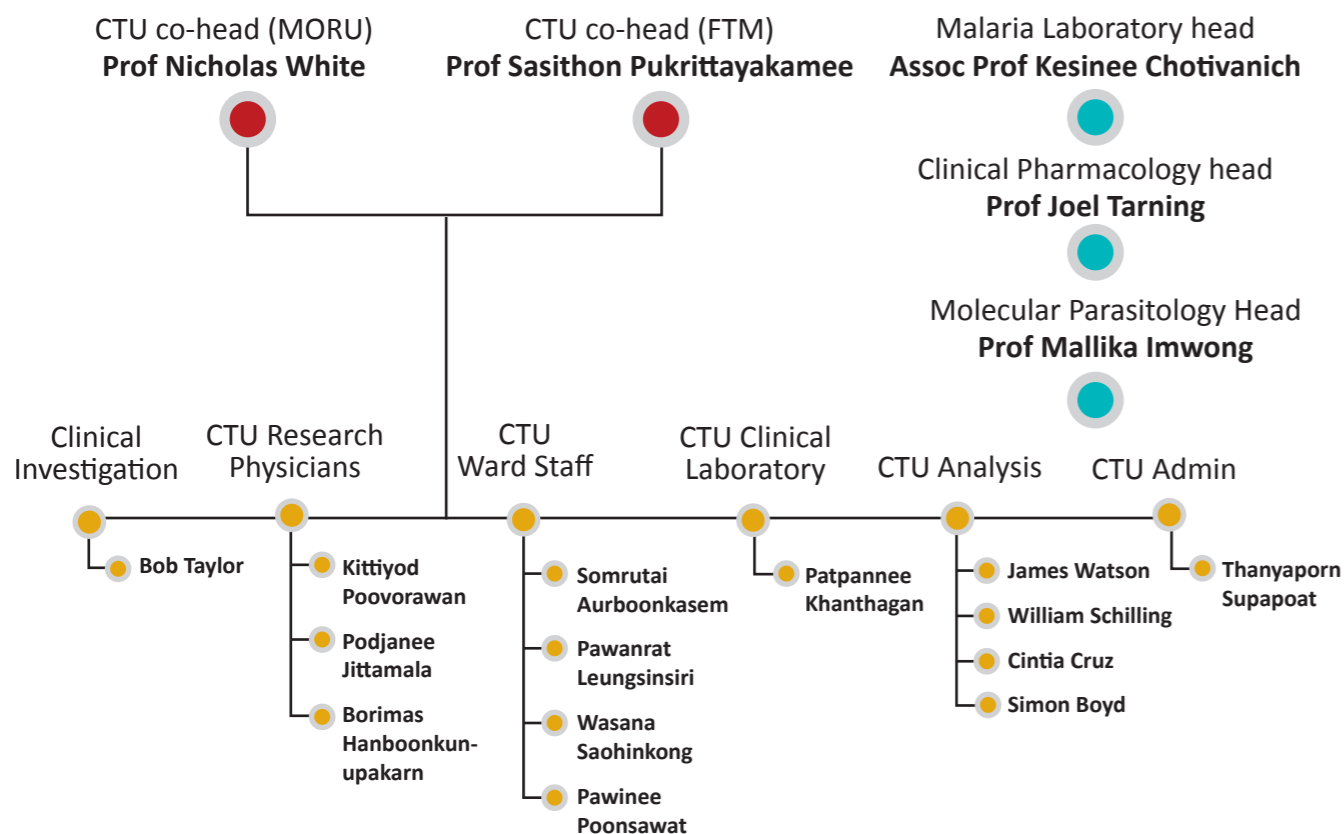
Dr Bob Taylor has been studying the optimal use of primaquine – leading multinational randomised controlled trials, developing new dose regimens and addressing the neglected problem of primaquine formulations and dosing in children. CTU is currently evaluating an ascending dose regimen for primaquine in G6PD deficiency which may obviate testing. James Watson works with Nick White analysing data and modelling pathological responses in both uncomplicated and severe malaria, haematological responses in G6PD deficiency, *Plasmodium vivax* relapse, and evaluating anti-infective drug pharmacokinetic and pharmacodynamics data. James has developed new statistical methodologies for genome wide association studies where phenotyping is imprecise. He has focussed on severe falciparum malaria and shown that approximately one third of African children enrolled in prospective studies of severe malaria have been misdiagnosed. This has led to simple improvements in diagnosis to increase specificity, and thus power in clinical trials. CTU also has a particular interest in the interpretation of parasite genotyping data in epidemiological and therapeutic studies.

Dr Cintia Cruz, a paediatrician from Argentina is setting up a pharmacometric platform to assess new treatments for Chagas disease (South American trypanosomiasis). These studies will take place with our collaborators in Brazil (Prof Israel Molina) and Argentina (Prof Jaime Altech).

Dr Borimas Hanboonkunupakarn, Dr Kittiyod Poovorawan and Dr Podjane Jittamala lead studies of antimalarial drug interactions. A particular feature of these antimalarial drug studies is the need for protracted follow-up because many of these drugs are very slowly eliminated. These studies have underpinned large clinical trials conducted by MORU and partners.

CTU has an active postgraduate student programme, with Dr XH Chan having just completed her DPhil successfully (on antimalarial cardiotoxicity), and Dr Cintia Cruz (Treatment of Chagas disease) and Dr Will Schilling (COVID-19 therapeutics) having recently started their DPhil studies.

II. Our team



III. Scientific achievements in 2021

CTU has conducted pharmacokinetic and PK-PD studies on antimalarial drugs, antiviral drugs, and endectocides. It is currently evaluating an ascending dose regimen for primaquine in G6PD deficiency and conducting studies of antimalarial drug-drug interactions. These studies, mainly designed to optimise dosing, have underpinned drug registration and the large clinical trials conducted by MORU and partners.



The clinical team conducts studies on the treatment of uncomplicated malaria in the hospital inpatient wards and healthy volunteer clinical pharmacology and vaccinology studies. © MORU 2022. Photographer: Gerhard Jøren.

Healthy volunteer studies

Antimalarial drug interaction studies

An ongoing series of studies is assessing the pharmacokinetics and safety of triple artemisinin combinations (TACTs). An assessment of the interaction between artemether-lumefantrine and amodiaquine is in progress.

Cardiovascular toxicity of the antimalarial drugs

Our studies of the cardiovascular effects of antimalarial drugs have characterised the effects of malaria on electrocardiographic indices and illustrated the pitfalls of failing to incorporate this in cardiotoxicity assessments. The cardiovascular effects of amodiaquine have been investigated. These studies have shown that amodiaquine causes bradycardia and prolongs the QT interval (*PLoS Medicine*, 2021). The underappreciated

contribution of intraventricular conduction delay to QT prolongation has been quantitated for chloroquine, and the interaction with azithromycin characterised (*Clin Pharm Ther* 2022). This indicates that the arrhythmogenic toxicity of chloroquine has been substantially overestimated, particularly in the spate of reports that originated at the beginning of the COVID-19 pandemic.

Development of a new primaquine radical cure regimen

Primaquine is widely recommended, but often not used. We have shown, in the largest ever randomised multinational trial in vivax malaria, that a seven day course of high dose primaquine is as effective as the conventional 14 day course of treatment (*Lancet* 2019). Using a new approach combining genotyping and time to event modelling, we have shown that if primaquine is used properly it can prevent nearly all relapses of vivax malaria. This currently requires testing for G6PD deficiency which is relatively expensive and generally unavailable. We have modelled an ascending dose regimen that should avoid dangerous haemolytic toxicity and could therefore be used without G6PD testing. This regimen is being tested in an adaptive trial design in known G6PD-deficient healthy volunteers.

COVID-19 prevention

We have conducted the largest multinational trial of COVID-19 prevention in the world, *Chloroquine prevention of coronavirus disease (COVID-19) in the healthcare setting (COPCOV)*. The COPCOV study is a double-blind placebo controlled evaluation of chloroquine or hydroxychloroquine chemoprophylaxis in the prevention of COVID-19. This has been a huge and difficult effort. Plans to start the study in Argentina, Bulgaria, Colombia, Croatia, Egypt, India, Italy, Jamaica, Luxembourg, Malawi, Maldives, Mozambique, Panama, Philippines, Portugal, Puerto Rico, Russia, Senegal, Sierra Leone, Tanzania, Ukraine, and Viet Nam have all been thwarted, often after lengthy negotiations, translations, and ethics and regulatory submissions. This experience has contributed to the COVID-19 Clinical Research Coalition (chaired by Nick White) which advocates



Shown with members of the CTU Ward Staff, Professor Kesinee Chotivanich (in red) and CTU are involved in a major new project in collaboration with the Mahidol Vaccine Research Unit (MVRU): volunteer controlled human *Plasmodium vivax* malaria challenge studies. © MORU 2022. Photographer: Gerhard Jøren.

to reduce the obstacles to COVID-19 clinical research in low resource settings. COPCOV has been conducted in 11 other countries, and finished all three-month follow-ups in 4,646 subjects. Samples are currently being freighted to Thailand for PCR, serology and drug measurement. Results will be available in Q3, 2022. We are collaborating with the Wellcome History of Medicine Unit in Oxford (Prof Mark Harrison) to document the COPCOV experience.

Treatment studies

COVID-19 antiviral pharmacometrics

There is no currently accepted methodology for assessment or comparison of potential antiviral drugs for COVID-19. Based on modelling of serial qPCR data from the US NBA surveillance program, we have developed a simple approach to assessing antiviral pharmacodynamics from serial daily duplicate oropharyngeal qPCR measurements in

Analysis

In 2021 the analytical team have:

- Shown that a data-tilting approach to weighting of severe malaria genetic association data improves their discriminatory power.



James Watson (*left*) works with Nick White analysing data and modelling pathological responses in both uncomplicated and severe malaria. CTU Clinical Research Physician Dr Podjane Jittamala works on CTU's various clinical studies. © MORU 2022. Photographer: John Bleho.

- Shown that approximately one third of African children diagnosed with severe malaria in prospective studies to date had another cause of severe illness (likely sepsis).
- Validated simple measures that improve diagnostic specificity in severe malaria.
- Confirmed the prognostic value of intraleukocytic pigment counts in severe malaria.
- Developed a new pharmacometric approach to the assessment of malaria chemoprevention in high transmission settings.
- Provided a quantitative approach to assessing therapeutic responses in vivax malaria.
- Developed statistical methodology to assess antiviral pharmacodynamics in COVID-19.
- Developed the statistical model for assessing early therapeutic responses in Chagas disease.

IV. Top 10 publications in 2021

1. Spend wisely to eliminate malaria. Smithuis FM, White NJ. *Lancet Infect Dis*. 2022 Jun;22(6):e171-e175. doi: 10.1016/S1473-3099(21)00256-5. Epub 2021 Dec 22. PMID: 34953537.
2. The WHO guideline on drugs to prevent COVID-19: small numbers- big conclusions. Schilling WH, Callery JJ, Chandna A, et al. *Wellcome Open Res*. 2021 Sep 21;6:71. doi: 10.12688/wellcomeopenres.16741.2. PMID: 34395925; PMCID: 8356259.
3. Development of weight and age-based dosing of daily primaquine for radical cure of vivax malaria. Taylor WR, Høglund RM, Peerawaranun P, et al. *Malar J*. 2021 Sep 9;20(1):366. doi: 10.1186/s12936-021-03886-w. PMID: 34503519; PMCID: 8427859.
4. The cardiovascular effects of amodiaquine and structurally related antimalarials: An individual patient data meta-analysis. Chan XHS, Haeusler IL, Win YN, et al. *PLoS Med*. 2021 Sep 7;18(9):e1003766. doi: 10.1371/journal.pmed.1003766. PMID: 34492005; PMCID: 8454971.
5. Improving statistical power in severe malaria genetic association studies by augmenting phenotypic precision. Watson JA, Ndila CM, Uyoga S, et al. *Elife*. 2021 Jul 6;10:e69698. doi: 10.7554/eLife.69698. PMID: 34225842; PMCID: 8315799.
6. COVID-19 chemoprevention. Cruz C, White NJ. *Int J Infect Dis*. 2021 Jun; 107:31-33. doi: 10.1016/j.ijid.2021.04.045. Epub 2021 Apr 24. PMID: 33901652; PMCID: 8064811.
7. The prevention and treatment of *Plasmodium vivax* malaria. Chu CS, White NJ. *PLoS Med*. 2021 Apr 23;18(4):e1003561. doi: 10.1371/journal.pmed.1003561. PMID: 33891587; PMCID: 8064578.
8. Anti-malarial drug effects on parasite dynamics in vivax malaria. White NJ. *Malar J*. 2021 Mar 21;20(1):161. doi: 10.1186/s12936-021-03700-7. PMID: 33743731; PMCID: 7981980.

9. A systematic review and an individual patient data meta-analysis of ivermectin use in children weighing less than fifteen kilograms: Is it time to reconsider the current contraindication? Jittamala P, Monteiro W, Smit MR, et al. *PLoS Negl Trop Dis*. 2021 Mar 17;15(3):e0009144. doi: 10.1371/journal.pntd.0009144. PMID: 33730099; PMCID: 7968658.

10. Protective effect of Mediterranean-type glucose-6-phosphate dehydrogenase deficiency against *Plasmodium vivax* malaria. Awab GR, Aaram F, Jamornthanyawat N, et al. *Elife*. 2021 Feb 5;10:e62448. doi: 10.7554/eLife.62448. PMID: 33543710; PMCID: 7884069.

V. Capacity building achievements in 2021

The development of a facility in the Faculty of Tropical Medicine to conduct human malaria challenge experiments has been a major joint achievement of MVRU and MORU, and a tribute to the CTU team. CTU has also built an international network of COVID-19 study sites.



Professor Sir Nick White (*left*), Co-Head of MORU's Clinical Trials Unit, with Professor Saye Khoo, a member of Wellcome's site review panel, at SMRU during their Feb 2020 visit for the 2020-2025 Wellcome Core Grant Renewal. © MORU 2022.

VI. Future vision

CTU underpins many of the clinical malaria studies conducted by MORU by conducting preliminary pharmacokinetic, drug-drug interaction studies or safety evaluations. CTU evaluates new and existing antimalarial drugs in order to improve the treatment of malaria. The establishment of the controlled *P. vivax* human infection model to study vaccines and drugs – and also the biology of relapse in *P. vivax* infections is a major project for the future. We are also about to conduct innovative pharmacometric studies in seasonal malaria chemoprevention in Africa, and Chagas disease in South America.

CTU continues to study the pharmacometric determinants of vivax malaria relapse, and relapse intervals. The severe malaria studies aim to improve the diagnosis (and thus management) of severe malaria. We are also studying the potential protective role of anaemia in severe malaria, which may lead to revision in severe malaria criteria and inform transfusion policies. James Watson has won a Sir Henry Dale Fellowship and will extend his work to develop statistical methodologies to improve genetic association studies where the phenotype is imprecise.

CTU aims to develop a multinational platform on which to conduct pharmacometric studies in COVID-19 and other respiratory viral infections.



CTSG enhances MORU's research infrastructure to ensure research is conducted to applicable Good Clinical Practice (GCP) standards and regulations. Experienced in developing, running and analysing clinical trials in an international setting, CTSG team members provide support and training to research teams and clinicians at all MORU Tropical Health Network settings. © MORU 2022. Photographer: Gerhard Jøren.

Clinical Trials Support Group (CTSG)

I. Overview

The Clinical Trials Support Group (CTSG) supports investigators conducting research for the MORU Tropical Health Network.

Established in 2008, CTSG enhances the research infrastructure at MORU to ensure research is conducted to applicable Good Clinical Practice (GCP) standards and regulations. CTSG is set up in three primary functional areas: Clinical Research; Data Management, headed by Naomi Waithira; and Statistics, led by Mavuto Mukaka.

CTSG staff are experienced in developing, running and analysing clinical trials in an international setting. Based primarily in MORU's Bangkok Unit, team members also regularly provide support and training to research teams and clinicians at all sister units.

The **Clinical Research team** is responsible for trial operations and submissions, implementing and managing clinical protocols and study activities to support MORU investigators. This includes:

- Handling regulatory submissions for initial protocols and ongoing correspondence with both the Oxford central and local Thai ethics committees



Tanya Cope (*left*) headed CTSG until she returned to the USA with her family in early 2022. In May 2022, Greg Fegan became Head of CTSG. © MORU 2022. Photographer: Gerhard Jøren.

- Developing study procedures, documentation and systems necessary to initiate study teams and oversee conduct of studies
- Conducting study-specific and general good clinical practice (GCP) training
- On-site and remote monitoring of clinical studies to ensure compliance
- Project management services to investigators, including tracking milestones and coordination

Our **Data Management** team supports investigators to collect, curate and store clinical research data. The team comprises

of data managers, software developers, a system administrator and data entry staff. Specifically, the team:

- Develops project-specific data management and sharing plans
- Designs Case Report Forms (CRFs) and questionnaires for data collection
- Develops, validates and maintains study databases
- Performs data entry for select studies
- Performs cleaning, coding and standardisation of datasets
- Provides advice and technical support for data sharing
- Develops bespoke software applications and websites



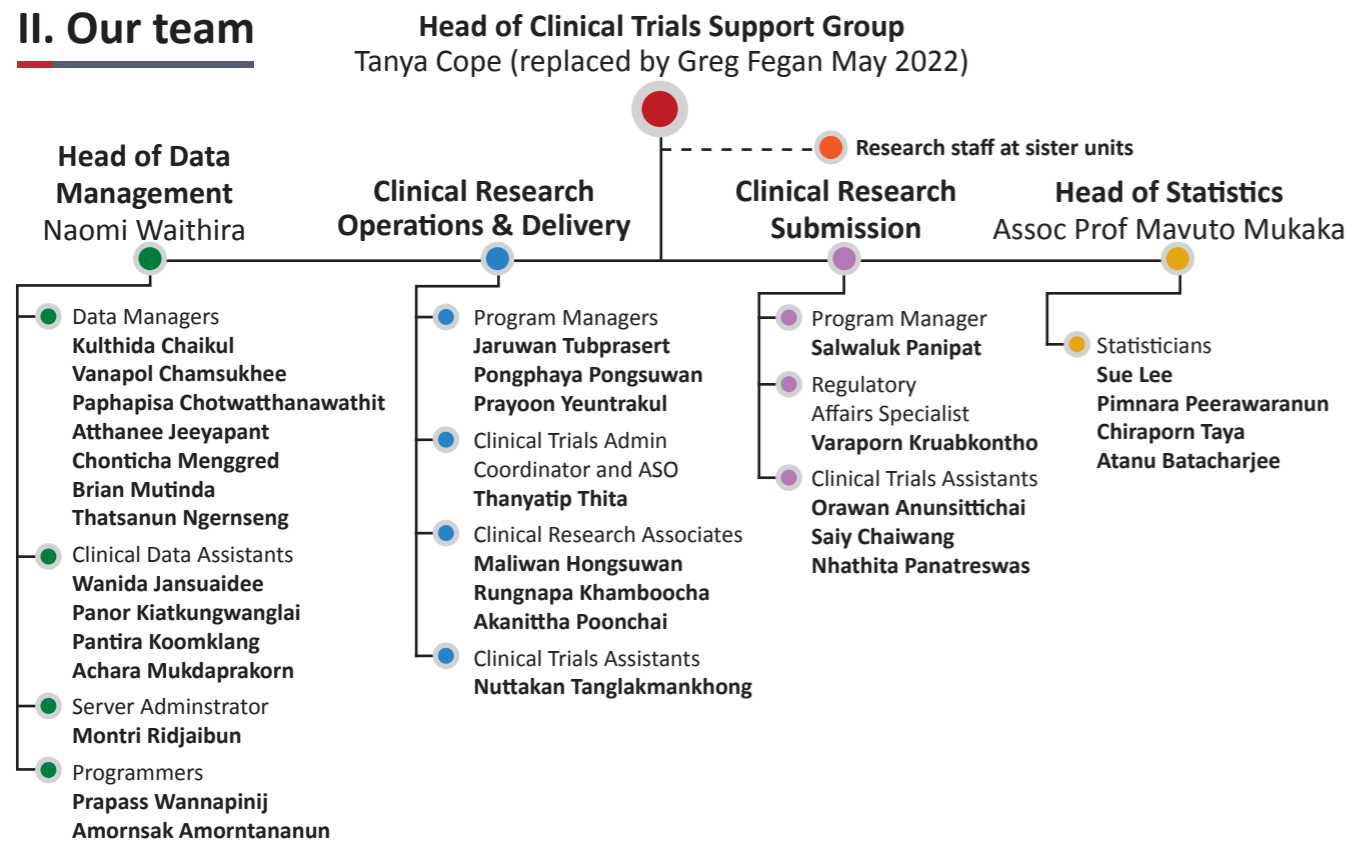
Head of Statistics Assoc Prof Mavuto Mukaka (*left*) and Head of Data Management Naomi Waithira. © MORU 2022. Photographer: Gerhard Jøren.

The **CTSG Statistics** team analyses and advises on all statistical elements of MORU's clinical trials. They work closely with key researchers to design research studies, develop the study's statistics analysis plan and related study documents such as Data Safety Monitoring Board (DSMB) charter, shell reports and statistical SOPs, ensuring that data capture and recording methods are suitable and that planned analysis is frequent and robust enough to meet the study's objectives.

During a clinical trial, interim statistical analyses are key to ongoing progress. The CTSG Statistics and Data Management teams work closely with project leads to undertake periodic reviews. When trials are under oversight of a DSMB, the Statistics Team prepares appropriate reports and leads the DSMB reporting. Upon trial completion, the Statistics team prepares for publications of the full statistical analysis of data collected during the trial. This enables critical insight and evaluation to inform further research questions.

CTSG team members are grant co-applicants or co-investigators on some projects. The team also organises and delivers a number of yearly statistics short courses in addition to teaching and post-graduate supervision at the University of Oxford, Mahidol University, and beyond.

II. Our team



III. Scientific achievements in 2021

- Continued oversight and coordination across all CTSG functions with investigators, MORU management, and sponsor teams to manage CTSG research portfolio within the context of COVID-19 (for both COVID-focused and other funded projects). This included working primarily remotely from the MORU offices and study sites during 2021.
- Provided unit seminars to raise awareness and inform latest updates to guidance from Wellcome clinical trial policy and the International Council for Harmonisation (ICH).
- Completed updates for key departmental procedures overseeing training and quality management for study documents.
- Provided continued academic support for Oxford and Mahidol training programs.
- Rolled-out an open-source platform that allows data collection using mobile devices as a replacement of paper-based data capture. The platform is now used for data collection in 6 clinical studies.

IV. Top 10 publications in 2021

- Arterolane-piperaquine-mefloquine versus arterolane-piperaquine and artemether-lumefantrine in the treatment of uncomplicated Plasmodium falciparum malaria in Kenyan children: a single-centre, open-label, randomised, non-inferiority trial. Hamaluba M, van der Pluijm RW, Weya J, Njuguna P, Ngama M, ... **Mutinda B, Mukaka M, Waithira N** ... Bejon P, Dondorp AM. *Lancet Infect Dis*. 2021 Oct;21(10):1395-1406. doi: 10.1016/S1473-3099(20)30929-4. Epub 2021 Jun 7. PMID: 34111412; PMCID: 8461080.
- Study protocol: an open-label individually randomised controlled trial to assess the efficacy of artemether-lumefantrine prophylaxis for malaria among forest goers in Cambodia. Maude RJ, Tripura R, Mom E, Sohka M, Peto TJ ... **Mukaka M, Waithira N, Jaruwan J**, von Seidlein L, Sovannaro S. *BMJ Open*. 2021 Jul 7;11(7):e045900. doi: 10.1136/bmjopen-2020-045900. PMID: 34233975; PMCID: 8264911.
- A randomized controlled trial of dihydroartemisinin-piperaquine, artesunate-mefloquine and extended artemether-lumefantrine treatments for malaria in pregnancy on the Thailand-Myanmar

border. Saito M, Carrara VI, Gilder ME, Min AM, Tun NW, ... **Lee SJ** ... Singhasivanon P, White NJ, Nosten F, McGready R. *BMC Med*. 2021 Jun 10;19(1):132. doi: 10.1186/s12916-021-02002-8. PMID: 34107963; PMCID: 8191049.

- Short maternal stature and gestational weight gain among refugee and migrant women birthing appropriate for gestational age term newborns: a retrospective cohort on the Myanmar-Thailand border, 2004-2016. **Lee SJ**, Hashmi AH, Min AM, Gilder ME, Tun NW ... Ner NM, Charunwatthana P, Nosten FH, Carrara VE, McGready R. *BMJ Glob Health*. 2021 Feb;6(2):e004325. doi: 10.1136/bmjgh-2020-004325. PMID: 33597278; PMCID: 7893649.
- Development of weight and age-based dosing of daily primaquine for radical cure of vivax malaria. Taylor WR, Hogle RM, Peerawaranun P, Nguyen TN, Hien TT ... Buchy P, Menard D, White NJ, Tarning J, **Mukaka M**. *Malar J*. 2021 Sep 9;20(1):366. doi: 10.1186/s12936-021-03886-w. PMID: 34503519; PMCID: 8427859.
- Clustering of malaria in households in the Greater Mekong Subregion: operational implications for reactive case detection. **Mukaka M, Peerawaranun P**, Parker DM, Kajeewiwa L, Nosten FH ... Imwong M, Day NPJ, Dondorp AM, White NJ, von Seidlein L. *Malar J*. 2021 Aug 26;20(1):351. doi: 10.1186/s12936-021-03879-9. PMID: 34446009; PMCID: 8393740.
- Feasibility pilot of an adapted parenting program embedded within the Thai public health system. McCoy A, Lachman JM, Ward CL, Tapanya S, Poomchaichote T, Kelly J, **Mukaka M**, Cheah PY, Gardner F. *BMC Public Health*. 2021 May 29;21(1):1009. doi: 10.1186/s12889-021-11081-4. PMID: 34051772; PMCID: 8164235.
- Community seroprevalence and risk factors for SARS-CoV-2 infection in different subpopulations in Vellore, India, and their implications for future prevention. Dayanand D, Irudhayanthan I, Kundu D, Manesh A, Abraham V ... **Peerawaranun P, Mukaka M**, Joseph J, Sivaprakasam M, Varghese GM. *Int J Infect Dis*. 2022 Mar;116:138-146. doi: 10.1016/j.ijid.2021.12.356. Epub 2021 Dec 28. PMID: 34971822; PMCID: 8712712.
- High levels of pathological jaundice in the first 24 hours and neonatal hyperbilirubinaemia in an epidemiological cohort study on the Thailand-Myanmar border. Thielemans L, **Peerawaranun P, Mukaka M**, Paw MK, Wiladphaingern J ... Wah TS, Beau C, Nosten F, McGready R, Carrara VI. *PLoS One*. 2021 Oct 7;16(10):e0258127. doi: 10.1371/journal.pone.0258127. PMID: 34618852; PMCID: PMC8496801.
- Identifying prognostic factors of severe metabolic acidosis and uraemia in African children with severe falciparum malaria: a secondary analysis of a randomized trial. Mzumara G, Leopold S, Marsh K, Dondorp A, Ohuma EO, **Mukaka M**. *Malar J*. 2021;20(1):282. Epub 2021/06/27. doi: 10.1186/s12936-021-03785-0. PMID: 34172046; PMCID: 8234663.

V. Future vision

CTSG's continued vision is to deliver quality study conduct and data, to support the advancement of the MORU Network's mission to find practical solutions to major tropical medical problems.

To continue building partnerships with MORU investigators and sites, future CTSG goals include:

- Enhancing compliance and consistency of MORU research projects by implementing a toolkit with core research materials and GCP training, which will be available to all investigators;
- Implementing a centralised risk matrix to be used with study development, to review and oversee clinical studies in a compliant and pragmatic manner; and
- Conducting further GCP and technical training forums, to extend clinical study knowledge across MORU units and investigators.

MORU Bangkok-based Departments



From *left*: MORU COO and Head of Operations & Administration David Burton, and Kanchana Pongsaswat and members of her HR & Admin team. © MORU 2022. Photographer: Gerhard Jøren.

Operations & Administration

I. Overview

Led by Chief Operating Officer (COO) David Burton (*top left*) and based in Bangkok, MORU's Operations & Administration team provides multifunctional support to Departments, Units and study sites across the MORU Tropical Health Network. In addition, HR & Training, Logistics, IT, Health & Safety, Compliance, Security, Communications, Finance, Admin, Legal / Research Services, Contracts and Funding teams based in the University of Oxford provide the MORU Network with valuable support, as do operations teams based in each MORU Unit.



Dave Gandy (*left*) leads Fundraising/ Grant Management. © MORU 2022. Photographer: Gerhard Jøren.

Fundraising/Grant Management is led by Grants & Contracts Manager Dave Gandy, whose team gather and communicate funding opportunities and closely support Principal Investigators (PIs) in securing and managing monies for their research projects. They work with the Oxford-based Grant Management team to ensure the quality and completeness of the applications.

In 2020, 83 applications were submitted with a 52% success rate, which was similar to 2019, (48% success rate of 81 applications). In 2021 the COVID affected environment meant a reduced total of 43 applications were submitted, whilst we still have 18 of those pending a decision, the success rate where the outcome is known is 76%.

Dave's team is split between Pre-Award and Post-Award to better support the PIs research throughout the lifetime of each project grant.



Sasitorn Chuaynoo, *standing 3rd from left*, heads the Finance & Accounting department. © MORU 2022. Photographer: Gerhard Jøren.

The **Finance & Accounting** department, is led by Sasitorn Chuaynoo (Joy) who oversees 2 distinct teams. Parina Wright (Ae) leads the GL & Financial Accounting team whose responsibilities include cash management, payments and advances and also ensuring Thailand-based activities are compliant with the Thai Financial reporting standards for Non-Publicly Accountable Entities. The MORU Accounts Reporting team is led by Paweena Apiwatomkhun (Na) and she oversees project financial management and financial reporting. During 2021 the team successfully implemented a new finance system, Oracle NetSuite, with the aim of improving oversight and reporting.

The **Purchasing & Logistics team**, led by Pornjarus Sukhapiwat (Jiab), is responsible for the timely procuring of supplies, equipment and consumables to support research activities. The team ensures that MORU is compliant with the Thai Import/Export requirements and facilitates the onward delivery of items around the Network.

HR & Administration Manager Kanchana Pongsaswat (Phung) leads the Bangkok-based **Human Resources & Administration team**, which provides recruitment, induction and admin services for the 239 (in Dec 2021) employees working for MORU Bangkok, and additional HR leadership and support for all 799 personnel employed across the Tropical Health Network.

The **IT team** is led by Head of IT Dean Sherwood, who manages infrastructure, servers, active directory accounts and hardware purchases. During the year Dean's team successfully implemented various software and cybersecurity measures including CrowdStrike further protecting MORU data and systems.

Gary Harkness, the newly appointed MORU Operations Officer, provides a broad range of **operational support** with specific focus on the career lifecycle of Oxford contracted employees and the new ERP (Enterprise Resource Planning) system. He also manages the NetSuite Administrator Tanathnun Wijitnukul (Jeng) who has administrative oversight of the recently implemented finance and purchasing system.



Gary Harkness, MORU Operations Officer. © MORU 2022.

The **Compliance & Quality Assurance team** is led by Chief Quality Officer Eoin Mac Hale. This team is responsible for ensuring that documentation for Laboratory and Research projects comply with applicable standards and guidelines. This is done through a version control document management system supporting the review and update of SOPs and process documents.

MORU **Training** activities are coordinated and delivered by Training & Development Manager Nantamon Netikul (Ploy) who also manages a virtual training platform to deliver training materials.

There is a **Health and Safety** function led by MORU Senior Microbiologist Prof Stuart Blacksell (in the role of Unit Safety Officer) who ensures that all working areas, especially the laboratories, fully comply with UK, national law and University of Oxford Safety policies. Each employee receives relevant training, and compliance reviews of each unit are undertaken with all incidents reported and managed through an incident management system and a Health and Safety Committee.

Communications activities are led by John Bleho, a specialist Media & Communications Manager who supports the MORU Tropical Health Network in all media interactions, newsletters, maintenance of the website and social media activities.



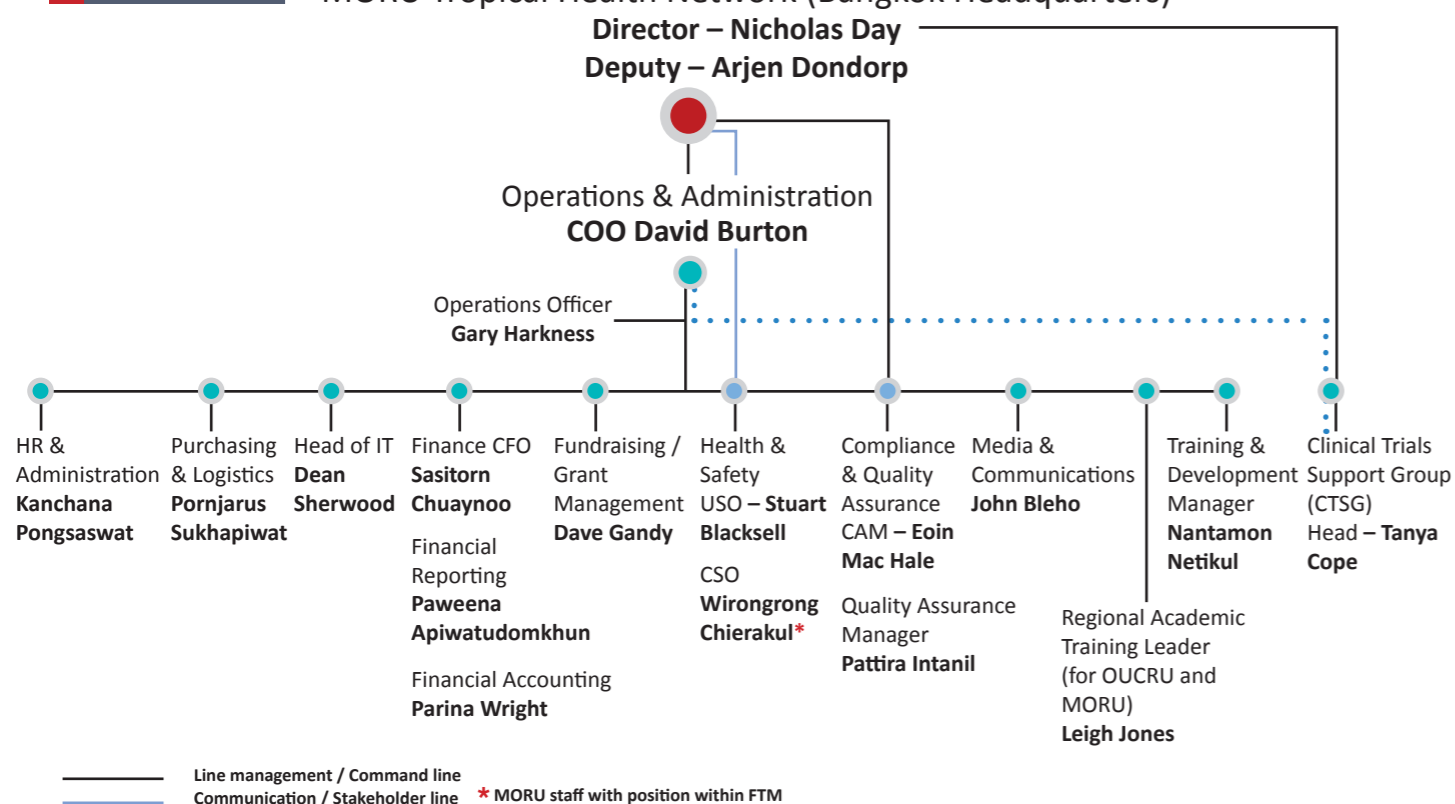
Dean Sherwood (2nd left) leads the IT team. Right, members of the Compliance & Quality Assurance team. © MORU 2022. Photographer: Gerhard Jørrén.

Regional Academic Training Leader for MORU and OUCRU Leigh Jones and her team work to create a larger, more connected student and supervisory network to enhance postgraduate learning at MORU and OUCRU. They seek to improve academic ecosystems, foster excellence in mentorship, engage with stakeholders to share best practices, and champion an enhanced research culture.

In addition to these Bangkok teams there are HR, Logistics, Communications, Finance, Legal teams based in the University of Oxford that provide valuable support to the MORU Tropical Health Network, as well as operations teams based in each MORU Unit.

II. Our team

MORU Tropical Health Network (Bangkok Headquarters)



III. Achievements in 2021

2021 saw a number of positive developments with augmentation of key teams and a focus on new systems and software. An Operations Officer was appointed to support the COO in managing Operational issues with key responsibilities around the interface with Oxford on areas such as HR and Finance.

The Finance team was strengthened with a new Chief Financial Officer who leads two distinct and now better resourced and skilled teams. A new ERP system (Oracle NetSuite) went live in Oct 2021. Both these developments have resulted in a marked improvement in the quality and accuracy of the financial accounting and reporting. Further work is to be done on the reporting in 2022.

A new Compliance, Development and Quality Assurance manager (CDQAM) was appointed who led a reorganisation of the Compliance and Assurance department function creating a new team to focus on all MORU Compliance and Assurance issues. The CDQAM also recruited a Thailand senior training position with designated funding and responsibilities. There has also been a more formalised approach to building staff capacity, training and supporting personal development.

During 2021 the operations teams had multiple work streams to manage whilst also having to deal with the continued effects of COVID-19. There were notable successes with continuing to support increased activities and global multi-site trials whilst still mostly working virtually.

IV. Capacity building achievements in 2021

- There was a focus on developing national staff members with the continued operation of the *Make a Difference (MaD) Programme*, MORU's 2-year leadership and personal effectiveness programme has been more challenging to run with COVID; however, in early 2022, two further cadres were recruited and face to face meetings were possible again.
- Potential scholarship scheme to support staff development is established under the Organisational Strengthening grant.
- A full training Needs assessment was undertaken across the MORU network resulting in more formalised plans and changes to HR processes

V. Future initiatives

Many actions have been completed in response to an earlier internal audit but there are some key focus areas for 2022 and beyond.

Organisational structures & responsibilities

- The Purchasing and logistics team will be reconfigured and trained to support inventory and stock management which can now be automated under the new ERP.
- Further work will be undertaken to review the regulatory environment in which MORU operates and a cost benefit analysis of establishing a new legal entity will be undertaken.

People

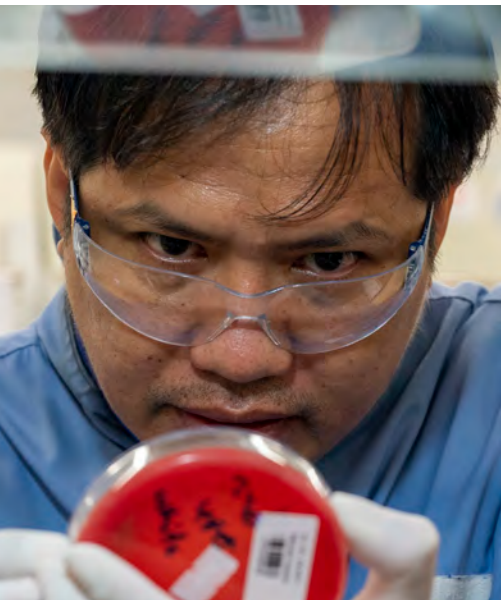
- Automation of processes around supporting people with a focus on building staff capacity and tracking and enabling personal development.

Systems

- Phase 2 implementation of the Finance system with a focus on providing automated business intelligence to support management decision making and improve donor reporting.
- Following the adoption of CrowdStrike and other cybersecurity related tools, there will be further reviews around possible enhancement of security through new solutions and penetration testing.

COVID-19 response

- The Crisis Management Committee (CMC) re-established in 2020 to support the management of COVID measures continued through 2021. Focus was given to ensuring that research could take place in a safe way and that as much as possible there was a virtual community established to support each other during this disruptive period. The main focus in 2022 will be on supporting staff to return to work and establishing whether the working business model should be updated.



MORU Units





Importantly for SMRU's continued success, SMRU has an extensive training programme for its local staff, training midwives, obstetric ultra-sonographers, healthcare assistants, public health students, laboratory technicians, and malaria post workers. © MORU 2022. Photographer: Gerhard Jøren.

Shoklo Malaria Research Unit (SMRU)

I. Overview

Founded in 1986 to work in camps for Myanmar refugees, the Shoklo Malaria Research Unit (SMRU) provides quality health care to marginalised populations on both sides of the Thai-Myanmar border near Mae Sot, Tak Province. SMRU combines research and humanitarian services, with an emphasis on maternal and child health, tuberculosis and other infectious diseases. It has extensive field research and laboratory infrastructure, including microbiology, entomology, molecular and haematology laboratories.

SMRU global impact studies provided much of the evidence underpinning current treatment of malaria (*P. falciparum* and *P. vivax*), and the worldwide move in 2006 to using artemisinin-based combination therapies (ACTs) as first line therapy to treat uncomplicated falciparum malaria. Our work includes studies on the treatment of *P. falciparum* and *P. vivax* malaria; questions related to pregnant women, newborns, and infants; tuberculosis, including multidrug resistant (MDR) TB; and work documenting the emergence and spread of antimalarial resistance. Activities include malaria elimination deep inside Myanmar; maternal and child health; laboratory diagnosis of infectious diseases and inherited blood disorders; entomology; bioethics and community engagement.



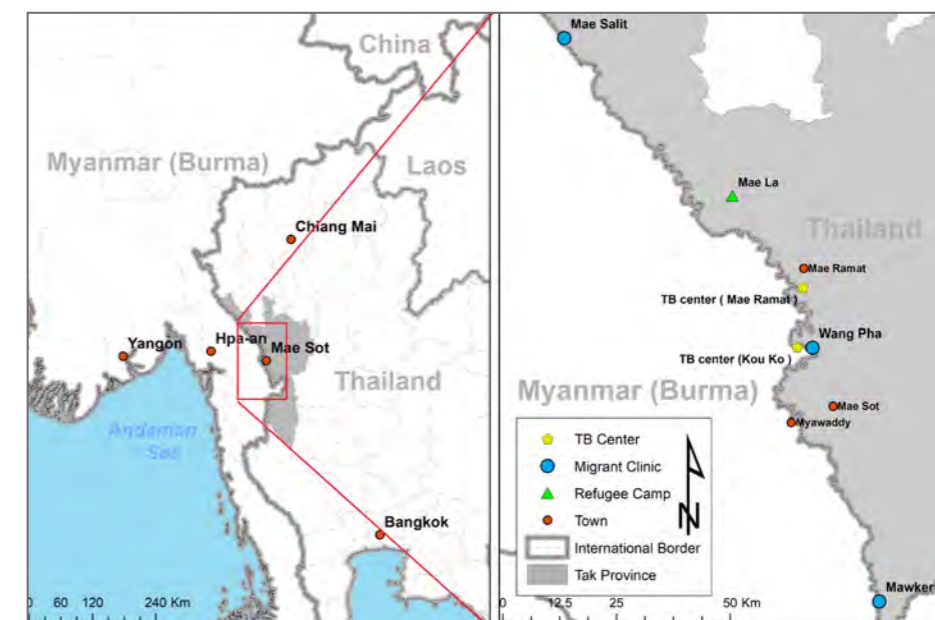
SMRU Director Professor François Nosten. © MORU 2022. Photographer: Gerhard Jøren.

In 2018 the Borderland Health Foundation (BHF) was registered in Thailand as a legal NGO structure attached to SMRU to further develop non-research activities essential to measure impact. Headquartered in an administrative, logistical and laboratory base in Mae Sot, SMRU operates several clinics along the border offering outpatient, inpatient, laboratory and maternity services and two TB residential clinics, and conducts the Malaria Elimination Task Force (METF), an extensive and highly effective malaria elimination programme in much of Myanmar's Karen State.

The combination of health care and research makes SMRU unique. Its research agenda is driven by the questions faced in clinical practice. Whether clinical or laboratory based, SMRU studies seek to identify community needs and strengths to help populations effectively fight infectious diseases. The resulting research has a direct impact on population health as demonstrated by a reduction in maternal and infant mortality and a dramatic decline in malaria morbidity and mortality.

Led since its inception by Prof. François Nosten, SMRU currently has 378 staff. For up-to-date information, please visit the SMRU website (www.shoklo-unit.com). SMRU's active student programme includes DPhil/PhD students at the University of Oxford and Open University UK. We regularly host University of Oxford medical students on elective and Masters students, as well as interns and students from other universities. Importantly for our continued success,

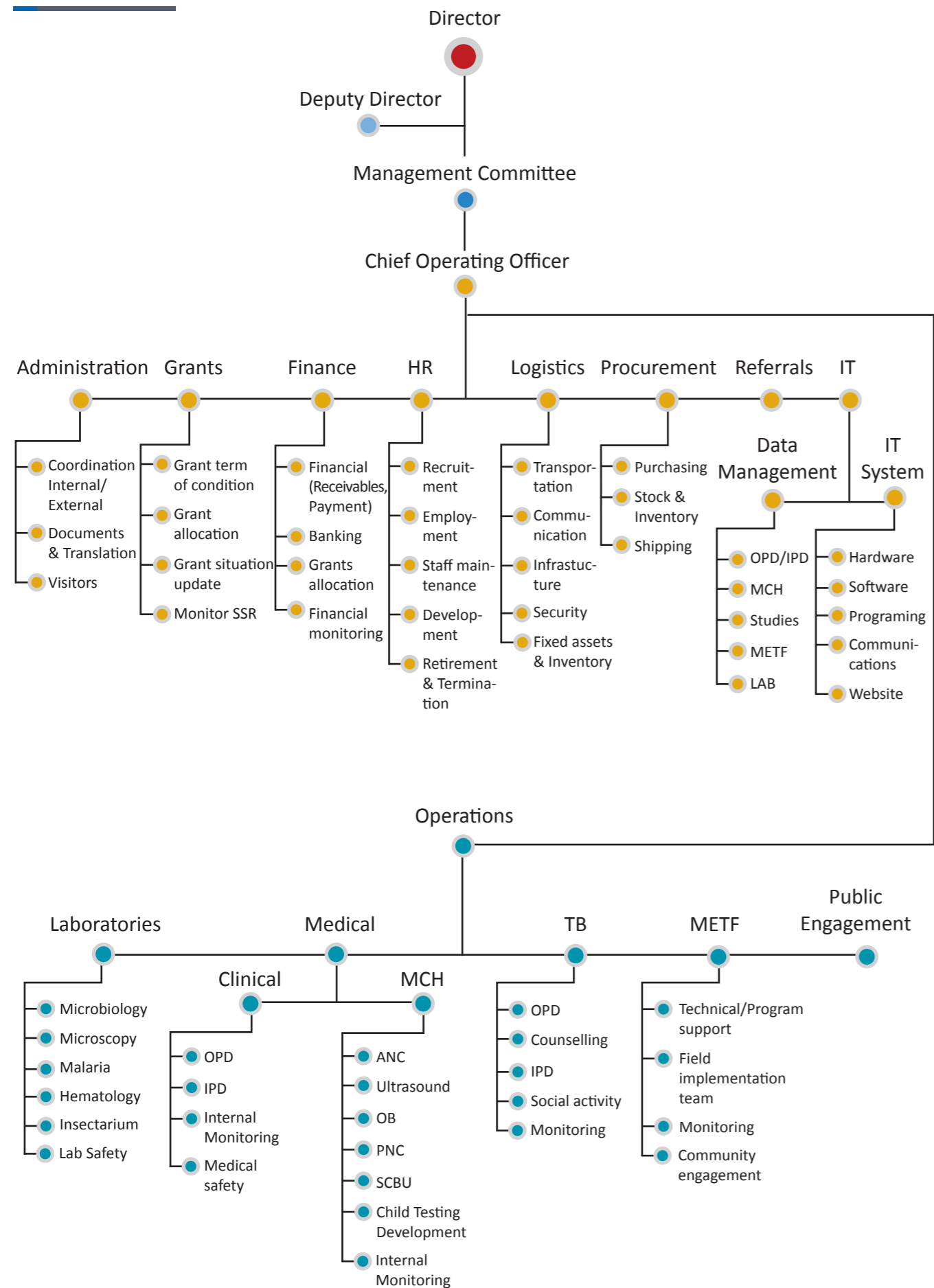
SMRU has an extensive training programme for its local staff, training midwives, obstetric ultra-sonographers, healthcare assistants, public health students, laboratory technicians, and malaria post workers.



Map of the Thai-Myanmar border showing SMRU operations areas and clinics. SMRU provides quality health care to marginalised populations on both sides of the Thai-Myanmar border near Mae Sot, Tak Province. © SMRU 2022.

The COVID-19 epidemic that peaked in August affected SMRU throughout 2021. Although initially we maintained clinic and laboratory activities, the number of patients able to reach our dispensaries declined. We actively engaged in a vaccination campaign for all team members and the most vulnerable patients under our care in the TB centres. By the end of 2021, the pandemic and increasing insecurity in Karen state following the February 2021 military coup in Myanmar resulted in a ~50% reduction in SMRU's overall activities.

II. Our team



III. Scientific achievements in 2021

Whether clinical or laboratory based, SMRU studies are driven by questions faced in clinical practice, and seek to identify community needs and strengths so populations can effectively fight infectious diseases. Scientific output continues to be prolific, with 336 publications since 2015, 60 of them in 2019, 43 in 2020, and 44 in 2021.



In 2021, SMRU continued collecting detailed information on malaria vectors to provide evidence on how their bionomics and resistance profiles affect the efficacy of vector-control interventions. Identification of the vectors captured in the area (left) and the team busy preparing new cages for the colonies of mosquitoes (right). © MORU 2022. Photographer: Gerhard Jørgén.

In the past year, SMRU’s unique research agenda has resulted in significant achievements in: malaria treatment; malaria elimination; tuberculosis; mother and child health; management of infections; health system strengthening; mental health; bioethics & community engagement; and laboratory based research.

Malaria

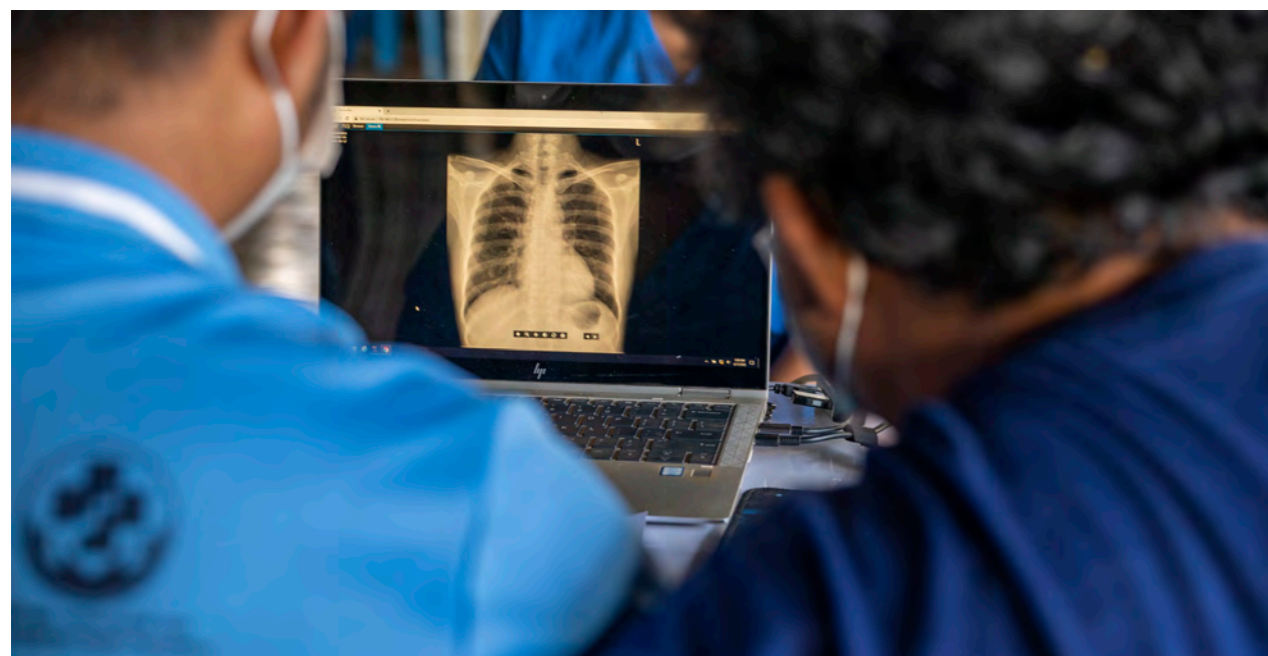
- Low adherence to 14-day primaquine regimens used for the radical cure of *P. vivax* malaria results in frequent vivax malaria recurrences. We used social construct theory to examine the behavioural factors associated with adherence to 14 day primaquine regimens. Data from this study will provide guidance on improving adherence to primaquine.
- We are conducting a retrospective analysis to determine the incidence of severe vivax infections between 2001-2016.
- SMRU published results of the largest randomised controlled trial (RCT) for treatment of *P. falciparum* and *P. vivax* trial in pregnancy with one of three ACTS (including randomization of first trimester women). This was the first assessment of a modified dosage of 5 tablets of artemether-lumefantrine for 4 days rather than the recommended 4 tablets for 3 days. We also assessed a subset of participants for ECG and demonstrated that all currently used antimalarials are safe as treatment (Saito M et al. *Antimicrob Agents Chemother.* 2021 Mar 18;65(4):e02473-20; Saito M et al. *BMC Med.* 2021 Jun 10;19(1):132).
- We examined a retrospective cohort of 23,262 singleton pregnancies in women who presented with falciparum but not vivax malaria during the first trimester and found it was associated with hypertensive disorders of pregnancy (Harrington WE et al. *BMC Med.* 2021 Apr 27;19(1):98).
- We tested compounds for activity against *P. vivax* hypnozoites using a platform set up in 2020.

Malaria elimination

- We continued collecting detailed information on malaria vectors to provide evidence on how their bionomics and resistance profiles affect the efficacy of vector-control interventions.
- We started deploying G6PD point-of-care tests in communities and villages to guide safe treatment with primaquine for radical cure of vivax malaria.

- SMRU participated in an international multi-centre study to evaluate reproducibility of quantitative point-of-care G6PD testing.
- Despite COVID-19 and political turmoil in Myanmar, the METF program continued to provide malaria services for Karen state communities. We produced evidence on how an effective malaria surveillance system can contribute to eliminating artemisinin resistant *P. falciparum*.
- In addition, METF, with the French National Research Institute (IRD) for sustainable development, launched the environmental analysis and surveillance platform (EASIMES) to guide the strategic deployment of malaria elimination interventions in Eastern Myanmar.
- The METF program continues to gather evidence to support the elimination of *P. vivax*.
- METF conducted cross sectional surveys and longitudinal follow up to measure the impact of various G6PD testing approaches.
- We launched the SG6 study, a world-first clinical trial of controlled exposure to malaria mosquito bites to identify and characterize serological markers of exposure to vector bites to evaluate vector-control and measure large-scale changes in transmission dynamics for malaria elimination in Southeast Asia.

Tuberculosis



TB team members conduct both in clinic and outreach TB screening with chest X-ray machines to reach Thai-Myanmar border migrant communities. © MORU 2022. Photographer: Gerhard Jøren.

- SMRU clinics were open regularly throughout 2021 to screen walk-in migrants for TB. In 2021, 153 TB patients were enrolled and treated in SMRU TB clinics. In addition, 14 MDR-TB patients stayed in two residential TB centres for their 20 months of treatment.
- As COVID-19 travel and security restrictions made it difficult for migrants to access health care, the TB team began outreach TB screening with portable chest X-ray machines to reach Thai-Myanmar border migrant communities. The TB team conducted mobile outreach in 11 villages in Thailand's Phoppra and Mae Ramat districts and in 16 village tracts near Shwe Kokko TB clinic in Myanmar. In all, it screened 2,745 migrants and villagers, with 25 (0.9%) of them diagnosed with TB.
- The TB team maintained a strong collaboration with the Tak and Mae Ramat public health offices (PHO) and local stakeholders to control TB on the Thai-Myanmar border.
- The analysis of pharmacokinetic data in TB patents was completed this year and the manuscript is in preparation.

Ongoing pharmacokinetic study in tuberculosis patients

Mother and child health

Clinical studies (other than malaria):



SMRU medic/midwife Nan San Mwe (left) during a Mother-Child Health (MCH) outreach consultation in a Myanmar migrant workers community in Thailand. In 2021, SMRU strengthened the health workers network in migrant worker communities to mobilize the population for COVID vaccination, and for SMRU MCH and TB programme outreach activities. © MORU 2022. Photographer: Gerhard Jøren.

- We assessed the contributions of genetic factors to the onset of neonatal jaundice requiring phototherapy treatment in a large cohort of Karen and Burman newborns.
- SMRU carried out a study to evaluate technical performances and usability of G6PD quantitative point of care (POC) tests and a non-invasive bilirubinometer to improve diagnosis of newborns at risk of severe hyperbilirubinaemia.
- We completed a study to define reference normal values of G6PD activity in infants (2-6 mos).

Infections

- We continued infectious disease work in the Thai-Myanmar border mother and child population.
- More than 50% of pre-term births (PTB) occur in Asia. Using 16S ribosomal RNA gene sequencing, identified a predictive vaginal microbiota signature for PTB detectable in first trimester of pregnancy, characterized by higher levels of *Prevotella buccalis*, and lower *Lactobacillus crispatus* and *Fingoldia* Spp, with decreased levels of cytokines including IFN γ , IL-4, and TNF α . This may allow us to predict PTB in low-resource setting Asian women at highest risk of adverse outcomes from unexpected PTB, and in Burman/Karen ethnic minority groups (Kumar M et al. *Front Cell Infect Microbiol*. 2021 Mar 4;11:639665).
- Associated with anaemia in pregnancy, soil transmitted helminth infections affect 20% of pregnant Thai-Myanmar border women. A new method, the formalin ethyl-acetate-based concentration technique, suggests that the burden is closer to 50% and that 13% of the population are infected with small liver flukes (Brummaier T et al. *Trop Med Infect Dis*. 2021 Apr 15;6(2):51; Brummaier T et al. *PLoS Negl Trop Dis*. 2021 Mar 1;15(3):e0009219).

- Research continued on preventing mother to child transmission of hepatitis B. In 2021 we examined knowledge, attitude and practice of mothers, and assessed the cost-effectiveness of tenofovir for prevention (there is still no point of care (POC) test for Hepatitis B e Ag in rural areas) (Bierhoff M et al. *BMC Pregnancy Childbirth*. 2021 Jul 23;21(1):525; Bierhoff M. *BMC Pregnancy Childbirth*. 2021 Feb 22;21(1):157).
- University of Oxford DPhil student Aung Myat Min conducted a systematic literature review exploring association between placental histopathological abnormality and preterm birth in the presence of confirmed infection; confirming a need to commit to standardised terminology and classification of histopathological abnormalities, and for preterm birth studies to occur in high burden countries (Min AM et al. *PLoS One*. 2021 Aug 12;16(8):e0255902).
- SMRU work contributed to recommendations on the management of Covid-19 patients in LMIC (Stilma W et al. *Am J Trop Med Hyg*. 2021 Mar 11;104(5):1676-1686).

Health system strengthening

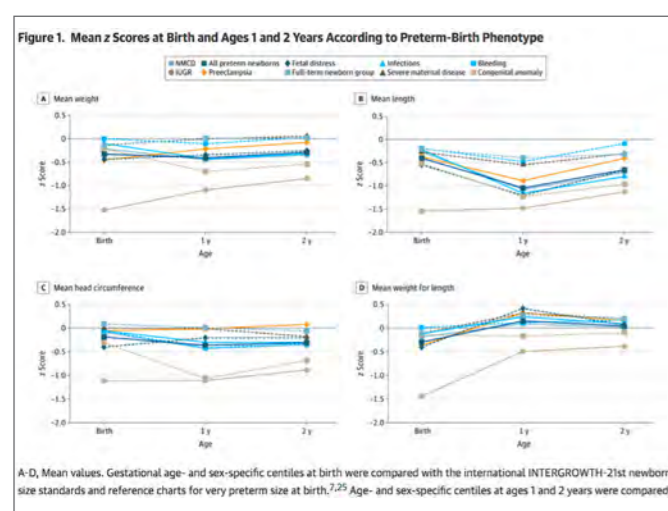
SMRU contributed to improved understanding of factors that can support marginalized health systems perform better for patients:

- Barriers in access to antenatal care and safe childbirth (Steinbrook E et al. *BMC Pregnancy Childbirth*. 2021 Dec 2;21(1):802)
- Training frontline workers in resource limited settings on obstetric emergencies evaluated (McGready R et al. *Wellcome Open Res*. 2021 Jun 28;6:94)
- Understanding the epidemiology of neonatal jaundice (Thielemans L et al. *PLoS One*. 2021 Oct 7;16(10):e0258127)
- We presented the case to include height not just BMI for robust pregnancy weight gain recommendations in limited-resource settings and special populations (Lee SJ et al. *BMJ Glob Health*. 2021 Feb;6(2):e004325).
- Safety of practice is an important part of strengthening health systems in low resource settings. After review of breastfed infants exposed to maternal ketamine, and infants exposed to diazepam through maternal breast milk, study concluded that ketamine appeared safe in lactating women and uninterrupted breastfeeding should be encouraged and supported. Preoperative oral diazepam may help reduce intraoperative anaesthetic doses, but intravenous diazepam

should be used with caution and avoided in high doses in lactating women (Gilder ME et al. *BMC Pregnancy Childbirth*. 2021 Feb 9;21(1):121).

Mental health

- Dr Gracia Fellmeth led two further evaluations of the Mental Health Study (MHS) cohort conducted at SMRU following 400 migrant and refugee women from first trimester to infants at one year of age. Suicidal ideation was identified as an important symptom among migrant and refugee women, and community-level interventions addressing social and gender inequalities and prioritization of family planning programmes are needed alongside targeted suicide prevention initiatives to help lower the rates of people dying by suicide. Social support was vital to prevent perinatal depression in Thai-Myan-



SMRU participated in the global INTERBIO-21st Newborn study, whose results suggested that phenotypic classification may provide a better understanding of the etiologic factors and mechanisms associated with preterm birth than continuing to consider it an exclusively time-based entity. © Nat Med.

mar border migrant women (Fellmeth G et al. *Philos Trans R Soc Lond B Biol Sci*. 2021 Jun 21;376(1827):20200030.; Fellmeth G et al. *J Public Health (Oxf)*. 2021 Aug 3;fdab297.).

- Aung Myat Min and Verena Cararra facilitated SMRU participation in the global INTERBIO-21st Newborn study, which followed up singleton newborns from birth to age 2 years (2012-2018). In 2021, a review of 6,529 infants suggested a phenotypic classification may provide a better understanding of the etiologic factors and mechanisms associated with preterm birth than continuing to consider it an exclusively time-based entity. This exciting research result suggests potential for preventive interventions in pregnancy to improve infant neurodevelopmental outcomes (Villar J et al. *JAMA Pediatr*. 2021 May 1;175(5):483-493; Villar J et al. *Nat Med*. 2021 Apr;27(4):647-652).

Bioethics & community engagement

Biomedical ethics

We continued activities in 2021 by the Tak Province Community Advisory Board (T-CAB), which provides a platform for the establishment of a Karen Ethics Committee, attached to the Borderland Health Foundation.

Community engagement

- SMRU's Public Engagement department expanded activities in 2021, and is now involved in out-reach programmes of the TB and the mother-child health teams.

Other laboratory work

- In collaboration with UGA, continued *in vitro* studies on the biology of the liver stages of *P. vivax* and the screen of compounds active against the hypnozoites.
- In collaboration with PATH, evaluated new qualitative and quantitative POC tests to diagnose G6PD deficiency.
- We generated, validated and made publicly available specific protein profiles for the rapid identification of *Burkholderia pseudomallei* using MALDI-TOF mass spectrometry.
- In collaboration with US-CDC and Thai public health authorities, and as part of the Thai certified SARs-CoV-2 testing laboratories, SMRU continued the testing service to detect COVID-19 at SMRU clinics and in displaced person shelters on the Thai-Myanmar border, with samples sent to Mahidol and to the Department of Medical Sciences for sequencing.

IV. Top 10 publications in 2021

1. Tenofovir disoproxil fumarate in pregnancy for prevention of mother to child transmission of hepatitis B in a rural setting on the Thailand-Myanmar border: a cost-effectiveness analysis. Bierhoff M, Angkurawanon C, Rijken MJ, Sriprawa K, Kobphan P, Nosten FN, van Vugt M, McGready R, Devine A. *BMC Pregnancy Childbirth*. 2021 Feb 22;21(1):157. PMID: 33618698; PMCID: 7901182.
2. Improved detection of intestinal helminth infections with a formalin ethyl-acetate-based concentration technique compared to a crude formalin concentration technique. Brummaier T, Archasukon L, Watthanakulpanich D, Paris DH, Utzinger J, McGready R, Proux S, Nosten F. *Trop Med Infect Dis*. 2021 Apr 15;6(2):51. PMID: 33921041; PMCID: 8167623.
3. Determinants of primaquine and carboxyprimaquine exposures in children and adults with *P. vivax* malaria. Chu CS, Watson JA, Phyo AP, Win HH, Yotyingaphiram W, Thinraow S, Soe NL, Aung AA, Wilaisrisak P, Kraft K, Imwong M, Hanpithakpong W, Blessborn D, Tarning J, Proux S, Ling C, Nosten FH, White NJ. *Antimicrob Agents Chemother*. 2021 Oct 18;65(11):e0130221. Epub 2021 Aug 16. PMID: 34398667; PMCID: 8522776.
4. Perinatal depression in migrant and refugee women on the Thai-Myanmar border: does social support matter? Fellmeth G, Plugge E, Fazel M, Nosten S, Oo MM, Pimanpanarak M, Phichitpadungtham Y, Fitzpatrick R, McGready R. *Philos Trans R Soc Lond B Biol Sci*. 2021 Jun 21;376(1827):20200030. Epub 2021 May 3. PMID: 33938275; PMCID: 8090811.

5. Falciparum but not vivax malaria increases the risk of hypertensive disorders of pregnancy in women followed prospectively from the first trimester. Harrington WE, Moore KA, Min AM, Gilder ME, Tun NW, Paw MK, Wiladphaingern J, Proux S, Chotivanich K, Rijken MJ, White NJ, Nosten F, McGready R. *BMC Med.* 2021 Apr 27;19(1):98. PMID: 33902567; PMCID: 8077872.



Ladda Kajeewiwa (3rd from right) and the SMRU Public Engagement department expanded activities in 2021, and are now involved in supporting the out-reach programmes of the TB and the Mother-Child Health teams. © MORU 2022. Photographer: Gerhard Jøren.

6. Anopheles salivary antigens as serological biomarkers of vector exposure and malaria transmission: A systematic review with multilevel modelling. Kearney EA, Agius PA, Chaumeau V, Cutts JC, Simpson JA, Fowkes FJL. *Elife.* 2021 Dec 23;10:e73080. PMID: 34939933; PMCID: 8860437.
7. Vaginal microbiota and cytokine levels predict preterm delivery in Asian Women. Kumar M, Murugesan S, Singh P, Saadaoui M, Elhag DA, Terranegra A, Kabeer BSA, Marr AK, Kino T, Brummaier T, McGready R, Nosten F, Chaussabel D, Al Khodor S. *Front Cell Infect Microbiol.* 2021 Mar 4;11:639665. PMID: 33747983; PMCID: 7969986.
8. Probing the distinct chemosensitivity of *P. vivax* liver stage parasites and demonstration of 8-aminoquinoline radical cure activity in vitro. Maher SP, Vantaux A, Chaumeau V, Chua ACY, Cooper CA ... Jiang RHY, Russell B, Bifani P, Campo B, Nosten F, Witkowski B, Kyle DE. *Sci Rep.* 2021 Oct 7;11(1):19905. PMID: 34620901; PMCID: 8497498.
9. A randomized controlled trial of dihydroartemisinin-piperaquine, artesunate-mefloquine and extended artemether-lumefantrine treatments for malaria in pregnancy on the Thailand-Myanmar border. Saito M, Carrara VI, Gilder ME, Min AM, Tun NW ... Proux S, Singhasivanon P, White NJ, Nosten F, McGready R. *BMC Med.* 2021 Jun 10;19(1):132. PMID: 34107963; PMCID: 8191049.
10. Fetal cranial growth trajectories are associated with growth and neurodevelopment at 2 years of age: INTERBIO-21st Fetal Study. Villar J, Gunier RB, Tshivuila-Matala COO, Rauch SA, Nosten F ... Uauy R, Eskenazi B, Bhutta ZA, Papageorghiou AT, Kennedy SH. *Nat Med.* 2021 Apr;27(4):647-652. Epub 2021 Mar 18. PMID: 33737749.

V. Capacity building achievements in 2021

SMRU capacity building activities in 2021 focussed on strengthening the health workers network in migrant worker communities to mobilize the population for COVID vaccination, and for SMRU Mother-Child Health and TB programme outreach activities.



The team involved in the SEACTN project led by Dr Aung Pyae Phy (back, center) in Thailand and in Myanmar. © MORU 2022. Photographer: Gerhard Jøren.

VI. Future vision

- SMRU will continue its work to eliminate malaria, improve maternal and child health, and combat TB. SMRU will concentrate on research activities, while its humanitarian arm, the Borderland Health Foundation (BHF), will provide much needed healthcare services to marginalised border populations in close collaboration with the Ministries of Health and national programmes of Thailand and Myanmar, and with local community-based organisations.
- SMRU will continue to play a critical role in MORU's work on pre-pregnancy interventions, which, based on a life-cycle approach to prevent poor maternal and child health outcomes, will focus on nutrition, malaria prevention of *P. vivax* by clearing the hepatic hypnozoite reservoir with primaquine, deworming, identification and treatment of anaemia.
- Research in pregnant women at the SMRU ante-natal clinics will include completion of a large cohort study using a transcriptomic approach to identify genetic signatures of gestational outcomes. We will study nutritional status in pregnancy and the determinants of maternal anaemia. Our aim is to use a biological systems approach to identify at-risk pregnancies.
- Finally, SMRU hopes to soon transition to new laboratories and offices in Mae Ramat to enable new collaborative research with Mae Ramat Hospital and the Tak PHO.



LOMWRU conducts research on a wide range of infectious diseases and participates in multicentre studies across the MORU Tropical Health Network and beyond. © MORU 2022. Photographer: Micka Perier.

Lao-Oxford-Mahosot Hospital-Wellcome Trust Research Unit (LOMWRU)

I. Overview

LOMWRU is a research collaboration between Oxford University (MORU), and Mahosot Hospital (part of the Lao Ministry of Health, MoH) in Vientiane, Lao People’s Democratic Republic, founded in 1999.

Prof Elizabeth Ashley has been the Director of LOMWRU since May 2019, when Prof Paul Newton moved to Oxford to lead a new Medicine Quality Research Group. Currently there is a team of 75 research and support staff in the capital and the provinces working as part of the collaboration, including 23 Lao Government employees led by Dr Manivanh Vongsouvath, Head of the Mahosot Hospital Microbiology Laboratory, which provides a round-the-clock diagnostic service to the hospital. In addition, LOMWRU has molecular and serology laboratories and a BSL3 laboratory.



LOMWRU Director Professor Elizabeth Ashley. © MORU 2022. Photographer: Gerhard Jørén.

LOMWRU conducts research on a wide range of infectious diseases and participates in multicentre studies across the MORU Network and beyond. The head of field research is Prof Mayfong Mayxay, who is Vice President of the University of Health Sciences in Vientiane. LOMWRU also builds diagnostic, clinical and research capacity in Laos and, with the Infectious Diseases Data Observatory (IDDO), has conducted a range of research projects on medicine quality epidemiology, diagnostics, forensics and advocacy.

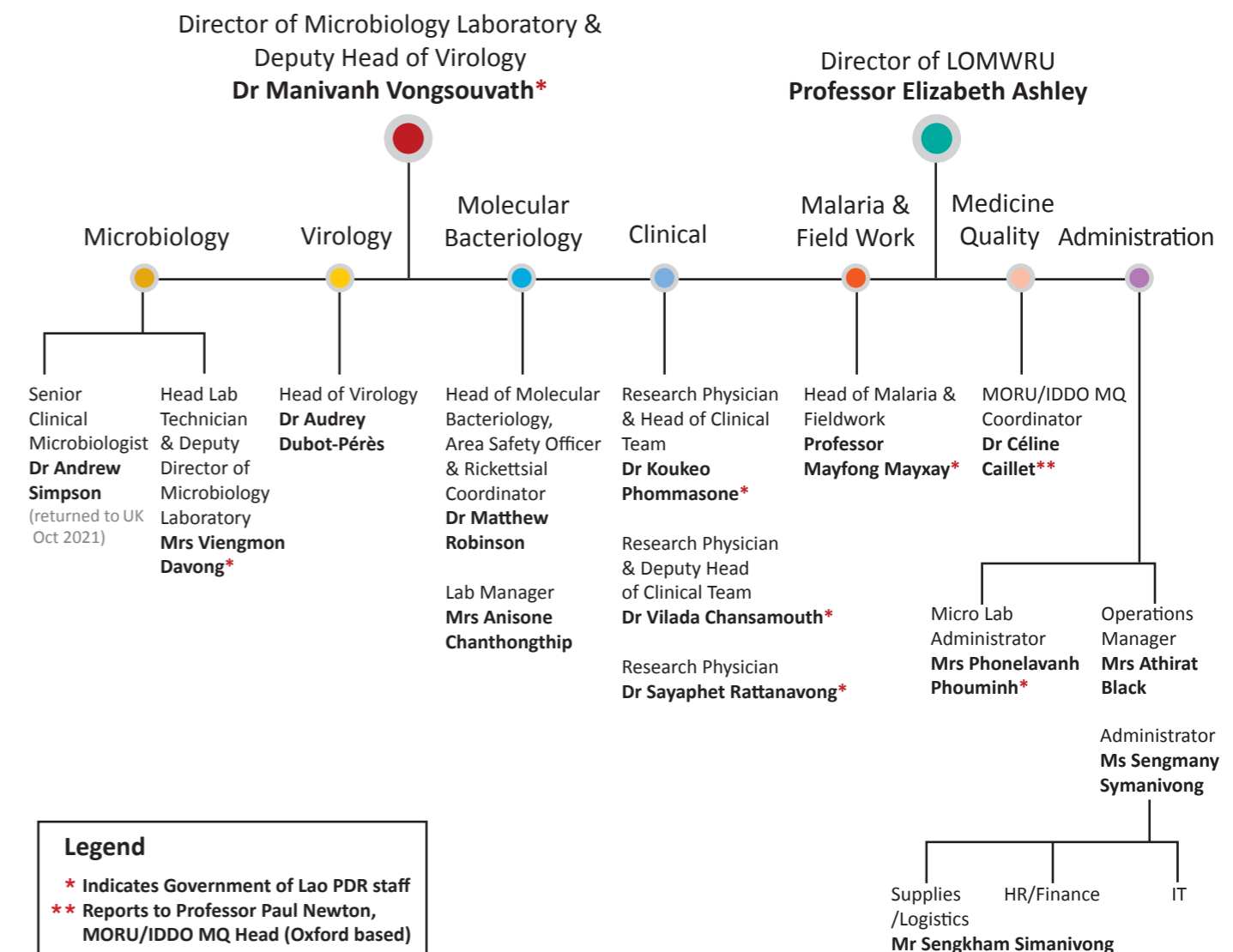
In April 2021, the number of community cases of COVID-19 increased dramatically in Laos. Mahosot Hospital/LOMWRU is a national testing centre for SARS-CoV-2 and operated a seven-day service to meet the demand, running about 41,000 PCRs in 2021. Research projects slowed down considerably due to travel restrictions and patients staying away from hospitals but our activity level increased again at the end of 2021 as vaccination coverage increased in Laos and there was some easing of restrictions, although international borders remained closed.



LOMWRU’s new home, the Infectious Diseases Building of the newly built Mahosot Hospital. © MORU 2022. Photographer: Gerhard Jørén.

In November 2021 LOMWRU moved to new laboratories and offices in the Infectious Diseases Building of the newly built Mahosot Hospital, donated to Laos by the government of China and our old buildings were demolished.

II. Our team



Legend
 * Indicates Government of Lao PDR staff
 ** Reports to Professor Paul Newton, MORU/IDDO MQ Head (Oxford based)



Critical care specialty trainee and DPhil student (University of Oxford) Dr Rebecca Inglis giving ICU training with Dr Khamsay Detleuxay, Director of the Department of Healthcare & Rehabilitation. At the start of the COVID-19 pandemic, Rebecca won an Institutional Translational Partnership Award to adapt for critically ill COVID patients a training course she'd developed to improve the care of critically ill adults. The revised course was accredited by the WHO, taken up by the Lao government, and rolled out to every ICU in the country by Rebecca and her trainers. The intervention reached 128 staff in 21 ICUs. © MORU 2022.

III. Scientific achievements in 2021

In 2021 LOMWRU continued to work on antimicrobial drug resistance (AMR), epidemiology, diagnosis and management of infectious diseases, investigation and management of non-malaria febrile illness, medicine quality, and policy engagement/health technology assessment. LOMWRU produced 69 publications in 2021.

COVID-19

Since 2019 we have been conducting surveillance for respiratory viruses in symptomatic patients presenting to three provincial hospitals around the country and are sharing the data with the International Severe Acute Respiratory and Emerging Infection Consortium (ISARIC). We were able to detect the increase in community transmission of SARS-CoV-2 at these sites and the disappearance of influenza and respiratory syncytial virus compared to previous years. We also conducted a point prevalence sero-survey of blood donors from multiple provinces to document the delayed emergence of COVID-19 in Laos. Early in the pandemic all detected cases were admitted to hospital or treatment centres and only discharged once two PCR tests for SARS-CoV-2 were negative; however, this became unsustainable as case numbers increased. LOMWRU led a small collaborative study in Vientiane in June 2021 to look for evidence of onward transmission in household contacts of patients who were discharged home with a positive PCR test after two weeks and found no evidence of spread. Results were presented to the Minister of Health to support a change in discharge policy.

At the end of 2021 we started SARS-CoV-2 whole genome sequencing and found the Delta variant was the prominent circulating strain of SARS-CoV-2 followed by a surge of cases of the Omicron variant, starting from February 2022.

Antimicrobial drug resistance (AMR)

Awareness of AMR is increasing in Laos, with rising rates of extended spectrum beta-lactamase (ESBL) producing, multi-drug resistant *Escherichia coli* a growing concern. We have continued to conduct regular Point Prevalence Surveys of Antimicrobial Use (AMU) across six Lao hospitals. We have worked with the Department of Healthcare and Rehabilitation of the Ministry of Health to draft national adult and paediatric antimicrobial prescribing guidelines. These have been introduced in six hospitals, and compliance by prescribers is being evaluated, led by Dr Vilada Chansamouth, a Wellcome International Training Fellow.

In 2020 we were a pilot site for the Wellcome-funded ACORN (A Clinically-Oriented Antimicrobial Resistance Surveillance Network) project and we are now participating to ACORN-2, also supporting Setthathirath Hospital, another central hospital in Laos, to start case-based AMR surveillance.

Mahosot Hospital shared 20 years of AMR surveillance data with the GRAM project, contributing to representation of low-and-middle-income countries in the Global Burden of Disease-AMR paper published in *The Lancet*. We produced a review of all AMR and AMU data in human and animal sectors in Lao and English languages which is being used to support the National Strategic Plan to tackle AMR. We are a recipient of the UK Fleming Fund Lao Country grant and have been supporting five provincial hospitals to strengthen AMR surveillance on site.



Dr Manivanh Vongsouvath (*centre*), Director of Microbiology Laboratory & Deputy Head of Virology, and the Microbiology Lab team provide a round-the-clock diagnostic service to Mahosot Hospital. © MORU 2022. Photographer: Gerhard Jørgén.

Finally, in order to better understand the development of the environmental microbiome in hospitals, we are conducting prospective environmental surveillance in the new hospital to capture dynamic trends in environmental colonisation with drug resistant bacteria.

Non-malaria febrile illness

In September 2021 we completed recruiting patients for the Spot Sepsis study in Salavan Provincial Hospital. This multicentre study with two sites in Laos sponsored by Médecins Sans Frontières and Wellcome (Co PIs Sakib Burza and Prof Yoel Lubell) aims to study 4,900 children and develop a risk prediction algorithm, combining measurements of host biomarkers and clinical features at the point-of triage, for children aged between 1 month and 5 years with an acute febrile illness in resource-limited settings.



A young patient enrolled in the SEACTN study at Savannakhet Hospital in August 2021. Led by MORU Assoc Prof Yoel Lubell, the SEACTN programme will collect data on >100,000 febrile episodes in hundreds of villages across SE Asia. SEACTN will use these data and the outcomes of Spot Sepsis to design optimal packages to extend the role of village malaria workers. © MORU 2022.

We launched the Laos site of Southeast Asia Clinical Trials Network (SEACTN), led by Professor Yoel Lubell in MORU, in which we will study 20,000 consultations for febrile illness at health centre level in Savannakhet Province, southern Laos.

Medicine Quality

The medicine quality work in Laos is led by Professor Paul Newton and Dr Céline Caillet, from the MORU Medicine Quality Research Group in Oxford. In 2021 we published a PLOS collection, *A multiphase evaluation of portable screening devices to assess medicines quality for national Medicines Regulatory Authorities*.

Medicines Regulatory Authorities (MRAs) in many low- and middle-income countries (LMICs) are under-resourced. New innovative portable tools could help improve MRA efficiency in post-market surveillance of medicines, to better detect and remove substandard or falsified medicines before they reach patients.

Policy engagement and Health Technology Assessment

In 2021 Prof Mayfong Mayxay set up the Unit for Health Evidence and Policy (UHEP) in the University of Health Sciences in Vientiane, funded by the NIHR–Wellcome Partnership for Global Health Research Policy, in collaboration with LOMWRU, MORU (MAEMOD) and the Health Intervention and Technology Assessment Program (HiTAP) in Thailand. We have been conducting a situational analysis on use of research evidence to inform policy in Laos and awareness of health technology assessment. As a pilot project we have conducted a cost-effectiveness analysis of typhoid vaccine introduction in Laos, which will lose GAVI support soon.

Public Engagement

LOMWRU continues to support Dr Vatthanaphone Latthaphasavang, who hosts a live radio show weekly on health and research topics on Lao Youth Radio.

In November 2021 Dr Vilada Chansamouth raised awareness about antibiotic use and antimicrobial resistance to mark World Antimicrobial Awareness Week (WAAW) with a special event and photography competition at Mahosot Hospital.

IV. Top 10 publications in 2021

1. Antimicrobial use and resistance data in human and animal sectors in the Lao PDR: evidence to inform policy. Chansamouth V, Mayxay M, Dance DA, Roberts T, Phetsouvanh R ... Day NP, Turner P, Ashley EA, van Doorn HR, Newton PN. *BMJ Glob Health*. 2021;6(12):e007009. PMID: 34853032; PMCID: 8638151.
2. Nasopharyngeal pneumococcal colonization density is associated with severe pneumonia in young children in the Lao People's Democratic Republic. Carr OJJ, Vilivong K, Bounvilay L, Dunne EM ... Do LAH, Dubot-Peres A, Satzke C, Dance DAB, Russell FM. *J Infect Dis*. 2022;225(7):1266-73. PMID: 33974708; PMCID: 8974848.
3. Genetic diversity of *Leptospira* isolates in Lao PDR and genome analysis of an outbreak strain. Grillová L, Robinson MT, Chanthongthip A, Vincent AT, Nieves C ... Douangnouvong A, Šmajš D, Veyrier FJ, Newton PN, Picardeau M. *PLoS Negl Trop Dis*. 2021;15(12):e0010076. PMID: 34962921; PMCID: 8746763.
4. A spatio-temporal analysis of scrub typhus and murine typhus in Laos; implications from changing landscapes and climate. Roberts T, Parker DM, Bulterys PL, Rattanavong S, Elliott I, Phommasone K, Mayxay M, Chansamouth V, Robinson MT, Blacksell SD, Newton PN. *PLoS Negl Trop Dis*. 2021;15(8):e0009685. PMID: 34432800; PMCID: 8386877.

5. *Orientia tsutsugamushi* dynamics in vectors and hosts: ecology and risk factors for foci of scrub typhus transmission in northern Thailand. Elliott I, Thangnimitchok N, Chaisiri K, Wangrangsimakul T, Jaiboon P, Day NPJ, Paris DH, Newton PN, Morand S. *Parasit Vectors*. 2021;14(1):540. PMID: 34663445; PMCID: 8524837.
6. Antimicrobial resistance detection in Southeast Asian hospitals is critically important from both patient and societal perspectives, but what is its cost? Roberts T, Luangsanatip N, Ling CL, Hopkins J, Jaksuwan R, Lubell Y, Vongsouvath M, van Doorn HR, Ashley EA, Turner P. *PLOS Glob Public Health*, 2021;1(10):e0000018. PMID: 34746931; PMCID: 7611947.
7. A comparative field evaluation of six medicine quality screening devices in Laos. Caillet C, Vickers S, Zambrzycki S, Fernández FM, Vidhamaly V, Boutsamay K, Boupha P, Peerawaranun P, Mukaka M, Newton PN. *PLoS Negl Trop Dis*. 2021;15(9):e0009674. PMID: 34591852; PMCID: 8483322.
8. The effectiveness of the 13-valent pneumococcal conjugate vaccine against hypoxic pneumonia in children in Lao People's Democratic Republic: An observational hospital-based test-negative study. Weaver R, Nguyen CD, Chan J, Vilivong K, Lai JYR ... Mulholland K, Gray A, Dubot-Pérès A, Dance DAB, Russell FM. *Lancet Reg Health West Pac*. 2020;2:100014. PMID: 34327372; PMCID: 8315332.
9. Dynamics of intestinal multidrug-resistant bacteria colonisation contracted by visitors to a high-endemic setting: a prospective, daily, real-time sampling study. Kantele A, Kuenzli E, Dunn SJ, Dance DAB, Newton PN ... Hatz C, Snaith A, Kallonen T, Corander J, McNally A. *Lancet Microbe*. 2021;2(4):e151-e158. PMID: 33821248; PMCID: 8009952.
10. Targeted capture and sequencing of *Orientia tsutsugamushi* genomes from chiggers and humans. Elliott I, Thangnimitchok N, de Cesare M, Linsuwanon P, Paris DH, Day NPJ, Newton PN, Bowden R, Batty EM. *Infect Genet Evol*, 2021;91:104818. PMID: 33771726; PMCID: 8164161.

V. Capacity building achievements in 2021

- LOMWRU and Mahosot Hospital have been technical implementing partners for the Fleming Fund Lao country grant which is strengthening surveillance for AMR in Laos. We have worked with five provincial hospitals and trained laboratory technicians to support them to do more diagnostic microbiology on site. We worked with the Faculty of Medical Sciences in Chiang Mai University to develop a six-month course intensive course in microbiology for nine Lao government laboratory technicians in 2021. Dr Manivanh Vongsouvath, Head of Mahosot Microbiology, was awarded a Fleming Fellowship.
- Dr Rebecca Inglis, a critical care specialty trainee and DPhil student (University of Oxford) from the UK hosted by LOMWRU, developed and evaluated a training course to improve the care of critically ill adults. The methodology employs behaviour change techniques that she was able to show led to a measurable improvement in patient care in the three intensive care units (ICUs) in Laos. At the start of the pandemic, Rebecca won an Institutional Translational Partnership Award to adapt the course for critically ill COVID patients. The revised course was accredited by the WHO, taken up by the Lao government, and rolled out to every ICU in the country by Rebecca and her trainers. The intervention reached 128 staff in 21 ICUs.
- Dr Weerawat Phuklia, a Wellcome International Training Fellow working on antimicrobial susceptibility of rickettsial infections, travelled to Washington State University for one year to work in the laboratory of Dr Anders Omsland, an expert in intracellular pathogens.
- Dr Vilayouth Phimolsarnnousith, a Wellcome International Master's Fellow, left for London in September 2021 for the MSc in Medical Microbiology degree course at the London School of Hygiene and Tropical Medicine.



Lao government laboratory technicians in front of Chiang Mai University, Thailand. LOMWRU worked with the Faculty of Medical Sciences in Chiang Mai University to develop a six-month course intensive course in microbiology for nine Lao government laboratory technicians in 2021. © MORU 2022

- Mr Vanheuang Phommadechack, LOMWRU molecular bacteriology junior scientist, is studying for a Master's in Tropical Medicine at Mahidol University, Bangkok. He was awarded the Sylvia Meek scholarship for Entomology.
- We continued to support the publication of the Lao Medical Journal, the first Lao language medical journal.

VI. Future vision

In 2022 we hope to see our activity level return to normal. We plan to continue to work to tackle AMR in Laos, taking a multidisciplinary approach. We will use the results of our evaluation of antimicrobial guidelines to plan interventions to improve appropriate antimicrobial prescribing.



Dr Siho Sengsavang (left), Deputy Director of Vientiane Provincial Hospital, with Professor Mayfong Mayxay, LOMWRU's Head of Malaria & Fieldwork, at the dissemination of the FIEBRE research results in January 2021. © MORU 2022. Photographer: Elizabeth Ashley.

We want to increase our capacity to conduct health economics research to support the use of health technology assessment in evidence-based decision making in health policy in Laos which will be led by Prof Mayfong Mayxay in the nascent Unit for Health Evidence and policy (UHEP). We are strengthening our ties with similar regional initiatives and have a strong collaboration with HiTAP in Thailand.



Dr Tamalee Roberts (left, shown with Joy Silisouk and Souksakhone Volavong in the Mahosot Microbiology Laboratory) was awarded an ESCMID Research Grant application (year 2021) for the project, *Evidence for Leishmania in Laos and Myanmar*. © MORU 2022. Photographer: Gerhard Jørrén.

We will continue to work on improved treatment of infectious diseases in Laos and other low resource settings. We have funding from the Medical Research Council to improve the management of neonatal sepsis by developing a rectal formulation of ceftriaxone to enable earlier access to treatment.



While hazmat suits are no longer an unusual sight on the streets of Vientiane, the LOMWRU safety team donned their personal protective equipment to fumigate the old labs safely before moving in late 2021 to new laboratories and offices in the Infectious Diseases Building of the newly built Mahosot Hospital. © MORU 2022.



Prof Paul Turner (*back, centre*) and the COMRU team focus on the causes and reduction of morbidity and mortality in Cambodian children. © MORU 2022. Photographer: Gerhard Jøren.

Cambodia-Oxford Medical Research Unit (COMRU)

I. Overview

Embedded within the Angkor Hospital for Children (AHC) in Siem Reap, Cambodia, the Cambodia-Oxford Medical Research Unit (COMRU) was established in 2006 as a collaboration between MORU and AHC, a non-profit paediatric healthcare organisation. AHC comprises a tertiary level teaching hospital, a clinical training site for Cambodian healthcare workers, and a comprehensive community outreach and engagement programme. Despite recently graduating to lower middle-income status, Cambodia remains one of the poorest nations in Southeast Asia with high rates of neonatal, infant and childhood mortality.

Led by Prof Paul Turner (Paediatric Clinical Microbiologist) and Assoc Prof Claudia Turner (Paediatrician and AHC Chief Executive Officer), COMRU's research focusses on the causes and reduction of morbidity and mortality in Cambodian children. Studies at COMRU have defined the epidemiology of some of the key infectious diseases affecting Cambodian children. We have contributed to development of the Cambodia National Antimicrobial Resistance Surveillance System and helped revise the country's National Action Plan for Antimicrobial Resistance. Locally, we have implemented an electronic antibiotic prescription guideline app at AHC and led development of a comprehensive hospital infection and antimicrobial stewardship programme.



Assoc Prof Claudia Turner, Paediatrician and AHC CEO. © MORU 2022. Photographer: Paul Turner.

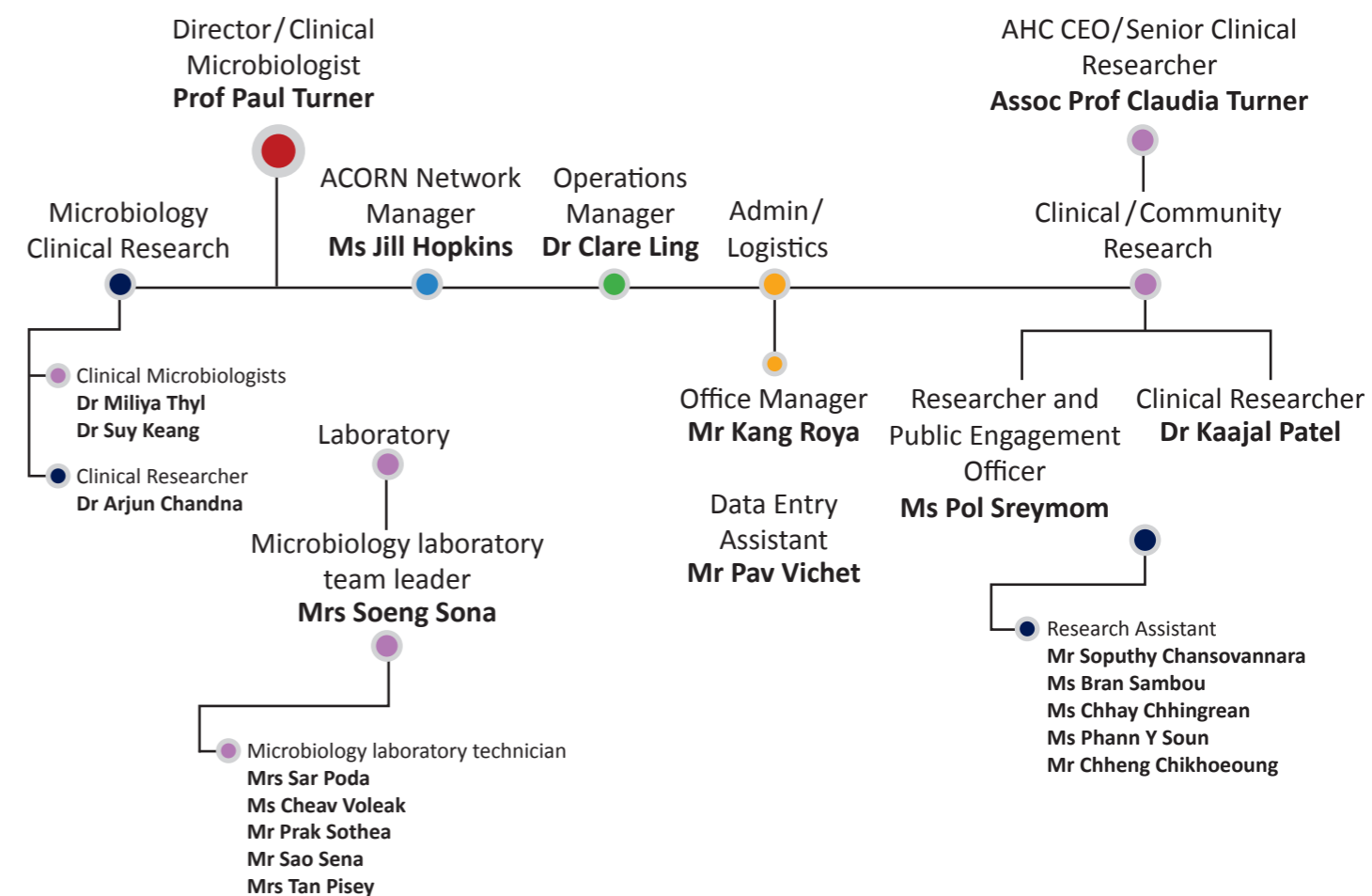
Reflecting the Unit's major research focus on bacterial infection and antimicrobial resistance (AMR), COMRU has a well-equipped diagnostic and research microbiology laboratory onsite at AHC, including facilities for bacterial culture, molecular pathogen characterisation by PCR and whole genome sequencing (WGS), and serological testing.



The unit also carries out research in the communities of Siem Reap Province. AHC's neonatal research programme takes place in the nearby province of Preah Vihear.

Dr Miliya Thyl (*2nd right*), AHC-COMRU clinical microbiologist, providing a clinical consult at the AHC inpatient department.

II. Our team



III. Scientific achievements in 2021

Newborn survival

Saving Babies' Lives (SBL, <https://angkorhospital.shinyapps.io/SBLP/>) is a cluster-randomised trial implemented by AHC and COMRU (*BMC Pediatr.* 2021;21(1):390). Over five years SBL will develop, implement, and assess an iterative package of neonatal interventions combining community and primary care strategies to reduce perinatal mortality in a rural Cambodian province. A nested qualitative study supported by the University of Oxford Ethox Centre will explore the Ethics of healthcare

Programme Implementation in Cambodia (EPIC). Recently, SBL has regained momentum following numerous disruptions to fieldwork during the worst of the COVID-19 pandemic in Cambodia. Roll-



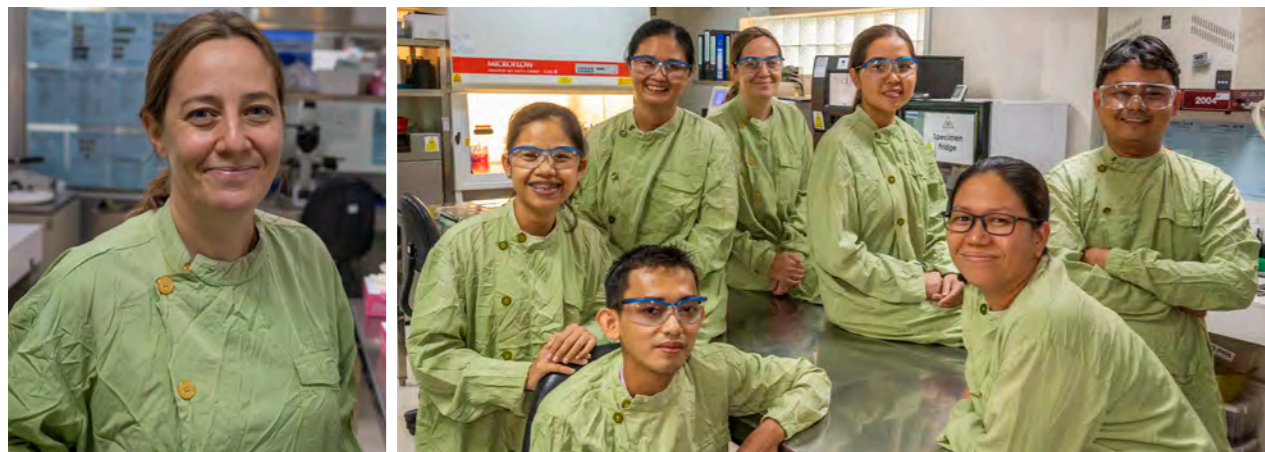
AHC's Saving Babies' Lives team is developing and assessing a package of neonatal interventions combining community and primary care strategies to reduce perinatal mortality in rural Cambodia. © MORU 2022.

out of the intervention has been completed in 14 out of 22 clusters, which involved participatory learning and action with 350 community health workers and mentorship training at 24 primary care facilities. Five annual KAPES (knowledge, attitudes, practice, equipment and staffing) surveys have been conducted to measure quality of neonatal care at all health facilities. Data on nearly 24,000 deliveries and 360 verbal autopsies have been collected to date, which will provide the first detailed description of neonatal epidemiology in Cambodia. The SBL project team completed recently a qualitative study to determine community-level understanding of stillbirth and newborn death (*Cambodia Journal of Public Health*. 2021;2(8):1-9).

Bacterial infections and AMR

The major achievement in 2021 was the commencement of the second phase of the Wellcome funded ACORN AMR surveillance project (<https://acornamr.net>; *JAC Antimicrob Resist.* 2020;2(1):dlaa018.). ACORN (A Clinically-Oriented antimicrobial Resistance Network) is an implementation of hospital-based clinical AMR surveillance, collecting clinical and microbiology data on community- and hospital-acquired infections. The impacts of AMR on duration of hospitalisation and mortality will be assessed in collaboration with the WHO Global AMR Surveillance System (GLASS) team. The model for ACORN was developed at AHC-COMRU and subsequently piloted in 2019-20 at AHC, Mahosot Hospital (Vientiane, LOMWRU), and the National Hospital for Tropical Diseases (Hanoi, OUCRU). The second phase expands ACORN to 18 sites across 9 Asian and African countries and will deliver 2-2.5 years of surveillance data from each site. One of the strengths of ACORN is immediate and user-customisable site data visualisation via an RShiny app (<https://moru.shinyapps.io/acorn2/>). An early output of the ACORN pilot was an assessment of the laboratory costs of AMR surveillance in SE Asia (*PLOS Glob Public Health*. 2021;1(10):e0000018).

The four-year multi country Robert Koch Institute – International Vaccine Institute TuNDRA infection surveillance project completed mid-2021, with COMRU enrolling 3,754 febrile children over the course of the study. An additional 105 children were co-enrolled into a parallel cost of illness study. Results are expected in 2022.



Operations Manager Dr Clare Ling (left) and COMRU's Microbiology Laboratory team. © MORU 2022. Photographer: Gerhard Jørén.

As part of the MORU Clinical Microbiology Network, the COMRU laboratory contributed to laboratory studies to determine (1) the impacts of processing delays and environmental conditions on blood culture positivity (*BMC Infect Dis.* 2021;21(1):173) and (2) the value of MALDI-TOF for identification of *Burkholderia pseudomallei* (*BMC Microbiol.* 2021;21(1):213).

The COMRU laboratory continues to contribute to international genomic pathogen surveillance, with recently completed work on *Shigella sp.* (led by OUCRU; *Commun Biol.* 2021;4(1):353) and *Streptococcus pneumoniae* (led by Imperial; *Elife.* 2021;10). We worked with colleagues in Oxford, Kilifi (Kenya), and London on a successful assessment of stool metagenomics for prediction of antimicrobial susceptibilities in invasive Enterobacterales infections (*EClinicalMedicine.* 2021;36:100910).

COMRU works on development and field-testing of laboratory informatics and data visualisation tools for wider use (*Lancet Infect Dis.* 2021;21(6):e170-e4). Paul Turner leads the steering committee for SEDRI-LIMS, a Wellcome funded software project to deliver a microbiology-focused open-source laboratory information management system (LIMS) fit for purpose across a range of laboratory capacities. SEDRI-LIMS, which has its origins in a system developed locally at the Shoklo Malaria Research Unit (SMRU), is currently undergoing early piloting in several locations in Asia (including COMRU and LOMWRU), Africa, and South America.

Microbiota dynamics and bacterial evolution

Building on previous colonisation studies in both hospital (*Escherichia coli*, *Klebsiella pneumoniae*) and community settings (*E. coli*, *K. pneumoniae*, *Streptococcus pneumoniae*), COMRU began a longitudinal respiratory and rectal microbiome project in September 2021. This project, a collaboration with Jukka Corander, University of Oslo, will explore the dynamics of bacterial carriage in a cohort of approximately 1,000 children followed from a hospital visit or admission for six months. A mixed culture and sequencing based approach will be used to determine the impact of hospitalisation and/or antibiotic exposure on the carriage of antibiotic susceptible and resistant organisms.

Laboratory work was completed to identify colonisation by *Haemophilus influenzae* and *Moraxella catarrhalis* from >1,000 nasopharyngeal specimens collected during pneumococcal colonisation surveys in 2014-18. Isolates will be sequenced at the Wellcome Sanger Institute (UK) to determine the regional population structure of these important respiratory pathogens (part of a suite of projects led by Nick Croucher, Imperial, and Jukka Corander). This work will also include characterisation of isolates collected during the SMRU Maela Acute Respiratory Infection cohort study (Paul Turner's Wellcome training fellowship project 2007-11).

The Unit has contributed to modelling work led by Jukka Corander on development of tools to improve assessment of heritability in *S. pneumoniae* (*BMC Bioinformatics.* 2021;22(1):164 and *NAR Genom Bioinform.* 2022;4(1):lqac011).

Severity of febrile illness

COMRU continued to co-lead studies on the severity of febrile illness together with colleagues in Laos (LOMWRU) and Thailand (MORU). This translational programme of work is being implemented in partnership with Médecins Sans Frontières (MSF) and the Department of Primary Care Health Sciences at the University of Oxford, and is embedded within the Wellcome-funded Southeast Asia Clinical Trials Network (SEACTN), led by Prof Yoel Lubell in MORU. In 2021, the Spot Sepsis project was active in nine locations across six countries in Asia and aims to support the development of practical tools, combining clinical and laboratory severity markers, to help primary care health workers identify which children with febrile illness might benefit from facility-based care (*BMJ Open.* 2021;11(1):e045826). The COMRU team have recruited over 800 children into this study (total recruitment ~2,500 participants) and led work investigating the stability of various host biomarkers stored in different environmental conditions to inform future field-based phases of this

research programme. During the COVID-19 pandemic, the team were able to leverage the research architecture established for Spot Sepsis and rapidly implement the PRIORITISE study, a prospective cohort study at two sites in India, which identified factors associated with disease progression in moderate COVID-19. The tools developed during the PRIORITISE study could help health workers identify which patients presenting with moderate COVID-19 are safe for community-based care, and help protect health systems during future surges in SARS-CoV-2 infections (*Clin Infect Dis*. In Press;10.1093/cid/ciac224).

IV. Top 10 publications in 2021

1. Laboratory informatics capacity for effective antimicrobial resistance surveillance in resource-limited settings. Turner P, Rupali P, Opintan JA, Jaoko W, Feasey NA, Peacock SJ, Ashley EA. *Lancet Infect Dis*. 2021 Jun;21(6):e170-e174. PMID: 33865461.

2. Antimicrobial resistance detection in Southeast Asian hospitals is critically important from both patient and societal perspectives, but what is its cost? Roberts T, Luangsanatip N, Ling CL, Hopkins J, Jaksuwan R, Lubell Y, Vongsouvath M, van Doorn HR, Ashley EA, Turner P. *PLoS Glob Public Health*. 2021 Oct 13;1(10):e0000018. PMID: 34746931; PMCID: 7611947.

3. Community Understanding of Stillbirths and Neonatal Deaths in Cambodia: Family Education and Communication is Vital to Improve Outcomes. Pol S, Soputhy C, Patiel K, Leng D, Kounng L, Turner C. *Cambodia Journal of Public Health*. 2021;2(8):1-9.

4. Predictors of disease severity in children presenting from the community with febrile illnesses: a systematic review of prognostic studies. Chandna A, Tan R, Carter M, Van Den Bruel A, Verbakel J, Koshiaris C, Salim N, Lubell Y, Turner P, Keitel K. *BMJ Glob Health*. 2021 Jan;6(1):e003451. PMID: 33472837; PMCID: 7818824.

5. Improving treatment and outcomes for melioidosis in children, Northern Cambodia, 2009–2018. Chandna A, Bonhoeffer M, Miliya T, Suy K, Sao S, Turner P. *Emerg Infect Dis*. 2021;27(4):1169–72. PMID: 33754990; PMCID: 8007301.

6. Population-level faecal metagenomic profiling as a tool to predict antimicrobial resistance in Enterobacteriales isolates causing invasive infections: An exploratory study across Cambodia, Kenya, and the UK. Auguet OT, Niehus R, Gweon HS, Berkley JA, Waichungo J ... Crook DW, Lambale S, Turner P, Cooper BS, Stoesser N. *EClinicalMedicine*. 2021 May 30;36:100910. PMID: 34124634; PMCID: 8173267.

7. Boosting heritability: estimating the genetic component of phenotypic variation with multiple sample splitting. Mai TT, Turner P, Corander J. *BMC Bioinformatics*. 2021;22(1):164. PMID: 33773584; PMCID: 8004405.

8. Impact of delays to incubation and storage temperature on blood culture results: a multi-centre study. Ling CL, Roberts T, Soeng S, Cusack TP, Dance DAB ... Wangrangsimakul T, Newton PN, Nosten FH, Turner P, Ashley EA. *BMC Infect Dis*. 2021;21(1):173. PMID: 33579205; PMCID: 7881545.

9. Saving babies' lives (SBL) - a programme to reduce neonatal mortality in rural Cambodia: study protocol for a stepped-wedge cluster-randomised trial. Patel K, Say S, Leng D, Prak M, Lo K, Mukaka M, Riedel A, Turner C. *BMC Pediatr*. 2021;21(1):390. PMID: 34493225; PMCID: 8421466.

10. Prediction of disease severity in young children presenting with acute febrile illness in resource-limited settings: a protocol for a prospective observational study. Chandna A, Aderie EM, Ahmad R, Arguni E, Ashley EA ... Waithira N, Watson JA, Yosia M, Burza S, Lubell Y. *BMJ Open*. 2021;11(1):e045826. PMID: 33495264; PMCID: 7839891.

V. Capacity building achievements in 2021

- On-going molecular microbiology training for laboratory staff: Work in 2021 focussed on optimising the in-house bacterial WGS workflow and bioinformatics pipeline.
- Continued work towards ISO:15189 accreditation for the microbiology laboratory. As a result of the pandemic, formal assessment was delayed by the Thailand-based accreditors until 2022.

VI. Future vision

COMRU aims to become one of Southeast Asia's leading paediatric infectious diseases and microbiology research centres. We will become a national and regional lead for bacterial infection epidemiology, develop and test tools to improve global AMR surveillance activities and conduct internationally relevant research on antibiotic stewardship and infection control.



The AHC-COMRU antimicrobial stewardship team; members include intensive care paediatricians, clinical microbiologists, and pharmacists. © MORU 2022. Photographer: Gerhard Jøren.

Expanding our engagement with government, local healthcare workers, researchers and the general public, the AHC-COMRU partnership will develop an evidence base for optimal neonatal care and implement a research programme on paediatric healthcare topics relevant to Cambodia and other LMICs.

The unit is also committed to development of local staff capacity building and training activities.

Neonatal care

- Building on the SBL project, work on development and deployment of community-based interventions to reduce newborn mortality.

Child health

- Define epidemiology of hospital- and community-acquired invasive infections, supported by in-house rapid turnaround sequencing, with the aim of identifying modifiable risk factors and monitoring impact of existing interventions.
- Lead international AMR surveillance via the ACORN project and continue to work on improving laboratory informatics for resource limited settings.
- Continue work on pneumococcal colonisation as part of the recently re-funded Wellcome Sanger Institute-led Global Pneumococcal Sequencing project. Scientific questions are related to impact of current pneumococcal conjugate vaccines and ideal components of expanded valency vaccines.
- Co-lead respiratory and gastrointestinal colonisation and microbiome studies.
- Develop digital datasets that can be used to model the impacts of novel pneumococcal, and other respiratory pathogen, vaccines on the nasopharyngeal microbiome.
- Determine the impacts of viral infections, antibiotics, and hospitalisation on the nasopharyngeal and gastrointestinal resistome.
- Collaborate on studies to determine the optimal use of biomarkers for detection of sepsis and prediction of poor outcomes in unwell children.

Laboratory infrastructure

- Complete application for ISO:15189 accreditation and subsequently maintain accredited status.
- Work with MORU and the Mahidol Faculty of Tropical Medicine (FTM) in Bangkok on an integrated genomics / bioinformatics platform.



MOCRU Director Frank Smithuis during a ward round in one of the 18 oxygen treatment wards MOCRU and MAM had set up in Myanmar for the treatment of severe COVID (SpO₂ <90%). © MORU 2022.

Myanmar Oxford Clinical Research Unit (MOCRU)

I. Overview

Led by Professor Frank Smithuis, formerly with *Médecins sans Frontières* (MSF) and later with *Medical Action Myanmar* (MAM), the Myanmar Oxford Clinical Research Unit (MOCRU) was established in 2013.

MOCRU has a strong link with MAM, a medical aid organisation with a well-established infrastructure of 1,100 staff, 11 clinics, 18 COVID-19 treatment centres and over 2,000 Community Health Workers (CHW) spread across Myanmar's poorest rural areas. Most research questions originate from medical issues MAM staffs face while implementing their health activities (MAM conducts over 1 million patient consultations per year). The aim of MOCRU's research is to improve clinical management of MAM's public health interventions and, more importantly, all health care services in Myanmar.

Ongoing research projects include:

Malaria: Assessment of interventions to eliminate malaria (mass drug administration (MDA), Mass Screening and Treatment (MSAT) and malaria treatment combinations.

HIV and Opportunistic Infections: Determining predictors of mortality and loss-to-follow up in HIV clinics; pre-exposure prophylaxis of HIV for people with high risk; hepatitis C treatment; gonorrhoea and chlamydia incidence among high-risk women in jade mine region; cervical cancer screening; and determining the prevalence of HPV infection in HIV+ women.

Fever: Explore the aetiology of fever:

- Fever Flagship South and Southeast Asian Community-based Trials Network (SEACTN) RFI (Fever Surveillance).

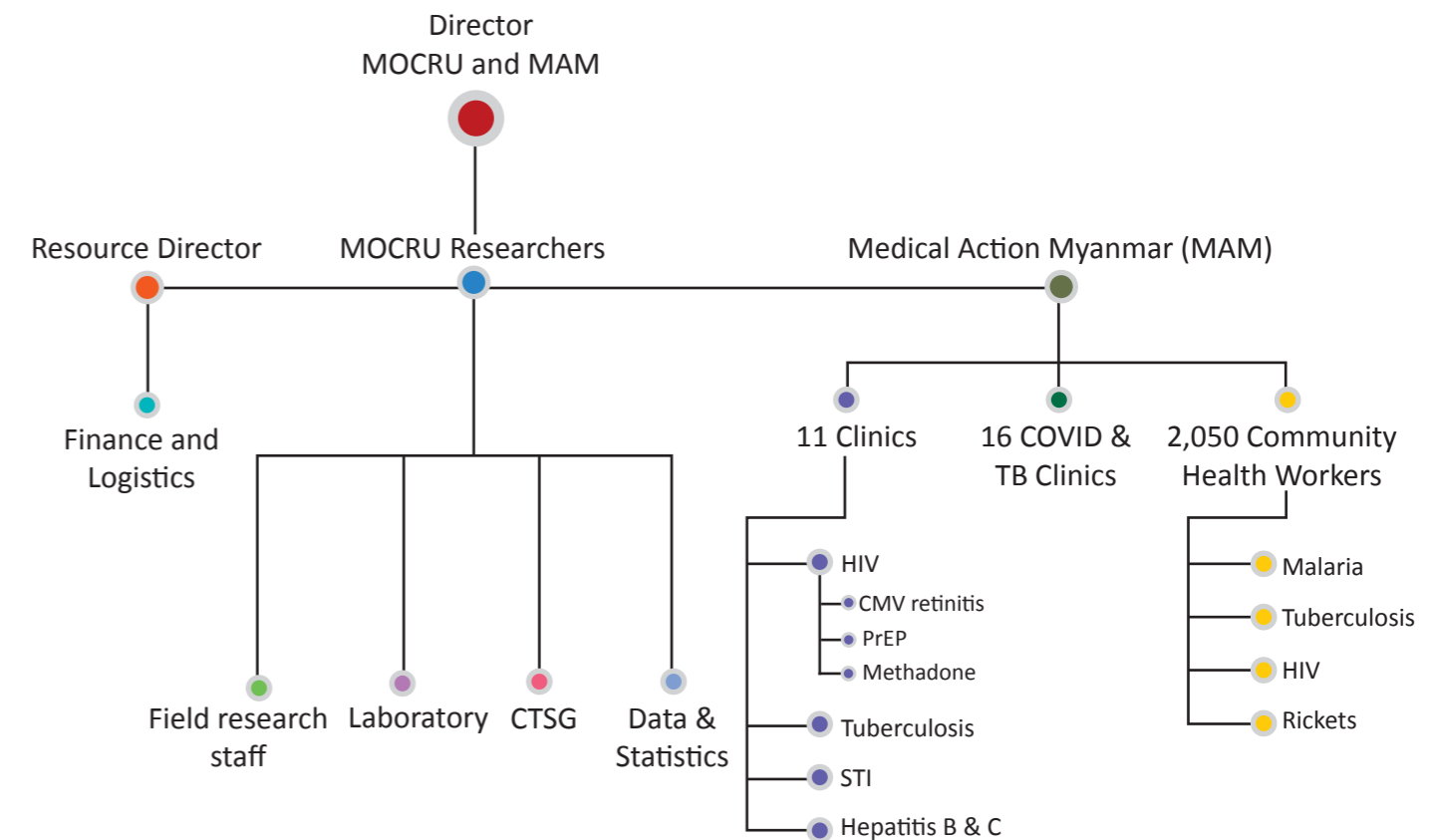
- The prevalence of scrub typhus.
- Environmental sampling and mapping of the geographic distribution of *Burkholderia pseudomallei*.
- Etiology of pneumonia (melioidosis and TB, among others).

Snakebite: A survey of medically significant snake species of Myanmar, and determining the optimal dose of antivenom for Russell's viper envenomed patients.

Rickets: The aetiology, geographical distribution and prevalence of calcipenic rickets.

Antibiotic use and public engagement activities.

II. Our team



III. Scientific achievements in 2021

Community-based health care

a. Malaria

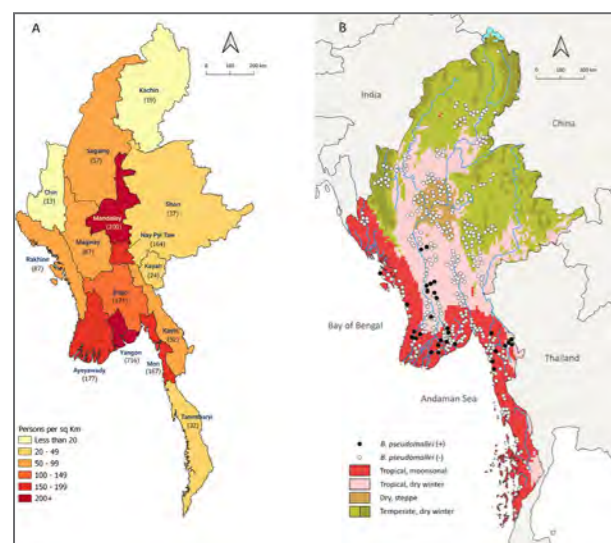
Through a large network of approximately 2,000 Community Health Workers (CHWs), MOCRU/MAM had considerable success in reducing and eliminating malaria in remote areas on the borders with India, China and Thailand through a combination of passive and active case finding activities.

The CHWs oversaw dramatic declines in *P. falciparum* and *P. vivax* malaria (with respectively 70% and 64% annual decrease in incidence for 5 years). Falciparum malaria was eliminated in 168 villages in Mon state within 6 years. In addition to malaria, a broad package of health care services is managed in the communities including respiratory tract infections, TB, HIV, hepatitis C and rickets. In high transmission areas where MDA is not approved, MOCRU/MAM are implementing Mass Screening & Treatment (MAST) with the aim to treat asymptomatic patients with patent parasitaemia who usually don't get tested.

confirmed a widespread distribution of *B. pseudomallei* in Myanmar. Clinical studies should follow to obtain a better picture of the burden of melioidosis in Myanmar.

b. Tuberculosis

The CHWs do active screening for TB in remote communities and have referred over 3,000 patients, 800 of which were started on TB treatment. But many suspected people are reluctant to go to the nearest hospital for fear of discrimination, COVID-19 and armed conflict. This delays treatment. To improve early detection we introduced screening in the villages with *Truenat*, a new mobile point-of-care highly sensitive molecular diagnostic tool to detect TB as well as rifampicin resistance mobile. We want to explore the feasibility of *Truenat* in remote settings of Nagaland and Puta-O.



A study by MOCRU's Myo Maung Maung Swe and Frank Smithaus confirmed a widespread distribution of *B. pseudomallei* in Myanmar (*PLoS Negl Trop Dis.* 2021 May 24;15(5):e0009372).

ses are not often made, with detrimental consequences for the patients. To explore the potential presence of melioidosis, we conducted a nationwide soil study, which confirmed a widespread distribution of *B. pseudomallei* in Myanmar. Clinical studies should follow to obtain a better picture of the burden of melioidosis in Myanmar. We also explored the spread of rickettsia and our findings indicate that rickettsial infections are widespread in Myanmar, with high seroprevalence of scrub typhus in rural and northern regions.

HIV and opportunistic infections

HIV in Myanmar is largely concentrated among female sex workers, men having sex with men (MSM) and intravenous drug users (IVDU). There are high HIV infection rates (20-40% in Yangon and north Myanmar), and high co-infection rates with TB and TB and HCV (hepatitis C virus) with 78% of IVDU being HCV+ in the far north of Myanmar, and high percentages of sexually transmitted infections. MOCRU and MAM are exploring a comprehensive package of integrated HIV/TB/HCV/STI (sexually transmitted infections) prevention and treatment services provided to high-at-risk populations at clinics and in remote communities. Community-based health workers increase the uptake of prevention services and support compliance of long-term treatments (HIV/TB and HCV). To improve the services to these at-risk populations, we carried out cohort analysis to explore factors related to mortality and disengagement.

Management of severe COVID-19 in resource-limited settings

Myanmar was hit by an extremely severe COVID-19 outbreak in July-September 2021. As a result of very low baseline immunity of the Myanmar population (almost no previous COVID-19 infections in the country before July 2021 and a very low vaccination rate), the highly contagious and clinically

c. Rickets

We identified and treated a large number of children with severe disabling rickets (>500) in remote North Myanmar (Nagaland). This was the first report of rickets in Myanmar in 120 years. Treatment is highly effective. In addition, we screened 1,600 children and pregnant and lactating women from 20 villages in an area with the highest case load to early detect and treat vitamin D deficiency and to explore aetiological factors to improve options for prevention and treatment.

Fever and infectious diseases

The aetiology of fever and epidemiology of infectious diseases is often not clear. In Southeast Asia melioidosis and typhus are known to be prevalent but the true burden of these diseases in Myanmar is obscured by a lack of awareness among clinicians and limited diagnostic facilities to identify the causative organism. As a result, these diagno-

more severe Delta variant rapidly invaded cross-border from India and caused havoc. Hospital services were almost non-existent because of the nationwide hospital strike and tens of thousands



A consultation at one of the MAM clinics that provides pre-exposure prophylaxis (PrEP) to men who have sex with men and transgender women. MOCRU is analyzing factors that influence uptake, discontinuation and HIV sero-conversion. © MORU 2022.

of people died without treatment over a couple of weeks. MAM and MOCRU hired and trained 400 new staff within 3 weeks and set up 805 beds in 18 locations spread out over the country, and treated over 2,900 severely ill COVID-19 patients (SpO₂ <90%) with oxygen and intensive medical care. The treatment success rate was over 80%. The MOCRU team, with technical support from MORU and LOMWRU, produced clinical treatment guidelines, training, and monitored and evaluated the quality of care.

Completed studies

- Pilot study of mass drug administration for malaria elimination in an area of artemisinin resistance.
- Melioidosis in Myanmar: Environmental soil sampling, culture and mapping of the geographic distribution of *Burkholderia pseudomallei* in Myanmar.
- A cross-sectional study investigating the causes of pneumonia in two community clinics in Yangon, Myanmar.
- A multicentre observational study to describe the prevalence of scrub typhus defined as a positive rapid diagnostic test among selected patients presenting with fever to clinics in Myanmar.
- Background sero-prevalence of rickettsial infections in Myanmar.
- HIV and opportunistic infections.
- Analysis of HIV services integrated with primary care services.
- Analysis of long-term management of talaromycosis.
- Rickets aetiology and prevalence survey: initial investigation.

IV. Top 10 publications in 2021

1. Spend wisely to eliminate malaria. Smithuis FM, White NJ. *Lancet Infect Dis.* 2021;S1473-3099 (21)00256-5. PMID: 34953537.
2. Accelerating malaria elimination in Myanmar with mass drug administration; a cluster-randomised trial in a region with artemisinin resistant falciparum malaria. McLean A, Indrasuta C, Khant Z. *Lancet Infect Dis.* 2021. PMID: 34147154.
3. Ambulatory induction phase treatment of cryptococcal meningitis in HIV integrated primary care clinics, Yangon, Myanmar. Warrell CE, Macrae C, McLean ARD, Wilkins E, Ashley EA, Smithuis F, Tun NN. *BMC Infect Dis.* 2021;21(1):375. PMID: 33882845, PMID: 8059000.
4. Evolution of multidrug resistance in *Plasmodium falciparum*: a longitudinal study of genetic resistance markers in the Greater Mekong Subregion. Imwong M, Suwannasin K, Srisutham S, Vongprommek R, Promnarate C ... Nosten FH, Smithuis FM, Dhorda M, White NJ, Dondorp AM. *Antimicrob Agents Chemother.* 2021;65(12):e0112121. PMID: 34516247; PMID: PMC8597770.
5. The 20-minute whole blood clotting test (20WBCT) for snakebite coagulopathy-A systematic review and meta-analysis of diagnostic test accuracy. Lamb T, Abouyannis M, de Oliveira SS, Shenoy KR, Geevar T ... Laloo DG, Ashley EA, Monteiro WM, Smithuis F, Eddleston M. *PLoS Negl Trop Dis.* 2021;15(8):e0009657. PMID: 34375338; PMID: 8405032.

6. Geographical distribution of *Burkholderia pseudomallei* in soil in Myanmar. Swe MMM, Win MM, Cohen J, Phyo AP, Lin HN, Soe K, Amorncha P, Wah TT, Win KKN, Ling C, Parker DM, Dance DAB, Ashley EA, Smithuis F. *PLoS Negl Trop Dis*. 2021;15(5):e0009372. PMID: 34029325; PMCID: PMC8143414.
7. Children with severe nutritional rickets in Naga region in north-west Myanmar, on the border with India. Aung H, Soe K, Smithuis FF. *Am J Trop Med Hyg* 2021;105(1):217-21. PMID: 34097648; PMCID: 8274785.
8. Observational study of adult respiratory infections in primary care clinics in Myanmar: understanding the burden of melioidosis, tuberculosis and other infections not covered by empirical treatment regimes. Warrell CE, Phyo AP, Win MM, McLean ARD, Watthanaworawit W ... Aung NM, Tun NN, Dance DAB, Smithuis FM, Ashley EA. *Trans R Soc Trop Med Hyg*. 2021;115(8):914-21. PMID: 33681986; PMCID: 8326957.
9. Inter-prescriber variability in the decision to prescribe antibiotics to febrile patients attending primary care in Myanmar. Swe MMM, Ashley EA, Althaus T, Lubell Y, Smithuis F, McLean ARD. *JAC Antimicrob Resist*. 2021;3(1):dlaa118. PMID: 33506197; PMCID: 7814214.
10. Serological evidence indicates widespread distribution of rickettsioses in Myanmar. Elders PND, Swe MMM, Phyo AP, McLean ARD, Lin HN ... Linn H, Htwe YY, Smithuis FM, Blacksell SD, Ashley EA. *Int J Infect Dis*. 2021;103:494-501. PMID: 33310022; PMCID: 7862081.

V. Capacity building achievements in 2021

Students/ interns

- Dr Myo Maung Maung Swe awarded a MORU DPhil studentship at the University of Oxford.
- Dr Thomas Lamb appointed first Hamish Ogston Fellow with the Nuffield Department of Medicine.
- Dr Ni Ni Tun graduated a Masters of Tropical Medicine & Research at Tropical Institute of Antwerp.
- Dr Ni Ni Tun and Dr Hein Aung were enrolled as PhD students at the University of Antwerp and the University of Amsterdam.

Training provided by MOCRU

- Trained MAM doctors to conduct in-depth interviews.
- Trained 400 MAM doctors and nurses to treat patients with severe COVID-19.
- Trained study staff in good clinical practice (GCP).

VI. Future vision

MOCRU will continue to build the translational research capacity of the extensive Medical Action Myanmar (MAM) network of clinics and village health workers and will strengthen our collaboration with the University of Community Health and other hospitals and universities.

HIV and opportunistic infections prevention and treatment

MOCRU will continue to work on treatment, prevention, and pre-exposure prophylaxis (PrEP) for HIV, opportunistic infections, HCV (treatment and prevention/ methadone), and infections that facilitate HIV transmission in high-risk populations.

MOCRU will also further explore HIV and related disease services, supported by community-based health workers for remote hard to reach regions. This can increase the uptake of prevention services and compliance of long-term treatments (HIV/TB and HCV). Specific studies planned:

- Anti-retroviral drug resistance surveillance.
- Analysis of factors associated with treatment failure and loss to follow up.

- Prevalence of cervical cancer among HIV+ women and the feasibility and effect of community based cervical cancer screening.
- Viral hepatitis. Long-term outcomes following community-based Hepatitis C treatment.
- Sexually transmitted infections prevalence, and incidence among high risk population.



A MAM worker provides sex workers with health education in a brothel in Hpakant, a large jade mine area in Myanmar. MOCRU and MAM are exploring a comprehensive package of integrated HIV/TB/HCV/STI (sexually transmitted infections) prevention and treatment services provided to high-at-risk populations at clinics and in remote communities. © MORU 2022.

Tuberculosis

- We will explore a new mobile point-of-care highly sensitive molecular diagnostic tool to detect TB and rifampicin resistance.

Malaria elimination

MOCRU will further explore strategies for elimination in low and higher transmission areas, trialling innovative tools to detect and treat asymptomatic people and identify the risk of malaria reintroduction and to monitor the spread of multi-drug resistant parasites. Specific studies planned:

- Development of Triple ACT (DeTACT) multi-centre project.
- Southeast Asian Dose Optimization of Tafenoquine (SEADOT) Phase-IV Multi-centre trial.
- Declining immunity to malaria in Myanmar post elimination and risk of reintroduction.
- Effectiveness of Mass Screening & Treatment (MSAT).

Fever aetiology, epidemiology and management

- MOCRU will collaborate with MORU units in Southeast Asia for surveillance of disease and of infections such as dengue, typhus, melioidosis and AMR, and will expand research interest in non-malaria febrile illness to explore epidemiology, disease burden and treatment trials: Fever aetiology surveys (related to C-reactive protein (CRP) studies).
- Melioidosis epidemiology: Blood culture surveys to define the relevance of melioidosis among patients with sepsis.
- Rapid diagnostic test (RDT) evaluation for the diagnosis of pneumonia.

Improved health care for hard-to-reach communities

- MOCRU will work with SEACTN to explore ways to improve and expand the role of community health workers to reduce morbidity and mortality of rural populations.
- We will work to prevent and treat calcipenic rickets.

Antimicrobial resistance (AMR)

- Zoonotic transmission of AMR bacteria in collaboration with University of Cambridge's Zoonoses and Emerging Livestock Systems (ZELS) Project and Myanmar Pig Partnership.

Prevalence, aetiology, treatment and prevention of calcipenic rickets

- MOCRU will study the prevalence and aetiology (risk factors) of calcipenic rickets.
- We will also investigate the effectiveness of the current national treatment guidelines and potential prevention strategies in the community.



Shown here discussing with Dr Villada Chansamouth, Professor Paul Newton (left) and the Medicine Quality Research Group work to better understand substandard and falsified medical (SF) products and evaluate innovative pharmaceutical forensics. © MORU 2022. Photographer: John Bleho.

Medicine Quality Research Group

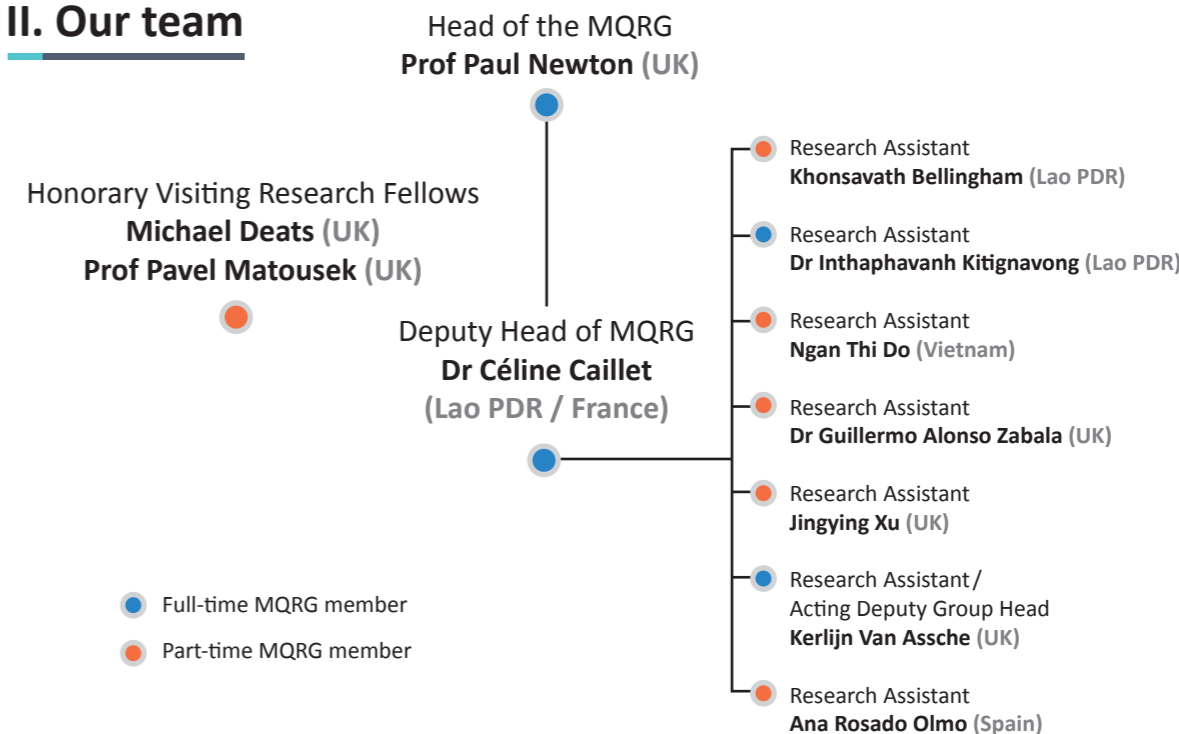
I. Overview

Now based in Oxford, UK, the Medicine Quality Research Group (MQRG) is a component of the MORU Tropical Health Network and the Infectious Diseases Data Observatory (IDDO). Our main aims are to:

- Improve our understanding of the epidemiology of substandard and falsified (SF) medical products and their impact on patient outcomes, health systems and antimicrobial resistance;
- Improve understanding of the diagnostic accuracy and implementation of innovative screening technologies for post-market surveillance of medicines and vaccines;
- Evaluate innovative techniques for pharmaceutical forensics, to understand falsified medicine trade routes;
- Engage with health workers and policy makers on how to intervene to improve the quality of the global medicine supply.

We work with many components of the MORU Tropical Health Network, especially with LOMWRU in Laos, and MORU's Department of Clinical Pharmacology in Bangkok. In 2021, Medicine Quality team members were based in the Lao PDR, Belgium, Spain, Viet Nam and the UK.

II. Our team



III. Scientific achievements in 2021

The COVID-19 pandemic has inevitably continued to greatly change work plans and priorities but we have adapted our systems, to assist with research for protecting the quality and supply of medical products overall and especially for COVID-19 therapy and prevention, and continued pre-pandemic planned work as much as we are able.

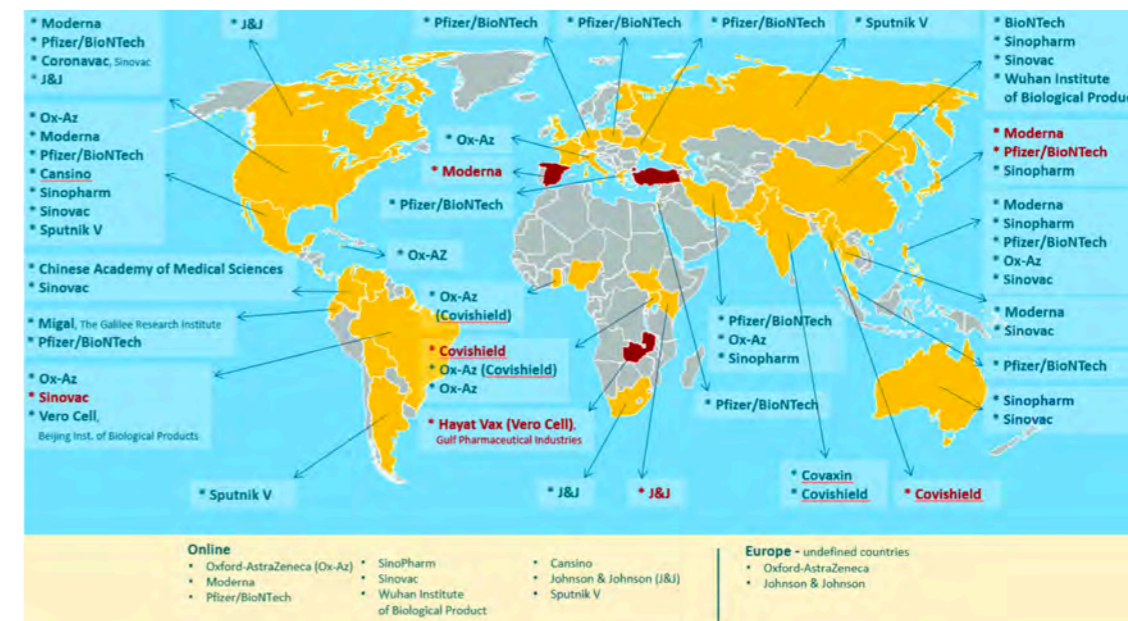


Figure 1. Countries with public reports on COVID-19 vaccine quality issues on the Medicine Quality Monitoring Globe (Aug-Sept 2021). Countries linked to incidents are indicated in orange. If a public report mentions a product name or a company, these details are indicated on the map, with in red the information that was added since the last issue. Ox-Az: Oxford-AstraZeneca, and J&J: Johnson & Johnson.

Medicine Quality Monitoring Globe (MQM Globe)

See: <https://www.iddo.org/mqmglobe/>. In 2020, we released the Medicine Quality Monitoring Globe, funded by the recently completed Wellcome MAPQAMP Biomedical Resource grant. This tool summarizes data from newspaper articles, retrieved from Google News in (English, French, Chinese, Vietnamese and Spanish), related to medicine quality, curated and mapped on a virtual Globe. This is a collaboration with Prof Clark Freifeld of HealthMap and Northeastern University, Boston and the building of the front end was led by Dr Andrew Payne of IDDO.

We have enhanced it for COVID-19 so that one can filter by different relevant medical products, such as hand sanitiser and COVID-19 vaccines. In 2021 we added in a system for viewing national medicine regulatory authorities (NMRA) and international organisation websites for public alerts of SF issues to provide one website where these fragmented reports can be searched for.

Medicine Quality Literature Surveyor

See: www.iddo.org/mqsurveyor/.

In 2020, we released the updated WWARN Antimalarial Quality Surveyor as the IDDO Medicine Quality Literature Surveyor. This system, also developed as part of the MAPQAMP project, summarizes the available curated scientific evidence on the quality of many classes of essential medicines, including antimalarials, antiretrovirals, antidiabetics, antibiotics, antitubercular medicines, medicines for cardiovascular and veterinary diseases, and vaccines. It is and will be accompanied by reviews of the epidemiology, impact and gaps of evidence on SF medical products for these classes of medicines. We are working on including details of the scientific literature on essential medical products for COVID-19 as this literature grows. We published a review of reports of SF cardiovascular medical products in 2021 and are completing many of the others.

Reports on public domain literature on articles on SF COVID-19 medical products

See: <https://www.iddo.org/mq/research/medical-product-quality-reports>. From July 2020 we started issuing curated monthly reports on current issues in the public domain for SF medical products for COVID-19. These summarise disparate lay and scientific reports in one place, and discuss the trends revealed and how organisations are intervening. They are used by diverse national and international bodies to keep abreast of the epidemiology and risks of SF COVID-19 medical products.

Medicine quality screening devices

Medicine quality screening devices offer hope that they can effectively empower medicine inspectors in national medicines regulatory authorities (NMRA) and related stakeholders in the objective screening of supply chains for SF medical products. The large report on the Asian Development Bank funded project, conducted in LOMWRU, as an independent evaluation of portable devices for screening for SF medicines to empower drug inspectors (<https://www.iddo.org/external-publication/evaluation-portable-screening-devices-assess-medicines-quality-national>) has been published as a collection of five papers in PLOS Medicine and PLOS Neglected Tropical Diseases.

We worked with colleagues at University College Cork, Ireland, evaluating a novel rapid, and relatively inexpensive technology for investigating whether BARDS (Broadband Acoustic Resonance Dissolution Spectroscopy) can distinguish falsified from genuine tablets. When a tablet is dissolved it gives an acoustic spectrum unique and intrinsic to the sample. A range of genuine and falsified medicines, including falsified antimalarial tablets from Southeast Asia, were tested, and compared to their counterpart genuine products. Significant differences between genuine and falsified doses were found in their acoustic signatures as they disintegrate and dissolve.

The project to examine whether advanced chemometric analysis of Raman and Near-Infrared (NIR) spectra, acquired using handheld devices, can allow quantitation of the amount of active pharmaceutical ingredient in tablets of two commonly used antibiotics was completed in 2020. The papers from this project, funded by the UK Department of Health and Social Care through the Foundation for Innovative Diagnostics (FIND), are being completed for submission. MedSnap is a technique for the detailed evaluation of the shape, size and colour of medicines using a smartphone camera and its software. As part of the FIND project we also evaluated the diagnostic accuracy of MedSnap for the screening of two antibiotics and the paper is being completed.

Devices for screening of vaccine identity and quality

There have been multiple examples of diverted, falsified and substandard vaccines in supply chains, both pre-pandemic and for COVID-19 vaccines. By December 2021 there had already been

74 reports from 44 countries and the dark web of diverted and SF COVID-19 vaccines in the public domain. With the predictable severe issues with inequity and impaired access for the global population, the risk of rampant falsification is high and its consequences dire, potentially leading to vulnerable communities being unprotected, increasing morbidity and mortality, a loss of faith in vaccines, and the fuelling of vaccine hesitancy. We are investigating innovative ways to reduce the risk, connecting multiple diverse stakeholders.

Medicine Quality Surveys

We are a part of the ABACUS-2 project, led by Radboud University, Nijmegen, the Netherlands, to work with the WHO and partners in Ghana, Mozambique, Bangladesh, and Viet Nam to survey antibiotic quality in demographic health surveillance systems.

Innovative pharmaceutical forensics

There is remarkably little public domain research on applying modern forensics to pharmaceuticals.



Making tablets in MORU Bangkok for evaluation of devices. *Left:* Laboratory technician Rattawan Kullasakboosri sieving granules before they are pressed into tablets. *Right:* Electric tablet press. Lubricated medicine granules are placed in a hopper that shakes them into the pressing tool to make tablets. © MORU 2022. Photographer: Daniel Blessborn.

We have been building on our earlier work on pollen and stable isotope analysis as tools for understanding the origins of falsified tablets. We have demonstrated that falsified antimalarial tablets contain distinctive environmental DNA (eDNA) spectra of very diverse taxa that are likely to give important clues as to location and timing of ingress of the constituents into the tablets.

Importantly, we have also found human DNA in falsified tablets through Massive Parallel Sequencing, suggesting that using mtDNA analysis we can estimate the ancestry of those, whether involved in the production or as bystanders, whose DNA we can detect. This raises

important ethical questions that we are discussing with ethicists and forensic specialists. The stable isotope work suggests that we will be able to estimate origin of some excipients used in tablets, in a similar way to which one can use this technique to estimate the home range of an elephant that was killed for poached ivory seized continents away.

The impact of SF antimicrobials on patient outcome

Antimicrobial resistance is very likely to be, at least partially, driven by SF antimicrobials, especially those containing reduced amounts of active pharmaceutical ingredients. We are working with the MORU Mathematical and Economic MODelling (MAEMOD) Group on modelling the relationships between SF antimicrobials and antimicrobial resistance (AMR). How important are SF antimicrobials as drivers, in comparison to other drivers such as poor prescribing and poor adherence? We are also investigating the ecology of AMR: Which antibiotic-pathogen pairs are the most at risk from SF antibiotics?

Wellcome Collaborative Award = Forensic epidemiology and impact of substandard and falsified antimicrobials on public health (FORESFA)

The two subjects described above have been brought together in this 4-year project, that aims to improve our understanding, and inform global policy and action, for substandard and falsified antimicrobials. Leading specialists investigating illegal wildlife trade, forensic genomics and chemistry, social network analysis and modelling, have been working together since October 2021 to answer two main aims:

1. How can innovative forensic tools be used to identify sources and trade routes?

How can novel genomic (pharmabiome), chemical and isotopic analysis with social network techniques be used to characterise the epidemiology of SF antimicrobials to inform policy and action to improve our global pharmaceutical supply quality? We will conduct high-throughput sequencing and novel chemical analysis of falsified and genuine antimicrobials to determine their comparative pharmabiome/chemical spectra, followed by social network analysis of origins and trade routes

2. What are the public health impacts of SF antimicrobials?

What are the modelled impacts of SF antimicrobials on patient outcome, global public health, especially engendering antimicrobial resistance and how can these be minimised? Using a One Health approach, which pathogen-antimicrobial pairs are at greatest risk of SF antimicrobials?

This links the Centre for Tropical Medicine & Global Health, the University of Cape Coast, Ghana, the National Institute of Medical Research, Tanzania, Edinburgh University, Fondazione Edmund Mach, Italy, the International Atomic Energy Authority, Austria, and Northeastern University, USA.

Data collection and sharing

We are working with the WHO on developing Epione, an online tool to facilitate the implementation of medicines quality surveys by medicines regulators. The tool helps regulators during all the steps of a survey, from the design (e.g. randomisation of the health facilities to be included) to the implementation of field collections (including a smartphone application for offline collection of medicines data) and laboratory analysis. It also includes dynamic dashboards to follow-up the survey progression and issues, as well as a barcode tracking system to follow the samples' route from their collection to their analysis in the laboratory. Epione is being piloted in Tanzania.

The sharing of data on incidents of SF medical products remains woeful and we are working on initiatives to encourage better data sharing by the pharmaceutical industry and by academics. We work with the Access to Medicine Index on our idea to rank innovative companies by when and who they share data on SF medical product incidents with. This has had an encouraging influence on pharmaceutical industry data sharing. We are writing a viewpoint arguing that academia also needs to improve timely reporting to NMRAs and WHO RapidAlert.

Advocacy and engagement

We are an Observer at the WHO Member State Mechanism on SF Medical Products and have close links with WHO SF Incidents Team and continue expanding working with this and many other institutions, especially on the current dangers of SF COVID-19 vaccines.

The Medicine Quality & Public Health Conference and MQPH Course that we had hoped to organise in 2021 have been postponed due to the pandemic and we are now starting to plan this.

We participated in webinars and online meetings on medicine quality, organized by the WHO, the Institute for Tropical Medicine, Antwerp, the United Nations Office of Drugs and Crime, the National Science Foundation/Boston University, COVID-19 Clinical Research Coalition, Royal Society of Tropical Medicine & Hygiene, Centre for Tropical Medicine & Global Health, BeCause Health, Save The Children, and University of Oxford Ethox Centre. We collaborated with the London School of Hygiene and Tropical Medicine, United States Pharmacopeia and the Institute for Tropical Medicine, Antwerp, on our regular, now online, collective informal medicine quality catch ups.

IV. Top publications in 2021

1. Multiphase evaluation of portable medicines quality screening devices. Caillet C, Vickers S, Zambrzycki S, Luangasanatip N, Vidhamaly V, Boutsamay K, Boupha P, Lubell Y, Fernández FM, Newton PN. *PLoS Negl Trop Dis*. 2021 Sep 30;15(9):e0009287. PMID: 34591864; PMCID: 8483331.

2. Evaluation of portable devices for medicine quality screening: Lessons learnt, recommendations for implementation, and future priorities. Caillet C, Vickers S, Vidhamaly V, Boutsamay K, Boupha P, Zambrzycki S, Luangasanatip N, Lubell Y, Fernández FM, Newton PN. *PLoS Med*. 2021 Sep 30;18(9):e1003747. PMID: 34591861; PMCID: 8483386.

3. A comparative field evaluation of six medicine quality screening devices in Laos. Caillet C, Vickers S, Zambrzycki S, Fernández FM, Vidhamaly V, Boutsamay K, Boupha P, Peerawaranun P, Mukaka M, Newton PN. *PLoS Negl Trop Dis*. 2021 Sep 30;15(9):e0009674. PMID: 34591852; PMCID: 8483322.

4. Laboratory evaluation of twelve portable devices for medicine quality screening. Zambrzycki SC, Caillet C, Vickers S, Bouza M, Donndelinger DV, Geben LC, Bernier MC, Newton PN, Fernández FM. *PLoS Negl Trop Dis*. 2021 Sep 30;15(9):e0009360. PMCID: 8483346.

5. Implementation of field detection devices for antimalarial quality screening in Lao PDR-A cost-effectiveness analysis. Luangasanatip N, Khonputsu P, Caillet C, Vickers S, Zambrzycki S, Fernández FM, Newton PN, Lubell Y. *PLoS Negl Trop Dis*. 2021 Sep 30;15(9):e0009539. PMID: 34591842; PMCID: 8483304.

6. The quality of medical products for cardiovascular diseases: a gap in global cardiac care. Do NT, Bellingham K, Newton PN, Caillet C. *BMJ Glob Health*. 2021 Sep;6(9):e006523. PMID: 34521627; PMCID: 8442059.

7. Preprints in times of COVID19: the time is ripe for agreeing on terminology and good practices. Ravinetto R, Caillet C, Zaman MH, Singh JA, Guerin PJ ... Merson L, Horby PW, Bottieau E, Hoffmann T, Newton PN. *BMC Med Ethics*. 2021 Jul 28;22(1):106. PMID: 34320970; PMCID: 8320096.

8. Sounding out falsified medicines from genuine medicines using Broadband Acoustic Resonance Dissolution Spectroscopy (BARDS). Alfarsi A, Caillet C, Fawbert G, Lawrence S, Krüse J, McSweeney S, O'Mahony M, Dondorp A, Newton PN, Fitzpatrick D. *Sci Rep*. 2021 Jun 16;11(1):12643. PMID: 34135361; PMCID: 8209214.

V. Capacity Building

We have built capacity within the MQRG team in the five countries in which we have been based in 2021. We taught on courses run by the Institute for Tropical Medicine, Antwerp, the London School of Hygiene and Tropical Medicine and the University of Oxford MSc in International Health & Tropical Medicine. We expect that three PhD positions in the MQRG, funded by the Wellcome Collaborative Award, will start in 2022. We are starting to explore restarting English language Medicine Quality & Public Health courses and also running a French language course.

VI. Future Vision

We will continue to adapt, within the pandemic and for our post-pandemic world, to pioneer multidisciplinary research to inform a rethinking of how we can improve the global medicine supply, especially for vulnerable communities. The field requires very broad multidisciplinary collaborations and we plan to expand the MQRG as a network of these interconnected specialties, learning from each other.

We will help seed further MQPH research groups (very few at the moment) in LMICs through targeted PhD programs with the group.



Members of the KIMORU team and Unit Director Dr Caterina Fanello (4th right) with patients. © MORU 2022.

KIMORU Unit, DR Congo

I. Overview

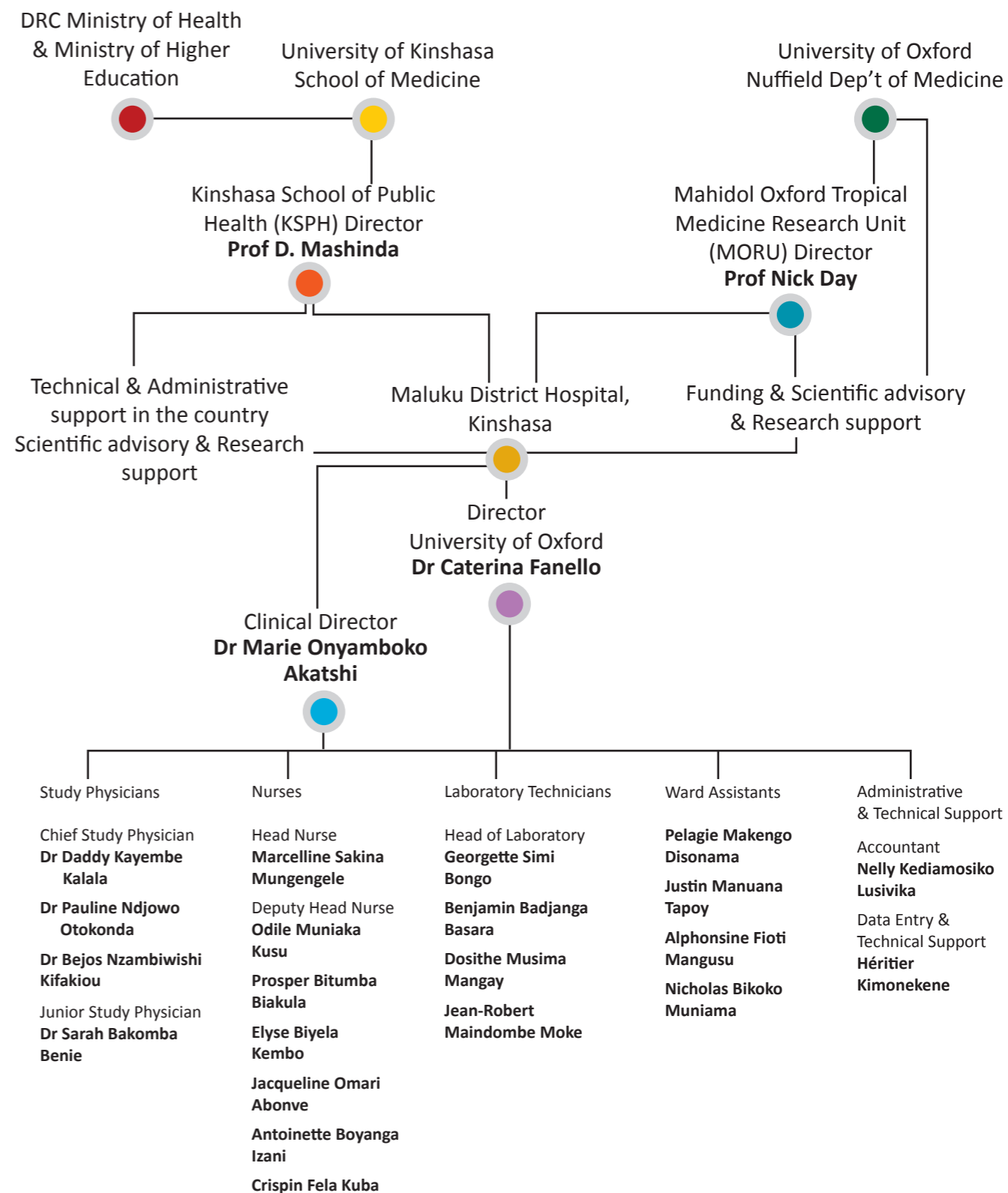
The Democratic Republic of Congo (DRC) is the second largest country in Africa but also one of the most fragile, with 19.6 million people in need of humanitarian assistance. Maternal and child mortality rates are among the highest in the world, with 473 maternal deaths per 100,000 live births and 81.2 deaths per 1,000 live births among children under 5. In 2021, already worn out by COVID-19, the DRC was hit by several other epidemics, including Ebola, plague and cholera, which required additional resource allocation and mobilisation of frontline health workers, depleting an already fragile health system and eroding community resilience. Malaria is endemic and remains a major cause of morbidity and mortality: in 2020 the country accounted for 12% of cases and 13.2% of deaths attributable to malaria globally, with a steady upward trend since 2015 (WHO 2021). Since 2010, MORU and the University of Oxford have collaborated with the Kinshasa School of Public Health (KSPH), University of Kinshasa, to conduct research aimed at improving maternal, newborn and child health in the DRC, with a special focus on malaria.

The research team of the Kinshasa-Oxford Medical Research Unit (KIMORU) consists of 23 doctors, nurses, laboratory technicians, administrative and logistical staff. Dr Caterina Fanello (MORU, University of Oxford) is the overall research director. Dr Marie Onyamboko (University of Kinshasa) is the clinical director. The unit's main facilities - two paediatric wards, one laboratory and two offices entirely dedicated to research - are currently hosted by the Maluku District Hospital, located in a semi-rural area of Kinshasa. The administrative and archive offices are located on the University of Kinshasa campus.

III. Scientific achievements in 2021

In 2021, the team's clinical and research activities continued, albeit with delays. The broader impact of the pandemic led to a significant increase in the cost of living, exacerbating the pre-existing conditions of poverty. Rising costs of healthcare, partial disruption of services, scarcity of medical supplies, fear of contracting COVID-19, and vaccine hesitancy contributed to a general distrust in

II. Our team



KIMORU is an independent MORU Study Site located within the main compound of the Maluku District Hospital, Kinshasa.

the healthcare system and led to a drastic decrease in attendance at hospitals. Human mobility increased, making participation in research more complex. Throughout the year, the team has devoted considerable time and efforts to regain the community's trust, through the deployment of community health workers and by ensuring a continuous, free service of malaria diagnosis and treatment for the paediatric population. As a result, we have recently started recording an improvement in research participation.

One of the major achievements in 2021 was the establishment of a molecular surveillance system for antimalarial drug resistance in pregnant women attending antenatal care services (Bill & Melinda Gates Foundation). The aim of the project is to determine whether this population can be considered a 'surrogate' for the paediatric population (the standard reference for surveillance), with the advantage of working with adults who routinely attend medical services, thus greatly simplifying the logistics of surveillance and reducing costs. The parasites (genome sequences, Wellcome Sanger Institute, Cambridge, UK) of pregnant women will be compared with those of children living in the same areas. This new surveillance platform also aims in the medium and long term to collect relevant data on the health of pregnant women to advance women's health.

The team has also:

- Began to recruit children with severe malaria in the RCT *Evaluation of the renoprotective effect of acetaminophen in paediatric severe falciparum malaria* (Canadian Institutes of Health Research).
- Continued the recruitment of children with uncomplicated malaria in the *Development of triple artemisinin-based combination therapies for uncomplicated falciparum malaria* (DeTACT), a multinational clinical trial which will evaluate efficacy, safety, and tolerability of triple artemisinin-based combination therapies for the treatment of uncomplicated *falciparum* malaria (DFID/Wellcome Trust).
- Completed the clinical part of the study *Implementation of lung ultrasound (LUS) to differentiate causes of respiratory distress in paediatric severe falciparum malaria* (Institution Translational Partnership Award (iTPA), statistical analyses ongoing).
- Completed the study *Baseline assessment of neonatal hyperbilirubinaemia in a cohort of new-borns in Kinshasa, Democratic Republic of Congo* (laboratory analyses to identify presence of haemoglobinopathies and G6PD deficiency in mothers and new-borns ongoing).

We secured funding for the following studies (recruitment start planned mid-2022):

- *Convenience and cost-aspects of a new 1-step reconstitution injectable artesunate compared to conventional 2-step injectable artesunate for the treatment of severe falciparum malaria: a multi-centre study* (FOSUN Pharmaceutical).
- *Innovative health technologies for low-resource settings: lung ultrasound-implemented differential diagnosis of acute respiratory distress in African children*, which extends the research on the application of LUS to all patients with acute respiratory distress, with the aim of improving differential diagnosis and initial patient management (iTPA).

IV. Top publications in 2021

1. An open dataset of *Plasmodium falciparum* genome variation in 7,000 worldwide samples. MalariaGen, Ahouidi A, Ali M, Almagro-Garcia J, Amambua-Ngwa A, Amaratunga C ... Wendler J, White NJ, Wright I, Yavo W, Ye H. *Wellcome Open Res.* 2021;6:42. PMID: 33824913; PMCID: 8008441.
2. Genetic surveillance in the Greater Mekong subregion and South Asia to support malaria control and elimination. Jacob CG, Thuy-Nhien N, Mayxay M, Maude RJ, Quang HH ... Rockett K, Day NP, Dondorp AM, Kwiatkowski DP, Miotto O. *Elife.* 2021;10. PMID: 34372970; PMCID: 8354633.
3. Pharmacokinetic study of rectal artesunate in children with severe malaria in Africa. Fanello C, Høglund RM, Lee SJ, Kayembe D, Ndjowo P ... Woodrow C, Gomes M, Day NP, White NJ, Onyamboko MA. *Antimicrob Agents Chemother.* 2021;65(4). PMID: 33526485; PMCID: 8097454.
4. The cardiovascular effects of amodiaquine and structurally related antimalarials: An individual patient data meta-analysis. Chan XHS, Haeusler IL, Win YN, Pike J, Hanboonkunupakarn B ... Onyamboko MA, Siqueira AM, Ashley EA, Taylor WR, White NJ. *PLoS Med.* 2021;18(9):e1003766. PMID: 34492005; PMCID: 8454971.

V. Capacity building achievements

Throughout 2021, meetings and training activities continued to be 'virtual', as were visits to initiate and monitor studies. Better availability of internet service and greater familiarity with the tools improved the efficiency of virtual work and its integration with clinical and laboratory activities. MORU's Clinical Trial Support Group (CTSG) was instrumental in enabling the team to manage



KIMORU Clinical Director Dr Marie Onyaboko Akatshi. © MORU 2022. Photographer: Caterina Fanello.

multiple studies while maintaining excellent quality of results, and to implement, for the first time, local data entry (using REDCap®). The KIMORU team's research is closely integrated with the research of MORU Bangkok and SMRU, in particular research by the Malaria & Critical Illness Department directed by A. Dondorp, and benefits from the continuous support of many MORU colleagues and logistics staff. We thank in particular: S.J. Lee for the continuous statistical support and advice on all KIMORU projects; O. Miotto for the support in setting-up the molecular surveillance, G. Bancone for the laboratory support on neonatal jaundice, F. Nosten, N. Waithira, V. Chamsukhee, P. Yuentrakul, M. Dondorp, B. Mutinda and K. Srinamon for supporting us through the many steps of research.

VI. Future vision

Our mission remains to support our partner institution in conducting research to improve maternal, new-born and child health in general, and the fight against malaria. In the short term, we will consolidate the research activities launched in 2020-21 and strengthen the team's capacity to manage several studies simultaneously. In the medium and long term, research will be developed around two primary areas: malaria, and women's health and gender equity. These two areas align with the UN Sustainable Development Goals (SDGs) 3 and 5, and their development builds on and continues the work done by the team in the previous years.

Malaria: Clinical trials will increasingly focus on paediatric patients with severe malaria, aiming first to improve diagnosis, treatment, and care in a low-resource setting, and secondly to investigate its pathophysiological mechanisms in more detail, particularly regarding severe anaemia. The molecular surveillance system for antimalarial drug resistance will be extended to other sentinel sites. The data will inform us of the presence and spread of mutations associated to resistance and support evidence-based malaria control policies. Preliminary results show 15-20% malaria prevalence in asymptomatic pregnant women, regardless of their adherence to preventive treatment; molecular analyses will help to better understand the problem and evaluate different options for malaria prevention in pregnancy. Molecular surveillance can also be used for other important objectives, such as monitoring the spread of deletions in *P. falciparum* HRP2/3 genes that affect the efficiency of rapid diagnostic tests.

Women's health & gender equity: Women are disproportionately affected by malaria. Surveillance of the effectiveness of therapies for malaria prevention and treatment in pregnancy allows for the development of better and more tailored therapies for women, thus contributing significantly to gender equity. The antenatal care service-based surveillance system we are developing provides an opportunity to integrate malaria data with other data and indicators on women's health, for which little information is available, especially in rural areas and marginalised communities. Disparity in the availability of gender and sex sensitive data exists in all countries, regardless of income level but occurs more systematically in low-resource settings. However, these data are essential to generate evidence that can adequately inform health policies. Our project lays the foundation for building a data platform that can be used to address other critical health issues with the aim of improving women's health in Africa.

Annex A

MORU Tropical Health Network Staff

Senior Management

Nick White – SE Asia Chairman

Nick Day – MORU Director

Arjen Dondorp – Deputy Director

David Burton – Chief Operating Officer

MORU Bangkok-based Departments

Operations and Administration

David Burton – Chief Operating Officer

Annerberg, Anna	Quality Assurance Consultant	Mac Hale, Eoin	Compliance & QA Manager
Apiwatudomkhun, Paweena	Accounting Manager, Reporting & AR	Netikul, Nantamon	Training & Development Manager
Ariyalikit, Buaboun	Travel Administrator & Executive Assistant	Nopparatbanpot, Natthitha	Maid
Banyatsil, Dumrong	HR & Administrative Assistant	Pongsaswat, Kanchana	HR & Administration Manager
Bleho, John	Consultant, Media & Communications	Pornthong, Montha	Janitor
Chanhom, Pinyada	Senior Accountant	Powtong, Pawinee	PA & Executive Assistant
Chomthoranin, Natchaleo	Senior HR Officer	Proctor, Gaye	Training Consultant
Chuaynoo, Sasitorn	Chief Financial Officer	Ruangchai, Kittinan	Senior Purchasing & Logistics Officer
Chumintrajug, Supaporn	Purchasing & Logistics Officer	Saowara, Noppamard	Post-award Grant Officer
Chumpanee, Thunwa	Purchasing & Logistics Assistant	Sherwood, Dean	Head of IT
Dachkun, Kridsana	Senior Accountant	Sithaveravuth, Ekguy	Purchasing & Logistics Officer
Day, Nick	MORU Director	Sriwattana, Nantawat	IT Service Desk
Deddoung, Manusanun	Quality Assurance Officer	Sukhapiwat, Pornjarus	Purchasing & Logistics Manager
Gandy, David	Grants & Contracts Manager	Tangtrakul, Patchareeya	Accounting Supervisor
Hannay, Patrick	DeTACT Grant Manager	Thaipichit, Prachanihathai	Post-award Grant Officer
Harkness, Gary	Operations Officer	Thajaeng, Aemmarin	QA Administrator
Intanil, Pattira	Senior Quality Assurance Officer	Thumjoho, Manop	Messenger & Admin Assistant
Jenkosol, Intira	Pre-award Grant Officer	Tutsanawiwat, Chutporn	IT Technical Support
Jones, Leigh	Regional Academic Training Leader (for OUCRU and MORU)	Voratartrakul, Anan	Post-award Team Leader
Kaewkong, Winai	Senior Purchasing & Logistics Officer	Wichaya, Thunyachart	Grants Assistant
Kochayutkul, Darun	Accountant	Wongkaewchua, Ketchaya	Accounts Reporting Officer
		Wongsaming, Jeerawan	Senior Accountant
		Wright, Parina	Accounting Manager – Operating & AP

Malaria & Critical Illness

Arjen Dondorp – Head of Department

Amaratunga, Chanaki	DeTACT Coordinator	Chiewpoo, Pornpawee	Lab Technician
Awab, Ghulam Rahim	Consultant	Chotivanich, Kesinee	Head of Malaria Laboratory
Beane, Abigail	Coordinator Crit Care Asia	Dhorda, Mehul	DeTACT Coordinator
Callery, James	Postdoc Researcher	Disratthakit, Areeya	Scientific Coordinator GMS, GenRe-Mekong
Charunwatthana, Prakaykaew	Research Physician	Duangta, Chorphaka	Lab Technician

Duanguppama, Jureeporn	Lab Coordinator	Piaraksa, Nattaporn	Research Assistant/Coordinator
Faiz, Abul	Consultant	Pisani, Luigi	Clinical Researcher
Haniffa, Rashan	Coordinator Crit Care Asia	Piteekan, Tianrat	Research Scientist
Inglis, Rebecca	Clinical Researcher	Plewes, Katherine	Consultant
Imwong, Mallika	Head of Molecular Malaria Laboratory	Promda, Nutthawoot	Scientific Coordinator
Jiramonai, Luksika	Lab Technician	Promsongsil, Amornrat	Lab Technician
Kaewwiset, Nattinan	Research Assistant/Coordinator	Recht, Judith	Consultant
Khanthagat, Patpannee	Lab Technician	Ruecker, Andrea	Senior Postdoc
Kouhathong, Jindarat	Research Scientist	Sa-nguan, Sirinatda	Lab Technician
Leaver, Meghan	Consultant	Sangsri, Raweewan	Senior Research Scientist
Madmanee, Wanasanan	Quality Manager	Schultz, Marcus	Consultant
Masingboon, Pannapat	Executive Administrator	Srilawong, Apinya	Lab Technician
Miotto, Olivo	Senior Informatics Fellow, Head Genetic Surveillance Group	Supapoat, Thanyaporn	Research Assistant/Coordinator
Moonesinghe, Ramani	Consultant	Suwannasin, Kanokon	Lab Manager
Nuntharattanapong, Niyada	Lab Technician	Taylor, Bob	Senior Clinical Research Fellow
Pagornrat, Watcharee	Technical Supervisor	Thongmee, Narisa	GMS Coordinator, GenRe-Mekong Team
Pattanarudee, Chaiyaporn	Research Assistant/Coordinator	Tripura, Rupam	Clinical Researcher
Pell, Christopher	Consultant	Tuntipaiboonana, Runch	Molecular Analyst
Peto, Tom	Postdoc Researcher	von Seidlein, Lorenz	Senior Researcher
		Wasakul, Varanya	Research Scientist
		Wongchai, Yannawan	Lab Technician
		Yipsirimetee, Achaporn	Lab Technician

Microbiology

Direk Limmathurotsakul – Head of Department

Abdad, Yazid	Diagnostic Development Lab Manager	Faosap, Areeya	Lab Technician
Amornchai, Premjit	BSL Lab Manager	Giengkam, Suparat	Research Scientist
Angchagun, Kesorn	Research Nurse	Hantrakun, Viriya	Research Scientist
Areerob, Jeeranan	Consultant, DTRA Project	Huangsuranun, Witchayoot	Lab Technician
Ariyaprasert, Pitchayanant	Research Nurse	Hughes, Tom,	Consultant, DTRA/FAO Project
Batty, Elizabeth	Senior Bioinformatician	Jaiyen, Yanin	Postdoc Scientist
Blacksell, Stuart	Senior Researcher/Head of Safety/Biorisk & Zoonosis group leader	Jones, Leigh	Post graduate Student and Training consultant
Boonklang, Phumrapee	Research Assistant	Kaewwiset, Ploypatcha	CCRU
Boonyakanjanapon, Pawadee	Postgraduate Student Assistant	Khamjaroen, Supanee	Project Admin./PA
Chaichana, Panjaporn	Postdoc Immunologist	Kamolsiripichaiporn, Somjai	Consultant, DTRA Project
Chantratita, Narisara	Senior Scientist	Kanthawang, Nipaphan	CCRU
Cheewapreecha, Claire	Bioinformatician	Khatta, Nongyao	Lab Technician, CCRU
Chierakul, Wirongrong	Senior Physician	Klaytong, Preeyach	Research Assistant
Chomkatekaew, Chalita	Lab Technician	Kong, Lida	Consultant, DTRA Project
Chuenklin, Suthida	PhD Student	Kullapanich, Chitrasak	Postdoc Researcher
Dhawan, Sandhya	Research Assistant	Kusumoto, Marina	Intern, DTRA Project
Dokket, Yaowaret	Lab Technician	Langlah, Sayan	Lab Technician
Dolecek, Christiane	Senior Researcher	Lee, Mei-Ho	Consultant, DTRA/FAO Project
Dunachie, Susanna	Senior Researcher	Lim, Cherry	PhD Research Scientist
		Maharach, Chonlada	Research Nurse

Malasit, Mayura	Research Nurse	Setaphan, Sornsuda	Research Assistant
Maroongruang, Peerapol	Safety Administrator	Siengsanant-Lamont, Jarunee	Consultant
Matsumoto, Nina	PhD Student	Sonthayanon, Piengchan	Senior Scientist
Morrissy, Chris	Consultant, DTRA/FAO Project	Suntornsut, Pornpan	Research Nurse
Oyuchua, Malinee	Pathogen Database Coordinator	Suwannapruk, Jintana	Administrator
Pakdee-asa, Parporn	Rickettsia TRN Manager	Tanunchai, Phattaranit	Lab Technician
Pakdeerat, Sukritpong	Research Assistant	Tanganuchitcharnchai, Ampai	Serology Lab Manager
Perrone, Carlo	Head, Chiangrai Clinical Research Unit	Tasak, Nidanuch	Research Nurse, CCRU
Phuangsoombat, Papachaya	Research Nurse	Thaipadungpanit, Janjira	Head of Molecular Microbiology
Prapharsavat, Ravikanya	Social Scientist	Thaiprakhong, Areerat	Lab Technician
Rangsiwutisak, Chalida	Junior Programmer	Thongyen, Mintra	Lab Technician
Rienpradub, Panuvit	Lab Technician	Traichokgul, Thitiya	Lab Technician
Rongkard, Patpong	DPhil Student	Wangrangsimakul, Tri	DPhil Student
Ruanchaiman, Soiratchaneekorn	Safety Manager	Watanachaiprasert, Praweennuch	Research Nurse
Rungrojn, Artharee	Lab Technician	Wheatley, Mark	FMD RRL project manager
Salje, Jeanne	Senior Researcher	Wongsantichon, Jantana	Cell Biology Lab Manager
Sanyakamdhorn, Sriwana	Sr Project Administrator	Wongsuvan, Gumphol	Lab Manager of Ubon Ratchathani Unit
Saraswati, Kartika	DPhil Student, Rickettsiosis	Wongwattanasatean, Rampaipan	Research Nurse
Selleck, Paul	Consultant, DTRA/FAO Project	Wuthiekanun, Vanaporn	Senior Scientist

Epidemiology

Richard Maude – Head of Department

Asad, Afrida	Consultant GIS Specialist, GroupMappers (Bangladesh)	Kagoro, Frank	Research Physician and PhD Student (South Africa)
Barzilay, Alan	Intern (Brazil)	Khonputsas, Panarasri	Epidemiologist and Project Coordinator (Thailand)
Boonyakanjanapon, Pawadee	Postgraduate Assistant (Thailand)	Khuenpetch, Worarat	Administrator (Thailand)
Buntau, Thoek	Field Supervisor (Cambodia)*	Ko Ko, July	Data Manager and Project Coordinator (Myanmar)
Chanchawalit, Phanthakorn	Intern (Thailand)	Kyaw, Shwe Sin	Economic Modeller (Myanmar)
Ean, Mom	Public Engagement Officer (Cambodia)*	Liverani, Marco	Consultant Stakeholder Analyst (Thailand)
Ebener, Steeve	Consultant GIS Specialist (Philippines)	Mahboob, Maisha	Consultant GIS Specialist, GroupMappers (Bangladesh)
Chhunly, Sok	Field Supervisor (Cambodia)*	Malaphone, Vilayvone	ENDGAME Project Coordinator (Lao PDR)
Heng, Chhoeun	Trial Coordinator (Cambodia)*	Maneenet, Supitsara	Research Assistant (Thailand)
Hossain, Ismail	MD Consultant GIS Specialist, GroupMappers (Bangladesh)	Maude, Rapeephan	Consultant Research Physician (Thailand)
Hughes, Thomas	PhD Student (Malaysia)	Mukem, Suwanna	Project Coordinator (Thailand)
Inthasone, Soulixay	GHFD Database Update Technician (Lao PDR)	Narith, Teav	Field Supervisor (Cambodia)*
Jafari, Yalda	DPhil Student (Canada)	Ngor, Pengby	Project Coordinator and PhD Student (Cambodia)
Jongdeepaisal, Monnaphat	Social Scientist and DPhil Student (Thailand)	Nguyen, Ngoc Loan	GHFD Database Update Technician (Viet Nam)
Karim, Mohammad Jahiril	Research Physician and PhD Student (Bangladesh)	Nguyen, Thi Hue	RAI3E Social Scientist/ Epidemiologist (Viet Nam)

Opu, Nurullah	Consultant GIS Specialist, GroupMappers (Bangladesh)	Sila, Sheethal	Consultant Modeller (South Africa)
Orng, Long Heng	Social Scientist/Epidemiologist (Cambodia)	Sinha, Ipsita	Research Physician and DPhil Student (UK)
Pantanilla, Izay	Consultant GIS Specialist (Philippines)	Sinitkul, Ratchaneewan	Research Physician and DPhil Student (Thailand)
Pell, Christopher	Consultant Senior Social Scientist (The Netherlands)	Sirimatayanant, Massaya	Project Coordinator-APMEN (Thailand)
Pheakra, Thak	Laboratory Staff (Cambodia)*	Sokha, Meas	Epidemiologist (Cambodia)*
Phalivong, Sonexay	GenReMekong Project Coordinator (Lao PDR)**	Sror, Ek	Field supervisor (Cambodia)*
Prasert, Orathai	Research Assistant (Thailand)	Tam, Greta	PhD Student (Hong Kong)
Pongsoipietch, Kulchada	Spatial Data Engineer (Thailand)	Thongngern, Thianchai	Intern (Thailand)
Rae, Jade	PhD Student (Thailand)	Uddin, Didar	Research Assistant (Bangladesh)
Rahman, Obaidur	Consultant GIS Specialist, GroupMappers (Bangladesh)	Vattanak, Hem	Field Supervisor (Cambodia)*
Rotejanaprasert, Chawarat	Lecturer in Biostatistics (Thailand)	Vibol, Pann	Field Supervisor (Cambodia)*
Sary, Roeun	Field Supervisor (Cambodia)*	Wang, Qian	DPhil Student
Savoeun, Uch	Laboratory Staff (Cambodia)*	Xayvhang, Saiamphone	Project Coordinator (Lao PDR)**
		Zaman, Sazid Ibna	GIS Specialist and Data Manager (Bangladesh)
		Zaw, Wynn	GIS Specialist and Data Manager (Myanmar)

* RAI2E field team line managed by Malaria and ICU Department

** GenReMekong project staff line managed by LOMWRU

Clinical Pharmacology

Joel Tarning – Head of Department

Adehin, Ayorinde	Scientist	Masik, Manlika	Lab Technician
Assmus, Frauke	Senior Scientist	Mishra, Suchittra	Lab Technician
Blessborn, Daniel	Senior Scientist	Niamyim, Phettree	Lab Analyst
Chairat, Kalayanee	Consultant	Plitphonganphim, Supada	Scientist
Chanprasert, Chanchira	Lab Analyst	Puttaraksa, Kanoktip	Scientist
Chotsiri, Palang	Senior Scientist	Ruangsilaprasert, Sasithorn	Department Administrator & PA
Cruz, Cintia	PhD Student	Rungreuang, Suparb	Lab Assistant
Ekapirat, Nattwut	PhD student	Sriburin, Benjamas	Lab Technician
Hanpithakphong, Warunee	Senior Scientist	Theeraphongsakul, Chanjira	Purchasing & Logistics Officer
Hoglund, Richard	Head of Pharmacometrics	Wattanakul, Thanaporn	Scientist
Jiracheep, Nicharee	PhD Student	Wong, Phornpimon Tiphara	Senior Scientist
Kaewkhao, Natpapat	Senior Scientist	Yodsawat, Prasert	Consultant
Koesukwiwat, Urairat	Laboratory Manager		
Kullasakboonsri, Rattawan	Lab Technician		

Bioethics & Engagement

Phaik Yeong Cheah – Head of Department

Asarath, Supa-At	Research and Engagement Assistant, Bangkok	Greer, Rachel	PhD Student
Boonthaworn, Kanpong	Science Communication Officer	Kajeewiwa, Ladda	Head of Public Engagement, SMRU
Chansovannara, Soputhy	Public Engagement Officer, COMRU	Kanthawang, Nipaphan	Research Nurse and Masters Student, CCRU
Chanviriyavuth, Rita	Personal Assistant & Departmental Administrator, Bangkok	Khirikoekong, Napat	Social Science Researcher, SMRU

Kulpijit, Natinee	Senior PR & Communications Manager, Bangkok	Poomchaichote, Tassawan	Project Manager
Mom, Ean	Head of Public Engagement, Siem Pang	Praphasaval, Ravikanya	Social Scientist (seconded from Microbiology)
Naemiratch, Bhensri	Researcher	Ruangkajorn, Supanat	Participant Liaison Officer
Osterrieder, Anne	Public Engagement Coordinator	Schneiders, Mira	Post-doc Researcher
Perrone, Carlo	PhD Student (CCRU/Microbiology)	Thongdee, Primprapaporn	Public Engagement Coordinator, SMRU
Pol, Sreymom	Public Engagement Officer, COMRU	Tindana, Paulina	Researcher (0.5 FTE)
		Waithira, Naomi	DPhil Student

Mathematical and Economic Modelling (MAEMOD)

Wirichada Pan-ngum – Head of Department

Aguas, Ricardo	University Research Lecturer, Head of AToME	Lohavittayavikant, Salisa	Project IT Coordinator
Ardestani, Babak	Postdoc Researcher	Lubell, Yoel	Head of EIRG
Bharath, Anouska	Postdoc Researcher	Mo, Yin	DPhil Student
Bodhidatta, Ladaporn	Project Coordinator	Ngor, Pengby	PhD Student
Bonvoisin, Toby	DPhil Student	Oonsivilai, Mathupanee	Research Assistant, DPhil student
Chandna, Arjun	Project Coordinator, DPhil student	Pritchard, Mark	DPhil Student
Chaucharoen, Pavadee	PhD Student	Roberts, Tamalee	Postdoc Researcher
Chew, Chris (Rusheng)	Clinical Researcher, DPhil Student	Sarajan, Myka Harun	MSc Student
Cooper, Ben	MRC Senior Research Fellow, Head of DRIaDD	Saralamba, Sompob	Senior Computational Data Scientist
Ekkapongpisit, Maneerat	Translational Partnership Manager	Silal, Sheetal	Research Fellow
Ganjina, Grid	Project Manager	Swe, Myo Maung Maung	DPhil Student
Gao, Bo	Research Fellow	Thichimpa, Weerakorn	PhD Student
Greer, Rachel	Clinical Trial Coordinator, DPhil Student	Thongkuna, Sureeporn	Project Administrator
Hewson, Patrick	Senior Project Coordinator	Thongpiam, Watcharintorn	Project Management
Htun, Nan Shwe Nwe	Postdoc Researcher	Tun, Sai Thein Than	DPhil Student
Lim, Cherry	Senior Scientist	Vithayaveroj, Mingkhwan	Health Economist (Consultant)
Liverani, Marco	Senior Research Fellow	Wichaita, Tanaphum	Research Software Engineer

Clinical Therapeutics Unit (CTU)

Nick White, Sasithon Pukrittayakamee – Co-Heads of Department

Aurboonkasem, Somrutai	Research Nurse	Poonsawat, Pawinee	Research Nurse
Boyd, Simon	Clinical Researcher	Pooworavan, Kittiyod	Research Physician
Cruz, Cintia	Research Physician	Pukrittayakamee, Sasithon	Honorary Consultant
Hanboonkunupakarn, Borimas	Research Physician	Saohinkong, Wasana	Research Nurse
Jittmala, Podjane	Research Physician	Schilling, William	Research Physician, DPhil
Kaendiao, Thoopmanee	Research Associate	Supapoot, Thanyaporn	CTU Admin
Leungsinsiri, Pawanrat	Research Nurse	Taylor, Bob	Senior Researcher
Pollington, Tim	Mathematician	Watson, James	Postdoc Researcher

Clinical Trials Support Group (CTSG)

Tanya Cope – Head of Department

Amorntananun, Amornsak	Programmer	Mutinda, Brian	Senior Data Manager
Anunsittichai, Orawan	Clinical Trials Assistant	Ngernseng, Thatsanun	Senior Data Manager
Chaikul, Kulthida	Clinical Data Manager	Panapipat, Salwaluk	Program Manager
Chaiwang, Saiy	Clinical Trials Assistant	Peerawaranun, Pimnara	Statistician
Chamsukhee, Vanapol	Clinical Data Manager	Pongsuwan, Pongphaya	Program Manager
Chanchaivorawith, Salintip	Clinical Trials Assistant	Ponsap, Pimsiri	Senior Data Manager
Chotwatthanawathit, Paphapisa	Clinical Data Manager	Poonchai, Akanittha	Clinical Trials Assistant
Jansuaidee, Wanida	Clinical Data Assistant	Ridjaibun, Montri	CT Database/Software Architect Manager
Jeeyapant, Atthanee	Senior Data Manager	Schilstra, Marja	Clinical Data Manager
Kiatkungwanglai, Panor	Clinical Data Assistant	Tanglakmankhong, Nuttakan	Clinical Trials Assistant
Khamboocha, Rungnapa	Clinical Research Associate	Taya, Chiraporn	Statistician
Koomklang, Pantira	Clinical Data Assistant	Theankham, Kittichai	Clinical Trials Administrative Coordinator/Associate Safety Officer
Kruabkontho, Varaporn	Regulatory Affairs Specialist	Tubprasert, Jaruwat	Program Manager
Lee, Sue	Statistician	Waithira, Naomi	Head of Data Management
Mengged, Chonticha	Clinical Data Assistant	Wannapinij, Prapass	Senior Programmer
Mukaka, Mavuto	Head of Statistics	Yuentrakul, Prayoon	Program Manager

Infectious Diseases Data Observatory (IDDO) /

World-Wide Antimalarial Drug Resistance Network (WWARN)

Mehul Dhorda – Group Leader

Assawariyathipat, Thanawat	Senior Lab Technician	Rungrueang, Kittiphon	Lab Assistant
Aud-Ai, Nakarin	SMC Lab Technician	Srinamon, Ketsanee	Clinical Trials Technologist
Chaijun, Praphai	EQA Technologist	Suesatluesakun, Panuphong	Lab Data Entry
Champhai, Thanaporn	Admin Assistant	Vongprommek, Ranitha	SML & EQA Coordinator
Khomvarn, Teeradet	Molecular Biology Technician	Wattanasumpunno, Kwanruthai	Lab Administrator
Promnarate, Cholrawee	Lab Manager		

MORU Units

Shoklo Malaria Research Unit (SMRU)

François Nosten – Unit Director

Aae Aae Bu (Naw Eh Eh Pi)	Sonographer	Aryalamloed, Surang	Lab Assistant
Ar Sar	Data/Supply Coordinator	Aung Zaw Htun	Cleaner
Aranyakanon, Kodchakorn	Senior Lab Technician	Aung, Htet Ko Ko	Physician
Archasuksan, Laypaw	Lab In Charge	Aung Pyae Phyo	Physician
		Aye	Driver
		Bancone, Germana	Haematology Research Scientist

Bellar	Store keeper	Htar Tin	Midwife Junior	Lay Plar Soe	Lab Technician	Naw Aye Chit	Midwife Assistant
Bierhoff, Marieke	Research Clinician	Htay Paw	Nurse	Lay Wah Htoo	Health Worker	Naw Chit Mat	Midwife Assistant
Boonrueng, Unchuleeporn	Junior IT Helpdesk	Htee Hser Moo	Health Worker	Lerdwiriyparp, RehWah	Lab In Charge	Naw Dah	Nurse
Boonyatim, Rawin	Lab Stock & Inventory	Htee K Paung	IEC and Media Officer	Lin Mg Mg	Medic	Naw Dah	Nurse
Brummaier, Tobias	Research Clinician	Htile	Medic	Lwe Gay	Security Guard	Naw Dah Ler	Nurse
Bway Paw	Health Worker	Htun, Win Pa Pa	Program Technician Coordinator	Lwin, Khin Maung	Physician	Naw Dar Dar Poe	Midwife Junior
Carrara, Verena	Research Clinician	Htut, Saw Soe Win	Physician	Ma Hla Yee	Cleaner	Naw December Win	Nurse
Cecilia	Nurse	Inta, Aritsara	Lab Technician	Malla, Suwan	Driver	Naw Decer Paw	CE Facilitator
Chaumeau, Victor	Entomology Research Scientist	Islamp	Health Worker	Manabakban, Phawichor	HR Officer	Naw Due	Cleaner
Chirakiratinant, Miasa	Data Entry	Janurian, Naw	Physician	Mangkhongcharoen, Wannusorn	Sonographer	Naw Eh Moo Paw	Referral staff
Christena	Medic	Jaruwan	Lab Assistant	Manmongkoldej, Wararat	Finance Manager	Naw Eh Paw	Health Worker
Chu, Cindy	Clinical Researcher	Jasper	M & E Assistant	Mansomsakunchai, Manlika	Data Entry	Naw Eh Tha Blay	Nurse
Chumphu, Chiam	Driver	Jhon Aung Paing	Cleaner	Mar Htoo Yar Phan	Medic	Naw Eh Wah Soe	Midwife Assistant
Dahlia Khet	Counsellor in charge	Johnson, Saw	TB Project Director Assistant	Maung, Banyar Maung	Physician	Naw Elvina	Midwife Junior
Dam Rong	Logistician	K Por Thaw	TB Administrator Assistant	McGready, Rose	Professor of Tropical Maternal and Child Health / SMRU Deputy Director	Naw Gay Wah	Midwife Assistant
Darakamon, Muechae	Baby Test Site Supervisor	Ka Mwee Paw	Midwife Junior	Mee Mee	Midwife Junior	Naw Gloria	Lab Assistant
Daungdusadee, Moree	Lab Technician	Kaewkanya, Chalita	Lab Technician	Mg Bo Zin Yee Htun	Health Worker	Naw Hay Blute Paw	Counsellor
Day Lay	CE Facilitator	Kaewphanderm, Napaporn	Lab Technician	MgHni	Lab Technician	Naw Heh Klay	Cleaner
Dee Mu Htoo	Midwife Junior	Kajeechiwa, Ladda	CE Officer/PE Department Head	Mi Than	Nurse	Naw Hsa Tha Bwae Wah	Medic
Deena	Site Administrative Assistant	Kanchai	Medic	Min, Aung Myat	Physician	Naw Hsar Eh	Midwife Senior
E Molei	Administrative Officer	Kasettrakan, Rakduang	Referral staff	Min, Thaw Htwe	Physician	Naw Hser Eh Moo	Cleaner
Eh Heet	Midwife Senior	Kaweepornprai, Surat	Transportation In charge	Misa, Prapatsorn	CE Trainer & Supervisor	Naw Hser Nay Wah	CE Facilitator
Eh Hser Nay	Counsellor	Kay Cha	Health Worker	Monasikankird, Pattipat	Logistic Manager	Naw Htoo Gay	Sonographer
Eh Moo	Nurse	Keerecharoen, Daydaypo	Medic	Moo Kho Paw .S	Monitor	Naw K' Mwee Hser	CE Facilitator
Eh Mwee Paw	Midwife Junior	Keereevijit, Arunrot	Data Manager Assistant	Moo Paw Hei	TB Administrator Assistant	Naw Khee	Midwife Senior
Eh Say	Midwife Senior	Kengpasankoon, Yokor	Referral staff	Mu Dah	Nurse	Naw Khu	Cleaner
Ei Ei Thein	Midwife Assistant	Kertweeradet, Khanuengnit	Lab Technician	Mu Dah Thu	Midwife Senior	Naw K'paw Nay Mu Lah	Nurse
Esther	Survey Assistant	Khaung Klain	CE Facilitator	Mu Htunt Awar	Midwife Senior	Naw Lae Lai	Nurse
Gay Nay Htoo	Lab Assistant	Khin Hnin Htwe	Nurse	Mu Kaw Sher	Counsellor	Naw Laura Paw	Sonographer
Gilder, Mary	Clinical Researcher	Khin Mai Tin	Midwife Junior	Myint Hkin	Midwife Junior	Naw Len Da	Midwife Junior
Gornsawun, Gornpan	Senior Lab Technician	Khin Zar Moe	Midwife Junior	Myint Hlaing	Lab Assistant	Naw Ler Bwe Paw	Nurse (Pharmacy)
Hae Moo	Lab Technician	Kiestra, Douwe	IT specialist	Myint Zaw Oo	Nurse	Naw May Thwe Win	Nurse
Haohankhunnatham, Warat	Lab Technician	Kittima Mingpraiwet	Nurse	Myo Chit Min	Mapping Assistant	Naw Moo Tha	Lab Assistant
Hashmi, Ahmar Hussain	Researcher	Klay Htoo	Medic	Myo Naing Htun	Nurse	Naw Mu Dah	Midwife Assistant
Hataipongphen, Supasak	Logistic Assistant	Kle Ba Wah	Nurse	Naing, Naw May Phoo	Physician	Naw Mu Lar	Health Worker
Hillda	Medic	Kler Paw	Cleaner	Nan Aye Thin Zar Chit	Midwife Junior	Naw Mu Lwe Tha Dah	CE Facilitator
Hinfontong, Phattaraporn	Lab Technician	Kobphun, Pachinee	Lab Technician	Nan Khin San Myint	Medic	Naw Mu Puang Su	Lab Assistant
Hiranloetthanyakit, Woranit	Site Administrator	Kulabkeeree, Thithiworada	Lab Assistant	Nan Lin Lin Kyi	Counsellor	Naw Mu S'nay	Nurse
Hiranyakul, Sombat	Driver	Kyaw Sa Bo	Medic	Nan Ma Na San	Midwife Junior	Naw Mu Thu	Cook
Hirunyig, Saranya	Lab Technician	Kyaw Yeah	Health Worker	Nan Tin Moe Moe Thet	Midwife Assistant	Naw Mu Wah	Medic
Hser Gay Paw	Nurse	Kyi Thu Lwin	Supply chain Management Assistant	Nan Yin Yin Mya	Midwife Senior	Naw Mya Thinzar Tun	Counsellor
Hser Khu Moo	Midwife Assistant	Kyin	Logistician	Nan Yin Yin Thein	Medic	Naw P Lan Cho	Health Worker
Hser Moo	Nurse	laoongmak khachiphai, Dilaua	Lab Technician	Nant Htaesar	Nurse	Naw Paw Eh Shee	Sonographer
Hser Nay Htoo	Nurse	Lay Lay Wa	Midwife Junior	Natenirundon, Phaitoon	Senior Assistant to Grant Officer	Naw Paw Gay	Health Worker
Hser Nay Moo	Medic					Naw Paw Kmoo Eh	CE Facilitator
						Naw Paw Ler Lah	Baby tester
						Naw Paw Paw	Nurse
						Naw Paw Ray	Cleaner
						Naw Paw Wah Wah	Midwife Junior

Naw Pay	Nurse	Paw May Wah	Midwife Assistant	Saw Aung Hein	Health Worker	Saw Tin Aung	Nurse
Naw Peh Poe	Nurse	Paw Mu	Nurse	Saw Aung Htet Oo	Medic	Saw Tin Win Hlaing	Health Worker
Naw Phyu Phyu Htway	Health Worker	Paw Tha Wah	Clinical In charge	Saw Aung Htwe	Medic	Saw Wah Wah Poe	CE Facilitator
Naw Pic	Midwife Junior	Paw Yeh	Health Worker	Saw Ba Tin	Health Worker	Saw Way K' Paw	Data Entry
Naw Poe Dah	Nurse	Phakdikhunnatham, Nattaporn	Admin Assistant	Saw Be Nu	Medic	Saw Wie	Nurse
Naw Pway Nay Moo	Midwife Assistant	Phanaphadungtham, Monthicha	Lab Technician	Saw Cha Chi Lay	Nurse (Pharmacist)	Saw Win Htoo	Nurse
Naw Roh Paw	Cook	Phattharakokoedbun, Pase	Lab Technician	Saw Day	Nurse	Saw Win Tun	Program Manager
Naw San San Nwe	Counsellor	Phattharakokoedbun, Muenue	Lab Technician	Saw Dee Htoo	CE Facilitator	Saw Zaw Oo	Counsellor
Naw Say Htoo Paw	Midwife Assistant	Phaw Khu Moo	Lab Assistant	Saw Dellewe Htoo K'Nyaw	CE Facilitator	Sawasdichai, Sunisa	Entomologist
Naw Say Ler Wah	Midwife Junior	Phichitbanphod, Naree	HR Manager	Saw Di Noh	Security Guard	Say Lar Heh	Cleaner
Naw Say Say	Counsellor	Phichitphadungtham, Yuwapha	Counsellor	Saw Eh Gay Htoo	Health Worker	Seechaikham, Suttinee	HR Manager Assistant
Naw Say Thwe Paw	CE Facilitator	Phimanphanarak, Mueporjae	MCH In charge	Saw Eh Pho	Site logistician	Sher Sher	Lab Technician
Naw Si Hsa Paw Shee	CE Facilitator	Phongchaisak, Kengthu	Driver	Saw Eh Say	Lab Technician	Siriwatwaree, Pichetchai	Driver
Naw Sunday Paw	Health Worker	Pilaseng, Kasiha	Assistant Pro. Manager	Saw Hay Blut	Survey Assistant	Sisukthippanya, Suphichai	Senior Lab Assistant
Naw Sylverine Win	Midwife Junior	Pimolsornthong, Taklay	Lab Technician	Saw Hla June	Clinic Site Logistic	Sitipong	Referral Supervisor
Naw Ta Ma Lar Paw	Sonographer	P'lae Wa	Health Worker	Saw Hser Htee Nar	Cleaner	S'Nay Heh	Cleaner
Naw Tha Dah Paw	Lab Technician	Ploypoungtip, Amorn	Accountant	Saw Htaw Ray	Security Guard	Sombatrunjaroen, Sawat	Driver
Naw Tha Mee Su	Health Worker	Poe Say	TB Program Manager	Saw Htoo	Counsellor	Somrangwatjanakul, Surapol	Data Entry
Naw Tha Moo	Sonographer	Poh Gay	Data Entry	Saw Htoo Hsir	Health Worker (Outreach)	sonklinphai, Pholoihe	Lab Technician
Naw Than Yee	Cook Assistant	Pongpanapacharoen, Siriporn	Lab Assistant	Saw Kay Lay	CE Facilitator	Soung Hay Marn	Midwife Assistant
Naw Thaw Wah Paw	Nurse	Praisangdet, Norda	Counsellor Supervisor Senior	Saw Khu Hser Wah	Counsellor	Sriripim , Kasem	Lab Technician
Naw Thi Thi Aye	Medic	Proux, Stephane	Scientist	Saw Ku Aye	Nurse	Sriwatthanawari, Janjira	Accountant
Naw Thu Lay Paw	Midwife Senior	Raksapraidee, Rattanaorn	Monitor	Saw Ku Ler Moo	Epidemiologist Assistant	Su Klein	Medic
Naw Wah Wah Say	Sonographer	Raksuansak, Suree	Laboratory Admin	Saw Kyal Zin Tun	Health Worker	Su Myat Soe	Lab Technician
Naw Wai Wai	Health Worker	Ritratana, Nitaya	Lab Assistant	Saw Kyi Lwin	Lab Technician	Sudchalawmalai, Surachard	IT Systems Administrator
Naw Yeh Htoo	Midwife Assistant	Ritwongsakul, Wannee	Administrator	Saw Lay Taw	Health Worker	Suriyakan, Sangrawee	Senior Lab Technician
Naw Yu Lee	Lab Assistant	Rosy Soe	Midwife Junior	Saw Mer Ler Say	CE Facilitator	Taw Pla Paw	Health Worker
Nay Htet Lin	Health Worker	Rungwilailaekhiri, Suthasana	Sonographer In charge	Saw Mg Lu	Health Worker	Tawantochai, Wirawatn	Lab In Charge
Netnirandon, Kittisak	Driver	Saenkasettrakon, Phata	Driver	Saw Min Maw Kun	Data Entry	Than Than Oo	Midwife Junior
Ni Ni Aung	Medic	Sakhonmalee, Muenopi	Data Entry	Saw Min Soe	Data Entry	Than Than Soe	Sonographer
Nitikorn, Casla	Store Keeper	San Kyaw Swar Htoo	Driver	Saw Moo Khee Lar	Medic	Thidasan	Medic
Niwetphongprai, Laaongsri	Nurse	San Wai	Senior Midwife Consultant	Saw Nay Blut Htoo	Health Worker	Thidazin	Nurse
Nosten, Suphak	Mediator & Communication	Sandotwanaprai, Waraporn	Data Entry	Saw Nay Linn Htun	Medic	Thipwong, Chanikan	Lab Technician
Nyein Chan Oo	Clinical In charge	Saneanurak, Laethoo	Site Administrator	Saw Ngwe Thaw Zin	Nurse	Thu Lay Paw	Medic
Nyein Nyein	Social Worker	Sanhathaikamon, Punika	Midwife Junior	Saw Pah Day	Medic	Thu Zar Ma Ma Moe Min	Lab Technician
Nyo Nyo Win	Counsellor	Santirad, Armon	Lab Assistant	Saw Paw Gay	Store Keeper Assistant	Thu, Aung Myint	Medical Trainer & Supervisor
Nyo Nyo Win	Counsellor	Sappayabanphot, Jarntrah	PE Assistant	Saw Plar Shee	Myawaddy Health Worker Referral	Thwin, May Myo	CE Trainer & Supervisor
Nyo Nyo Win	Midwife Junior	Sapysinphanaphai, Oudom	Driver	Saw Poe Kyaw See	Logistician	Trakoolcheangkaew, Muesuwa	Lab Assistant
Oakkararungrot, Yanada	Lab Technician	Satanankan, Khruyo	Logistic Assistant	Saw Sat Plow Moo	Cook	Tu Tu Lay	Nurse
Pa Oo	Security Guard			Saw Sat Thar	Janitor	Tun, Nay Win	Physician
Paksawayu, Aeloi	Clinical In charge			Saw Saw Klo	Medic	Tway Kyi	Health Worker
Pan Aye	Midwife Senior			Saw Shel Gay	Nurse	Vanasawan, Jeerawan	Purchaser
Panachuenwongsakul, Nuttapol	Data Manager			Saw Taw	Lab Technician	Wananiwej, Thada	Data Entry
Paw Eh Moo	Data Entry			Saw Taw Taw	Clinic site Security Guard		
Paw Gay	Lab Technician			Saw Tha Dah Gay	Nurse		
Paw Kaw Khu	Nurse (Outreach)			Saw Thu Kha	Site Administration		
Paw Kyar	Logistic Assistant			Saw Thu Thit	Counsellor		

Wasisakun, Prapan	Senior Lab Technician	Winyoorat, Kanjana	CE Coordinator
Watthanaworawit, Wanitda	Scientist	Wirachonphaopong, Jindaporn	Clinical Research Assistant
Wiladphaingern, Jacher	Data Manager	Wongaeka, Mueanfan	Lab Technician
Wilaisrisak, Pornpimon	Data management	Yasan, Yuttana	Lab Technician
Wimol	Nurse	Ye Htet Kaw	CE Facilitator
Win Htay	Midwife Senior	Yee, December Chit	Physician
Win Susan	Midwife Senior	Ywar Htoo Paw	Midwife Junior

Lao-Oxford-Mahosot Hospital-Wellcome Trust Research Unit (LOMWRU)

Elizabeth Ashley – Unit Director

Atsamouth, Aphaphone	Laboratory Technician	Lattana, Olay*	Head of micro lab admin/ Senior Laboratory Technician
Black, Athirat	Operations Manager		
Boudthasavong, Latsaniphone	Senior Laboratory Technician/ Deputy IDC lab manager	Luangraj, Manophab Mayxay, Mayfong	Research Physician Head of Field Research/ Deputy Dean of University of Health Sciences
Bounkhoun, Toukta	Research Physician		
Bounmanivong*	Cleaner	Nasedone, Phouvieng	Junior Research Physician - Field
Bounphinegsy, Thipsavanh	Research Physician - Field	Opphalavong, Somphone	Security Guard
Bounvilay, Laddaphone	Research Physician - Field	Panapruksachat, Siribun	Molecular Bacteriologist
Buasy*	Cleaner		
Caillet, Céline	Medicine Quality Research Group Coordinator/ Research Scientist	Panyanouvong, Phonepasith*	Senior Laboratory Technician
Chansamouth, Vilada*	Senior Research Physician/ PhD Student	Phaiphichit, Chom Phalivong, Sonexay	Research Physician - Field Project Coordinator (CMPE)
Chanthaluanglath, Valin	Nurse – Patient Follow up	Phanmany,- Khwanta	Laboratory Technician - Field
Chanthongthip, Anisone	IDC Laboratory Manager	Phianthanom, Bountherng*	Laboratory Technician
Chindavong, Touny	Data Entry Officer		
Chommanam, Danoy	Research Physician	Phimolsannousith, Vilayouth	Research Physician
Davong, Viengmon*	Deputy Head of Microbiology Laboratory / Lab Manager	Phommadichak, Vanheuang	BSL3 Laboratory Manager
Duangmala, Souksavanh	Laboratory Technician - Follow up		
Duangmala, Khuanta*	Laboratory Technician	Phommahasay, Bounkhong*	Laboratory Technician
Duangnouvong, Anousone	Research Physician	Phommason, Koukeo*	Senior Research Physician
Audrey Dubot-Pérès,	Virology Group Head	Phonemixay, Ooyanong	Laboratory Technician
Hanthongsay, Nilamith*	Specimens Storage Manager	Phouminh, Phonelavanh*	Deputy Head of Micro Lab Administration & Senior Lab Technician
Jaksuwan, Risara	Laboratory Management Advisor		
Keokhamhoung, Dala	Patient Follow Up/ Lab Technician	Padith, Kaisone	Laboratory Technician
Keomoukda, Phatsalin	Laboratory Technician-Field	Phuklia, Weerawat	Postdoctoral Scientist
Khamsy, Chanthachone	Stock Officer	Phakhounthong, Khanxayaphone	Research Physician - Field
Khounpaseuth, Khamxeng	Laboratory Technician - Field		
Kouaykesone, Phoudthasone	Data Quality Manager	Phommavanh, Xaykhamphet	Research Physician - Field
Kunlaya; Khamfong	Research Physician-Field	Phoutthavong, Soulichanya	Research Physician - Field
Kiedsathid, Padthana	Laboratory Technician	Rattanavong, Sayaphet*	Senior Research Physician
Kingkeoudom, Nar	Data Entry Officer	Roberts, Tamalee	Microbiologist and Data Manager
Kitignavong, Inthaphavan	Research Physician	Robinson, Matthew	Group Head Molecular Bacteriology & Area Safety Advisor
Lathsachak, Thongsavanh	Laboratory Technician - Field	Seevanhthong, Khambang	Research Physician - Field

Sengdatka, Davanh*	Laboratory Technician	Thongpaseuth, Souliyasack	Senior Laboratory Technician
Sengduangphachanh, Amphonesavanh*	Quality Control/ Senior Laboratory Technician	Vang, Xao*	Laboratory Technician
Seubsanith, Amphaivanh*	Laboratory Technician	Vannachone, Souphaphone	Research Physician
Sibounheuang, Bountoy*	Senior Laboratory Technician	Vidhamaly, Vayouly	Medicine Quality Group Pharmacist – Senior Research Assistant
Silichack, Lanoi*	Laboratory Technician	Vilivong, Keoudomphone	Research Physician
Simanivong, Sengkham	Purchase & Supply Administrator	Volavong, Souksakhone	Specimens Storage Assistant
Simanivong, Souksavanh	Field Administrator/Logistician - Field	Vongsouvath, Manivanh*	Director of Microbiology Laboratory / Deputy Virology Group Head
Simmalavong, Manivone*	Deputy Head of Micro Lab Administration / Laboratory Technician	Vongsouvath, Viengsavanh	Administration Assistant
Simpson, Andrew	Senior Clinical Microbiologist	Vongsouvath, Malavanh	Laboratory Technician
Sirisouk, Joy*	Senior Laboratory Technician	Xaithilath, Parnthong	Data Entry Officer
Souksavanh, Manila	Laboratory Technician	Xayaphet, Xaipasong	Research Physician, Field
Solatthanavong, Tadam	Administrative and HR officer	Xayalath, Somdy	Laboratory Technician - Field
Soulivong Ailatda	Research Physician - Field	Xongmalaythong, Khamthasone	Data Entry Officer
Souvong, Vimalay	CTSG coordinator	Xayvhanghang, Saiamphone	Project coordinator
Syhalath, Somsavanh*	Laboratory Technician	Yang, Pao	IT Helpdesk Support Manager
Symanivong, Sengmany	Finance and HR Administrator	Yiaye, Touxiong	Research Physician - Field
Thamavong, Sompong	Laboratory Technician - Field		
Thepbandith, Sompany	Finance Officer		

* Indicates Government of Lao PDR staff

Cambodia-Oxford Medical Research Unit (COMRU)

Paul Turner – Unit Director

Bran, Sambou	Research Assistant	Phann, Y Soun	Research Assistant
Chhay, Chhingsrean	Research Assistant	Pol, Sreymom	Researcher and Public Engagement Officer
Chheng, Chikhoeung	Research Assistant		
Chandna, Arjun	Clinical Researcher	Prak, Sothea	Laboratory Technician
Cheav, Voleak	Laboratory Technician	Sao, Sena	Laboratory Technician
Hopkins, Jill	ACORN Network Manager	Sar, Poda	Laboratory Technician
Kang, Roya	Office Manager	Soeng, Sona	Microbiology Team Leader
Ling, Clare	Operations Manager	Soputhy, Chansovannara	Research Assistant
Mililya, Thyl	Clinical Microbiologist	Suy, Keang	Clinical Microbiologist
Patel, Kaajal	Clinical Researcher	Tan, Pisey	Laboratory Technician
Pav, Vichet	Data Entry Assistant	Turner, Claudia	Head of Clinical Research

Myanmar-Oxford Clinical Research Unit (MOCRU)

Frank Smithuis – Unit Director

Aung, Htet Htet	Clinical Research Assistant	Swe, Myo Maung Maung	MD/Researcher Coordinator, DPhil Student
Aung, Hein	MD, Researcher, PhD Student	Tun, Saw Kan Sint	Lab Supervisor
Htike, Myo Min Min	Data Coordinator	Tun, Ni Ni	MD/Researcher, PhD Student
Janssen, Sieb	Resource Director	Tun, Nyan Lynn	MD, Researcher, DPhil Student
Kyaw, Thar Tun	Senior advisor	Wai, Hla Phyto	MD/ Project Coordinator (MSAT Study)
Maw, Lu	MD/ MSAT Study Team		
Mon, Lin Lin	Finance Officer	Zaw, Aye Sandar	MD/Researcher
Soe, Kyaw	Lab Coordinator		

Medicine Quality Research Group

Newton, Paul – Medicine Quality Research Group Head

Alonso Zabala, Guillermo	Research Assistant (part-time)	Matousek, Pavel	Honorary Visiting Research Fellow (part-time)
Bellingham, Khonsavath	Research Assistant	Rosado Olmo, Ana	Research Assistant (part-time)
Caillet, Céline	Deputy Group Head	Thi Do, Ngan	Research Assistant (part-time)
Deats, Michael	Honorary Visiting Research Fellow (part-time)	van Assche, Kerlijn	Research Assistant/ Acting Deputy Group Head
Kitignavong, Inthaphavanh	Research Assistant	Xu, Jingying	Research Assistant (part-time)

KIMORU Study Site, Kinshasa, DR Congo

Caterina Fanello, Caterina – Study Site Director

Marie Onyamboko Akatshi – Clinical Director

Badjanga Basara, Benjamin	Laboratory Technician	Maindombe Moke, Jean-Robert	Laboratory Technician
Bakomba Benie, Sarah	Junior Study Physician	Makengo Disonama, Pelagie	Ward Assistant
Bikoko Muniama, Nicholas	Ward Assistant	Manuana Tapoy, Justin	Ward Assistant
Bitumba Biakula, Prosper	Nurse	Muniaka Kusu, Odile	Deputy Head Nurse
Biyela Kembo, Elyse	Nurse	Musima Mangay, Dosithe	Laboratory Technician
Boyanga Izani, Antoinette	Nurse	Ndjowo Otokonda, Pauline	Study Physician
Fela Kuba, Crispin	Nurse	Nzambiwishi Kifakiou, Bejos	Study Physician
Fioti Mangusu, Alphon-sine	Ward Assistant	Omari Abonve, Jacqueline	Nurse
Kayembe Kalala, Daddy	Chief Study Physician	Sakina Mungengele, Marcelline	Head Nurse
Kediamosiko Lusivika, Nelly	Accountant	Simi Bongo, Georgette	Head of Laboratory
Kimonekene, Héritier	Data Entry & Technical Support		

Annex B

MORU Tropical Health Network Publications 2021

2021: 376 publications (2020: 329 publications. 2019: 293 publications.)

Scientists affiliated to the MORU Network authored and co-authored 376 publications in 2021. This compares with 329 in 2020, and 293 in 2019.

Articles e-published in 2021 but with final publication date in 2022 are excluded, and will appear in the publications list of the 2022 Annual Report. They may however appear in the 'Top 10 Publications' section in each department/unit's report.

COVID-19 publications are sorted by e-publication date (earliest first). All other publications sorted by subject then first author. All publications only appear once in the list.

1. COVID-19

Crowding has consequences: Prevention and management of COVID-19 in informal urban settlements. von Seidlein L, Alabaster G, Deen J, Knudsen J. *Build Environ.* 2021;188:107472. Epub 2020/12/01. doi: 10.1016/j.buildenv.2020.107472. PMID: 33250561; PMCID: PMC7680649.

Pragmatic recommendations for identification and triage of patients with COVID-19 disease in low- and middle-income countries. Barros LM, Pigoga JL, Chea S, Hansoti B, Hirner S, Papali A, Rudd KE, Schultz MJ, Calvillo Hynes EJ. *Am J Trop Med Hyg.* 2021;104(3_Suppl):3-11. Epub 2021/01/08. doi: 10.4269/ajtmh.20-1064. PMID: 33410394; PMCID: PMC7957239.

Recommendations for the management of COVID-19 in low- and middle-income countries. Dondorp AM, Papali AC, Schultz MJ. *Am J Trop Med Hyg.* 2021;104(3_Suppl):1-2. Epub 2021/01/08. doi: 10.4269/ajtmh.20-1597. PMID: 33410393; PMCID: PMC7957236.

Pragmatic recommendations for the management of anticoagulation and venous thrombotic disease for hospitalized patients with COVID-19 in low- and middle-income countries. Ahmed HY, Papali A, Haile T, Shrestha GS, Schultz MJ, Lundeg G, Akrami KM. *Am J Trop Med Hyg.* 2021;104(3_Suppl):99-109. Epub 2021/01/13. doi: 10.4269/ajtmh.20-1305. PMID: 33432908; PMCID: PMC7957232.

Pragmatic recommendations for the prevention and treatment of acute kidney injury in patients with COVID-19 in low- and middle-income countries. Rudd KE, Cizmeci EA, Galli GM, Lundeg G, Schultz MJ, Papali A. *Am J Trop Med Hyg.* 2021;104(3_Suppl):87-98. Epub 2021/01/13. doi: 10.4269/ajtmh.20-1242. PMID: 33432912; PMCID: PMC7957240.

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Nebulised heparin for patients on ventilation: implications for COVID-19 pneumonia. Ball L, Schultz MJ, Pelosi P. *Lancet Respir Med.* 2021;9(4):321-2. Epub 2021/01/26. doi: 10.1016/S2213-2600(20)30513-0. PMID: 33493452; PMCID: PMC7826131.

Evaluating the impact of intervention strategies on the first wave and predicting the second wave of COVID-19 in Thailand: A mathematical modeling study. Mahikul W, Chotsiri P, Ploddi K, Pan-Ngum W. *Biology (Basel)*. 2021;10(2):80. Epub 2021/01/28. doi: 10.3390/biology10020080. PMID: 33499138; PMCID: PMC7911628.

Pitfalls of exceptions for COVID-19 travel quarantine: lessons from a dignitary visit to Thailand. Mungaomklang A, Atsawawaranunt K, Kochakarn T, Batty EM, Kaewmalang P, Kongklieng A, Panwijitkul P, Joonlasak K, Kotanan N, Loesbanluechai D, Pawun V, Chantratita W, Chookajorn T. *Journal of travel medicine*. 2021;28(2):taab010. Epub 2021/01/29. doi: 10.1093/jtm/taab010. PMID: 33506268; PMCID: PMC7901055.

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Severe falciparum malaria

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Annex C

Collaborators 2021

Collaborator(s), Project(s)/Study type, Institute

MORU Bangkok-based Departments

Malaria & Critical Illness	
1. Prof Marcus Schultz, <i>ICU studies</i> , AMC, University of Amsterdam, The Netherlands	13. Dr Sanghamitra Satpathi, Studies on malaria drug resistance, Hitech Medical College and Hospital, Rourkela, India
2. Prof Constance Schultsz, <i>ICU studies</i> , AMC, University of Amsterdam, The Netherlands	14. Cambodian Malaria Control Programme (CMCP), Studies on drug resistant malaria, Phnom Penh, Cambodia
3. Prof Zbynek Bozdeck, Transcriptome Malaria, Nanyang University, Singapore	15. National Institute of Malaria Research, India, Studies on drug resistant malaria, Delhi, India
4. Prof Dominic Kwiatkowski, Artemisinin resistance, Sanger Institute, Hinxton, UK	16. Medicines for Malaria Venture (MMV), Studies on new antimalarial drugs, Geneva, Switzerland
5. Dr Jetsumon Sattabongkot Prachumsri, Transmission blocking assessment, Mahidol Vivax Research Unit, Mahidol University, Bangkok, Thailand	17. Jakob Knudsen, Improved housing to prevent malaria transmission, The Royal Danish Academy of Fine Arts Schools of Architecture, Design and Conservation, Copenhagen, Denmark
6. Peter Preiser, Transcription profile, mechanism of ATS resistance, Nanyang University, Singapore	18. Chris Pell, Social science aspects of malaria elimination, University of Amsterdam, The Netherlands
7. Prof Leanne Tilley, Tracking pathway using molecular probe, University of Melbourne, Melbourne, Australia	19. Gyan Kayastha, an internist and head of the ICU in Patan Hospital, Kathmandu, Nepal
8. Prof John Adams, ATS resistance parasites, Liver stage, University of Florida, USA	20. Jorge Salluh, critical care physician from Brazil and a co-founder of Epimed Solutions.
9. MOPH Thailand, QA/QC slide reading, TMI techniques, Ministry of Public Health (MOPH) Thailand	21. Steve Harris, senior researcher from University College London (UCL), clinician and informatics consultant with expertise in organisational and strategic health development, UK
10. Prof Ric Price, Studies on <i>P. vivax</i> , Menzies School of Health Research/University of Oxford, Australia/UK	22. Prof Kevin Baird, Vivax malaria, EOGRU, Indonesia
11. Prof Nick Anstey, Studies on <i>P. knowlesi</i> , Menzies School of Health Research, Darwin, Australia	23. Prof Kath Maitland, Severe malaria- SMART consortium, Imperial College, London, UK
12. Prof Aniruddha Ghose, Studies on severe malaria, Chittagong Medical College Hospital, Chittagong, Bangladesh	24. Prof Tom Williams, Determinants of severe malaria, Imperial College, London, UK

Microbiology

1. Prof Susan Michie, Behaviour Change Trials and Social Science studies, UCL, UK
2. Prof Simon Hay, Spatial modelling for burden of melioidosis and burden of AMR/DRI, University of Washington, USA
3. Prof Sharon Peacock, AMR/DRI and melioidosis, University of Cambridge, UK
4. Soawapak Hinjoy, Toni Whistler, Siriluck Anunnatsiri, Rasana Wongratanacheewin, Ganjana Lertmemongkolchai, Chiyada Sitthidet, Kriangsak Kasemsupat, Prapit Teparrakkul, Kittisak Thanvisej, Rungrueng Kitphati, Sapon Iamsirithaworn, Prasit Palittapongarnpim, Somsak Thamthitawat, Wipada Chaowagul, Ploenchan Chetchotisak, Surasak Wongrata- nacheewin, Thailand Melioidosis Network and Projects to make policy changes for melioidosis in Thailand, Bureau of Epidemiology, Ministry of Public Health, Thailand, CDC-TUC (Thailand Ministry of Public Health-US Centers for Disease Control and Prevention Collaboration), Khon Kaen University, Chiang Mai University, Chiang Rai Hospital, Udon Thani Hospital, Prince of Songkla University, Sunpasitthiprasong Hospital, and NASTDA Thailand
5. Bart Currie, David Dance, Joost Wiersinga, Dionne Rolim, Ivo Stienmetz, Natkunam Ketheesan, Jay Gee, Gan Yunn Hwen, Eric Bertherat, Chiranjay Mukhopadhyay, Paul Keim, Surasak Wongratanacheewin, Sheilla Nathan, Susanna Dunachie and Brian Angus on behalf of the committee, International Melioidosis Society (IMS), hub for melioidosis information, case reports and maps (www.melioidosis.info), and projects to make policy changes for melioidosis on a global scale, WHO-Geneva, US CDC, Australia, Thailand, Laos, Cambodia, Vietnam, Singapore, Malaysia, Indonesia, India, Bangladesh, Sri Lanka, Brazil, countries in Africa, etc, among member of the network and contributed to IMS and www.melioidosis.info
6. Assoc Prof Eoin West, Sepsis and host inflammatory responses and outcome in sepsis and melioidosis, University of Washington, USA
7. Assoc Prof David Aucoin, Rapid diagnostic test for melioidosis, University of Nevada, USA
8. Prof Philippe J Guerin, Data sharing platform for NTD, KEMRI, Kenya
9. Kittipong Chaisiri, Joint research projects, Mahidol University, Thailand
10. Prof Serge Morand, Joint research projects, Kasetsart University, Thailand
11. Joann Prior and Adam Whelan, Immune response to *B. pseudomallei* and vaccine design, DSTL, Porton Down, UK
12. Chiranjay Mukhopadhyay. Impact of diabetes on the immune response to melioidosis and tuberculosis, Manipal Academy of Higher Education, India
13. Ivo Steinmetz, Diagnosis of *B. pseudomallei* from serum, University of Graz, Austria
14. Mitali Chatterjee, Immunology of SARS-CoV-2 and intracellular pathogens, Institute of Postgraduate Medical Education & Research, Kolkata, India
15. Sarah Gilbert, Andrew Pollard, Adrian Hill, Vaccine design for melioidosis and AMR, Oxford Vaccine Group, Department of Paediatrics and Jenner Institute, NDM, University of Oxford
16. Katharine Owen, Joint research projects, OCDEM, RDM, University of Oxford
17. Fazle Rabbi Chowdhury, The impact of diabetes on the host response to SARS-CoV-2 infection, Bangabandhu Sheikh Mujib Medical University Hospital, Dhaka, Bangladesh.
18. Robed Amin, Joint research projects, Dhaka Medical College, Bangladesh
19. Sam Akech, The CINAMR (Clinical Information Network-Antimicrobial Resistance) Project: A pilot microbial surveillance using hospitals linked to regional laboratories in Kenya, KEMRI/Wellcome Trust Programme, Kenya
20. Nuvee Prapasarakul, Leptospirosis research, Department of Veterinary Microbiology, Faculty of Veterinary Science, Chulalongkorn University, Bangkok, Thailand
21. Santi Maneewatchararangsri, Joint research projects, Department of Molecular Tropical Medicine and Genetics, Faculty of Tropical Medicine, Mahidol University, Bangkok, Thailand
22. Kristy Farris, Scrub typhus diagnostics development and validation, Naval Medical Research Center, Maryland USA
23. John Stenos and Stephen Graves, Characterization of rickettsial isolates and real-time PCR diagnosis for rickettsial disease, Australian Rickettsial Reference Laboratory, Geelong, Australia
24. Beth Skaggs, Regional biosafety, US CDC, Bangkok, Thailand.
25. Filip Claes, Regional biosafety, FAO Regional Office, Bangkok, Thailand
26. Russell Bush, Tropical zoonoses, University of Sydney, Australia
27. Phouvong Phommachanh and Watthana Theppannga, Tropical zoonoses, National Animal Health Laboratory, Vientiane, Lao PDR
28. Sabine Dittrich, Tropical fever diagnostics development, Foundation for Innovative Diagnostics, Geneva, Switzerland
29. Javan Esfandiari, Tropical fever diagnostics development, Chembio, USA
30. Tom Hughes, Tropical zoonosis surveillance, Conservation Medicine, Malaysia
31. Martha Stokes and Scott Vittarelli, Tropical biosafety support in SEA, Defense Threat Reduction Agency, US State Department, Washington, USA
32. Somponnat Sampattavanich and Siwanon Jirawatnotai, High content imaging screens for *Orientia tsutsugamushi*, Siriraj Hospital, Thailand
33. Lars Barquist, RNA sequencing of *Orientia tsutsugamushi*, University of Wurzburg, Germany
34. Graham Wright, Structured Illumination microscopy imaging, A*Star Singapore
35. Paul J. Brett and Mary N. Burtnick, Developing a vaccine for melioidosis, Department of Microbiology and Immunology, University of Nevada, Reno School of Medicine, Reno, USA
36. Jacqueline Cliff, Department of Immunology and Infection, Faculty of Infectious and Tropical Diseases, London School of Hygiene and Tropical Medicine, London, UK
37. Gregory J. Bancroft, Department of Immunology and Infection, London School of Hygiene & Tropical Medicine, London, UK
38. Professor Wasun Chantratita, COVID-19 genomic surveillance, Ramathibodi Hospital, Thailand
39. Rory Bowden, pathogen sequencing, Walter and Eliza Hall Institute of Medical Research, Australia
40. Peter Dazsek and John Epstein, Tropical zoonosis surveillance, EcoHealth Alliance, USA
41. Kaz Kojima, Global/Regional Biosafety, WHO, Geneva, Switzerland.
42. Francis Yesurajan, Regional Biosafety, WHO, New Delhi, India.
43. John Jones, Global/Regional Biosafety European Union project 81, UK
44. Allan Bennett, Global biosafety, Public Health England, UK
45. Julian Parkhill, Department of Veterinary Medicine, University of Cambridge, UK
46. Julian Knight, The Wellcome Centre for Human Genetics, University of Oxford, UK
47. Nicholas Croucher, Faculty of Medicine, Imperial College London, UK
48. Nicholas Thomson, Parasite and Microbe, Wellcome Sanger Institute, UK
49. Emma Davenport, Human Genetics, Wellcome Sanger Institute, UK
50. Jukka Corander, Department of Mathematics and Statistics, University of Helsinki, Finland

Epidemiology

1. Aung Thi, Thandar Lwin, ENDGAME project, Vector Borne Disease Control, Ministry of Health and Sports, Naypyitaw, Myanmar
2. Prayuth Sudathip, Darin Areechokchai, Surawadee Kitchikarn, Chiwanan Lertpiriyasuwat, ENDGAME and RAI2E projects, Bureau of Vector Borne Diseases, Ministry of Public Health, Bangkok, Thailand
3. Keobouphaphone Chindavongsa, Viengxay Vanisaveth, ENDGAME and RAI2E projects, Centre for Malaria Parasitology and Entomology, Vientiane, Lao PDR
4. Siv Sovannaroth, Huy Rekol, Cambodia. ENDGAME and RAI2E projects, National Center for Parasitology, Entomology and Malaria Control, Phnom Penh, Cambodia
5. Thang Ngo, Tran Thanh Duong, ENDGAME and Case-control study of malaria in Viet Nam, National Institute for Malaria, Parasitology and Entomology Hanoi, Viet Nam
6. Sanya Tahmina, MM Aktaruzzaman, Joint research projects on malaria in Bangladesh, National Malaria Elimination Programme, Dhaka, Bangladesh
7. Yongjua Laosiritaworn, Monitoring impact of COVID-19 lockdown in Thailand, Ministry of Public Health, Thailand
8. Nick Martin, Case-control study of malaria in Viet Nam, NAMRU2, US Navy, Bangkok, Thailand
9. Steeve Ebener, Izay Pantanilla, Malaria and dengue risk mapping and response planning in the GMS, Health GeoLab Collaborative, Manila, The Philippines
10. Wiparat Mnuyakorn, Maternal and Child Birth Cohort Study of Thai Children's Environmental Health in Bangkok and industrialized provinces, Ramathibodi Hospital, Bangkok, Thailand
11. Mallika Imwong, Kesinee Chotivanick, Borimas Hanboonkunupakarn, Sasithon Pukrittayakamee, Epidemiology of malaria in NE Thailand, Faculty of Tropical Medicine, Mahidol University, Thailand
12. Thanat Chookajorn, GenReMekong project, Faculty of Tropical Medicine, Mahidol University, Thailand
13. Dominic Kwiatkowski, GenReMekong project, Sanger Institute, Cambridge, UK
14. Hsiao-Han Chan, Impact of mobility on malaria and dengue in Thailand, National Tsing Hua University, Taiwan
15. Arif Khan, Sharmin Musa, Epidemiology of Malaria among the Rohingya refugees in Cox's Bazar of Bangladesh, Dhaka University, Dhaka, Bangladesh
16. Caroline Buckee, Matt Kiang, Tyler Brown, USA. Joint research projects on population movement, Harvard TH Chan School of Public Health, Harvard University, Boston, USA
17. Amy Wesolowski, Joint research projects on population movement, Johns Hopkins University, Baltimore, USA
18. Stefan Jaeger, Sameer Antani, George Thoma, Malaria Screener project, National Library of Medicine, National Institutes of Health, Bethesda, USA
19. Shyamanga Borooh, Joint research projects on malaria retinopathy, University California San Diego, USA
20. Tim Gant, Emma Marczylo, Maternal and Child Birth Cohort Study of Thai Children's Environmental Health in Bangkok and industrialized provinces, Centre for Radiation, Chemical and Environmental Hazards, Public Health England, UK
21. Philippe Guerin, Mehul Dhorda, Georgina Humphreys, Joint research projects on mapping antimalarial resistance, WWARN, Oxford, UK
22. John Robert Medina, Epidemiology of Dengue in the Philippines, College of Public Health, University of the Philippines, Manila, The Philippines
23. Kenth Engo-Monsen, Joint research projects on mobile phone data analysis, Telenor Research, Oslo, Norway

24. Sara Aparicio, Joint research projects on remote sensing, European Space Agency, Rome, Italy
25. Rima Shretta, Roly Gosling, Joint research projects on economic modelling of malaria, University of California San Francisco, USA
26. Kannappan Palaniappan, Joint research projects on image analysis, University of Missouri, USA
27. Karen Barnes, Mapping antimalarial resistance in Africa, University of Cape Town, South Africa
28. Sheetal Silal, Joint research projects on mathematical modelling of malaria, University of Cape Town, South Africa
29. Chris Drakeley, Seroepidemiology of Malaria in northeast Thailand, London School of Hygiene and Tropical Medicine, London, UK
30. Jennifer Flegg, Joint research projects on mathematical modelling of malaria, University of Melbourne, Australia

31. Tom Hughes, Peter Daszak, IDEEAL project, Ecohealth Alliance, New York, USA
32. Leo Braack, Dengue MYSCHOOL project, Malaria Consortium, Bangkok, Thailand
33. Hans Overgaard, Dengue MYSCHOOL project, Norwegian University of Life Sciences, Oslo, Norway
34. Julie Simpson, METF project, University of Melbourne, Australia
35. Alex Pompe, Monitoring the impact of COVID-19 control measures in SE Asia, Facebook, USA
36. Kumtorn Malathum, Improving KAP for COVID-19 in Thailand, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand
37. Ravi Shankar Santhana Gopala Krishnan, GHFD project, WHO GIS Centre, Geneva, Switzerland

Clinical Pharmacology

1. Prof Mats Karlsson, PK/PD modelling of antimalarial drugs, Uppsala University, Sweden
2. Dr Kevin Kobylinski, Pharmacology of ivermectin, Armed Forces Research Institute of Medical Sciences (AFRIMS), Thailand
3. Dr Pajaree Chariyavilaskul, PK/PD of MPA against kidney complications due to lupus, Chulalongkorn University, Thailand
4. Prof Suda Vannaprasaht, PK/PD of tacrolimus in kidney transplant recipients, Khon Kaen University, Thailand
5. Prof Philippe Guerin, Pooled meta-analyses of antimalarial drugs, Worldwide Antimalarial Resistance Network (WWARN), UK
6. Prof Saye Khoo, PK/PD and drug-drug interactions of antiviral and antimalarial drugs, University of Liverpool, UK
7. Prof Feiko ter Kuile, PK/PD of antimalarial drugs in pregnant women, Liverpool School of Tropical Medicine, UK
8. Rajinder Jalali, Shoibal Mukherjee, Amit Nasa, PK/PD of arterolane and piperazine, Sunpharma, India
9. Prof Ric Price, PK/PD of primaquine, Menzies, Australia
10. Professor James McCarthy, PK/PD of antimalarial drugs in the human challenge model, Queensland Institute of Medical Research (QIMR), Australia
11. Dr Julie Simpson, PK/PD modelling of antimalarial drugs, University of Melbourne, Australia
12. Dr David Wesche, Physiologically based pharmacokinetic modelling of antimalarial drugs, Certara/BMGF, USA
13. Ted Grasela, Data repository development for online PK/PD modelling, Cognigen, USA
14. Prof Jean-Bosco Ouedraogo, PK/PD of seasonal malaria chemoprevention (SMC) in young children, Institut de Recherche en Sciences de la Santé, Burkina Faso
15. Prof Sunil Parikh, PK/PD of antimalarial drugs in young children and pregnant women, Yale University, USA
16. Prof Umberto D'Alessandro, Treatment of pregnant women with malaria, Medical Research Council Unit, The Gambia

17. Dr Ivan Scandale, PK/PD and development of drugs for neglected diseases, Drugs for Neglected Diseases Initiative (DNDi), Switzerland

18. Dr Joerg Moehrle, PK/PD of antimalarial drugs in development, Medicines for Malaria Venture (MMV), Switzerland

19. Prof Anders Bjorkman, Mass drug administration of dihydroartemisinin-piperazine in Africa, Karolinska Institutet, Sweden

20. Prof Melissa Penny, PK/PD of tribendimidine in patients with *Opisthorchis viverrini*, Swiss Tropical and Public Health Institute (Swiss TPH), Switzerland

21. Dr Panisadee Avirutnan, PK/PD of Ivermectin in paediatric dengue patients, Siriraj Hospital, Thailand

22. Dr Matthew Coldiron, Adherence of seasonal malaria chemoprevention (SMC) in Niger, Epicentre, France

23. Prof Wuelton Monteiro, Malaria transmission blocking effects of ivermectin, Universidade do Estado do Amazonas, Brazil

24. Prof Charles Flexner, Drug-drug interactions of antiviral drugs and chloroquine, Johns Hopkins University School of Medicine, USA

25. Dr Graham Cooke, Efficacy, safety and pharmacology of Sofosbuvir and Daclatasvir in Hep C, Imperial College London, UK

26. Prof Guy Thwaites, PK/PD of antituberculosis drugs, Oxford University Clinical Research Unit (OUCRU), Viet Nam

27. Dr Bernhards Ogutu, Cardiotoxic effects of piperazine, Kenya Medical Research Institute (KEMRI), Kenya

28. Prof Kesara Na-Bangchang, PK/PD of mefloquine in patients in Thailand, Thammasat University, Thailand

29. Prof Kevin Baird, PK/PD of primaquine in Indonesian soldiers with vivax malaria, Eijkman-Oxford Clinical Research Unit (EOCRU), Indonesia

30. Prof John Adam, ivermectin hepatocyte cultures, University of Florida, USA

15. Professor Lisa Shwartz, McMaster's University, WHO COVID-19 Task Force of Good Participatory Practice

16. Dr Nina Gobat, Nuffield Department of Primary Care Health Sciences, University of Oxford, WHO COVID-19 Research Roadmap Committee (Social Science Working Group)

17. Dr Niyada Kiatying-Angsulee, Drug System Monitoring and Development Center, Chulalongkorn University, "AMR Dialogues" project

18. Chaiwat Thirapantu, Karnjariya Sukrung, Civinet Foundation, "AMR Dialogues" project

19. Nithima Sumpradit, Sirima Punnin, Thai Food and Drug Administration, Ministry of Public Health, "AMR Dialogues" project

20. Dr Sharon Kaur, University Malaya, joint research projects

21. Professor Lim Yang Mui, Universiti Tunku Abdul Rahman, Malaysia, joint research projects

Mathematical and Economic Modelling (MAEMOD)

1. Department of Clinical Tropical Medicine, Student projects and staff proposals, Faculty of Tropical Medicine, Mahidol University, Bangkok, Thailand

2. Department of Helminthology, Student projects and staff proposals, Faculty of Tropical Medicine, Mahidol University, Bangkok, Thailand

3. Department of Medical Entomology, Student projects and staff proposals, Faculty of Tropical Medicine, Mahidol University, Bangkok, Thailand

4. Department of Microbiology and Immunology, Student projects and staff proposals, Faculty of Tropical Medicine, Mahidol University, Bangkok, Thailand

5. Department of Social and Environmental Medicine, Student projects and staff proposals, Faculty of Tropical Medicine, Mahidol University, Bangkok, Thailand

6. Department of Tropical Hygiene, Student projects and staff proposals, Faculty of Tropical Medicine, Mahidol University, Bangkok, Thailand

7. Department of Tropical Pediatrics, Student projects and staff proposals, Faculty of Tropical Medicine, Mahidol University, Bangkok, Thailand

8. Dept of Disease Control, Leptospirosis Club Thailand, Ministry of Public Health, Thailand

9. Clinicians and researchers, Various research projects, Gastroenterological Association of Thailand

10. Dr. Yot Teerawattananon, Saudamini Dabak and team. HITAP and the International Unit (HIU), Thailand's Ministry of Public Health & National University of Singapore – COVID-19 vaccine modelling and cost-effectiveness analysis, Thailand

11. Assist. Prof. Hannah Clapham and Dr. Wang Yi, COVID-19 vaccine modelling and cost-effectiveness analysis at NUS Saw Swee Hock School of Public Health, Singapore

12. Assoc. Prof. Dr. Wanrudee Isaranuwatjai and team from (HITAP), Department of Health, Ministry of Public Health, Nonthaburi – on several modelling and economic analysis studies, Thailand

13. The International Decision Support Initiative (iDSI), Center for Global Development in Europe, Networking on health, policy and economic expertise to achieve Universal Health Coverage and the health Sustainable Development Goal, London, UK

14. Dr. Weerapong Thanapongtharm and Dr. Sith Premasathira, Rabies research and modelling, Department of Livestock Development, Bangkok, Thailand

15. Assoc. Prof. Anuwat Wiratsudakul and Assist. Prof. Sarin Suwanpakdee, Rabies research and modelling, Department of Clinical Sciences, and Public Health, and the Monitoring and Surveillance Center for Zoonotic Diseases in Wildlife and Exotic Animals, Faculty of Veterinary Science, Mahidol University, Nakhon Pathom, Thailand

16. Dr. Theerathorn Yoongthong, Cost-effectiveness study of dog sterilization programme to control rabies, Institute for Population and Social Research, Mahidol University, Thailand

Bioethics & Engagement

1. Professor Sassy Molyneux, Dr Alun Davies, Dr Dorcas Kamuya, KEMRI Wellcome Trust Programme, Kenya, Global Health Bioethics Network

2. Professor Mike Parker, Dr Susan Bull, Dr Maureen Kelley, Jennifer Roest, The Ethox Centre, University of Oxford, Global Health Bioethics Network

3. Dr Evelyne Kestelyne, Dr Mary Chambers, Dr Jennifer van Nuil, Joint research projects, OUCRU, Viet Nam

4. Dr Deborah Niriyenda, Malawi-Liverpool-Wellcome Clinical Research Programme, Blantyre, Malawi, Global Health Bioethics Network

5. Dr Christopher Pell, Dr Anita Hardon, Dr Daniel de Vries, Amsterdam Institute of Global Health and Development, SONAR Global project

6. Dr Tamara Giles Vernick, Joint research projects, Institute Pasteur

7. Dr Jetsumon Prachumsri, Joint research projects, Malaria Vaccine Research Unit

8. Dr Gill Black, Joint research projects, Sustainable Livelihoods Foundation

9. Dr Ana Lita, Joint research projects, Global Bioethics Initiative

10. Dr Katherine Littler, WHO Ethics Committee, Chair of the Global Forum for Bioethics in Research

11. Dr Liam Boggs, Professor Trudie Lang, Joint research projects, The Global Health Network

12. Dr Jan Piasecki, Jagiellonian University, co-instructor, Bioethics Summer School, Radboud University

13. Dr Robert Terry, WHO TDR, Strengthening health data access for health systems resilience and evidence informed policy for COVID-19 response (SHARE) study

14. Dr Oommen John, Dr Calvin Ho, Dr Lauren Maxwell, Professor Phillippe Guerin, Dr Susi Bull, Laura Merson et al, Data Sharing Working Group Working Group of the COVID-19 Clinical Research Coalition

17. Assoc. Prof. Charin Modchang, Rabies research and modelling, Department of Physics, Faculty of Science, Mahidol University, Bangkok, Thailand
18. Assoc. Prof. Dr. Nattachai Srisawat, leptospirosis research, Department of Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand
19. Dr Sopon Iamsirithaworn, Director of the Division of Communicable Diseases of the Department of Disease Control (DDC), Ministry of Public Health, Nonthaburi, Thailand
20. Prof. Deirdre Hollingsworth, Neglected Tropical Disease Modelling Consortium, Big Data Institute, University of Oxford, UK
21. Prof. Graham Medley, population dynamics and infectious diseases modelling, The Centre for the Mathematical Modelling of Infectious Diseases (CMMID) at the London School of Hygiene & Tropical Medicine, London, UK
22. Dr. Joaquin Prada, Leptospirosis and soil transmitted helminth modelling, School of Veterinary Medicine, Faculty of Health and Medical Sciences, University of Surrey, UK
23. Prof. Jodie McVernon, Prof. James McCaw and Prof. James Wood, Co-workshop organizing, SPARK (Strengthening Preparedness in the Asia-Pacific Region through Knowledge), The Peter Doherty Institute for Infection and Immunity, University of Melbourne, Australia
24. Dr. Wiriya Mahikul, COVID-19 modelling and human contact patterns, Faculty of Medicine and Public Health, HRH Princess Chulabhorn College of Medical Science, Bangkok, Thailand
25. Assoc. Prof Patama Gomutbutra, Pain intensity-related Facial Action Units and the Classification model for Chronic Pain in Asian Elders, Department of Family Medicine, Faculty of Medicine, Chiang Mai University, Thailand
26. Dr. Nopporn Apiwattanakul and team, Efficacy of vitamin A supplementation for prevention and severity reduction of hand- foot-mouth disease in young children, Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Thailand
27. Dr Supalert Natesuwan, CRP projects, Chiang Rai Provincial Health Office, Thailand
28. Dr Nithima Sumpradit, CRP projects, Thai FDA, Thailand
29. Dr Sabine Dittrich, CRP projects, The Foundation for Innovative New Diagnostics (FIND), Switzerland
30. Dr Marc Lipsitch, AMR modelling projects, Harvard TH Chan School of Public Health, USA
31. Dr Joseph Wu, AMR modelling projects, School of Public Health, University of Hong Kong
32. Dr Mark Jit, AMR modelling projects, LSHTM, UK
33. Dr Ruby Siddiqui, Hepatitis E project, Médecins sans Frontières (MSF), London, UK
34. Dr Dakshika Jeyaratnam, Rapid diagnostics, King's College London, UK
35. Prof Marc Bonten, AMR work, University Medical Center Utrecht (UMCU), Utrecht, The Netherlands
36. Dr Warunee Punpanich Vandepitte, Department of Paediatrics, College of Medicine, Rangsit University, Bangkok, Thailand & Division of Infectious Diseases, Department of Paediatrics, Queen Sirikit National Institute of Child Health, Bangkok, Thailand
37. Mike Sharland, St Georges, University of London, UK
38. Friederike Maechler, Charité – Universitätsmedizin Berlin, Germany
39. Marianne van der Sande, Institute of Tropical Medicine, Antwerp, The Netherlands
40. Dr Olga Tosas, AMR surveillance in LMICs, WHO, Geneva, Switzerland
41. Prof Stephen Harbath, AMR work, University of Geneva Hospital, Switzerland
42. Dr Craig Maclean, AMR work, Oxford Zoology, UK
43. Dr Jonathan Edgeworth, AMR work, St Thomas's Hospital, London, UK
44. Dr Paul Tambyah, AMR work, NUS, Singapore
45. Prof Timothy Walsh, China/UK/Thailand Program on Poultry Biosafety for Salmonella, *E. coli* and *Campylobacter*, University of Cardiff, UK
46. David Smith, Malaria elimination modelling projects, University of Washington, USA
47. Dr Chea Nguon, Malaria elimination modelling projects, National Center for Parasitology, Entomology and Malaria Control, Phnom Penh, Cambodia
48. Dr Jahirul Karim, Malaria elimination modelling projects, National Malaria Control Programme, Bangladesh
49. Dr Alice Jamieson, Predicting impact of medicine quality on the spread of drug resistance, Policy, Wellcome Trust, UK
50. Dr Sheetal Silal, Wellcome Trust funded research on malaria elimination in Southern Africa, University of Cape Town, South Africa
51. Dr Daniela DeAngelis, Trial design work, MRC Biostatistics Unit, Cambridge, UK
52. Dr Andre Siqueira, Modelling malaria elimination in Amazonas and integrated public health strategy for the arboviruses in Brazil, Fundação Oswaldo Cruz, Brazil
53. Dr Sakib Burza, Médecins sans Frontières, co-PI for Spot Sepsis and PRIORITISE, UK
54. Dr Melissa Richard Greenblatt, co-investigator and lab support for SEACTN and Spot Sepsis, University of Pennsylvania, USA
55. Prof Maciek Boni, Malaria drug resistance modelling, Penn State University, USA
56. Dr Lucy Okell, Malaria drug resistance modelling, Imperial College London, UK
57. Dr Oliver Watson, Malaria drug resistance modelling, Imperial College London, UK
58. Prof Melissa Penny, Malaria elimination strategy optimisation, Swiss TPH, Switzerland
59. Dr Adam Mahdi, Data analytics, Oxford Internet Institute, UK
60. Dr Kevin Kobylinski, Impact of Ivermectin on malaria transmission, Armed Forces Research Institute of Medical Sciences, Bangkok, Thailand

Clinical Therapeutics Unit (CTU)

1. Dr Nathalie Strub-Wourgraff, COVID-19 treatment, Drugs for Neglected Diseases Initiative, Geneva, Switzerland
2. Dr Andrea Bosman, Assessment of the cardiotoxicity of antimalarial drugs, Global Malaria Programme, WHO, Geneva, Switzerland
3. Dr Melba Gomes, Development of rectal ceftriaxone for neonatal sepsis, TDR, WHO, Geneva, Switzerland
4. Guilin Pharmaceutical Company, Development of a new parenteral artesunate formulation, Guilin Pharmaceutical Company, Guilin, PRC
5. Prof Philippe Guerin, Assessment of antimalarial and antiviral drug safety and toxicity, Worldwide Antimalarial Resistance Network (WWARN), University of Oxford, UK
6. Prof Julie Simpson, Studies of causal inference and antimalarial PK-PD modelling, University of Melbourne, Australia
7. Dr Aimee Taylor, Modelling of *P. vivax* relapses, TH Chan Harvard School of Public Health, Boston, MA, USA
8. Prof Chris Holmes, Artificial intelligence methods of clinical assessment, Turing Institute London, and Department of Statistics, University of Oxford, UK
9. Prof Israel Molina, Chagas disease pharmacometrics, Fiocruz, Minas Gerais, Brazil
10. Prof Jaime Altech, Chagas disease paediatric pharmacometrics, Hospital de Niños R. Gutiérrez de Buenos Aires, Argentina.
11. Dr Louisa Messenger, *T. cruzi* molecular biology, LSHTM, London, UK
12. Prof Ric Price, *P. vivax* assessment and treatment, Menzies School, Darwin, Australia
13. Dr Awab Gulam, Vivax malaria, Nangarhar Medical Faculty, Afghanistan
14. Prof Tom Williams, Modelling of severe malaria, Imperial College, London
15. Prof Martin Llewellyn, COVID-19 therapeutics, University of Sussex Medical School, Brighton

16. Prof Asim Beg, COVID-19 therapeutics, Aga Khan Medical School, Karachi, Pakistan

17. Prof Mauro Teixeira, COVID-19 therapeutics, University of Minas Gerais, Belo Horizonte, Brazil

18. Dr Chayada Piantham, Mathematical modelling of malaria transcription, Hokudai University, Japan

19. Dr Somya Mehra, Malaria modelling, University of Melbourne, Australia

Clinical Trials Support Group (CTSG)

1. Dept. of Tropical Hygiene, Student projects, Faculty of Tropical Medicine, Mahidol University, Bangkok

2. Prof Marcus Schultz, ICU studies, AMC, University of Amsterdam, The Netherlands

3. Prof Feiko ter Kuile, research projects, Liverpool School of Tropical Medicine, UK

4. Dr Proochista Ariana, Student projects, Nuffield Department of Medicine, Centre for Tropical Medicine and Global Health, University of Oxford, Oxford, UK

5. Dr Eric Ohuma, Student projects, Centre for Global Child Health, Hospital for Sick Children, Toronto, Canada

6. Prof Kamija Phiri, Research proposals, College of Medicine, University of Malawi, Malawi

7. Prof Victor Mwapasa, Research proposals, College of Medicine, University of Malawi, Malawi

8. Prof Wilson Mandala, Research proposals, Malawi University of Science and Technology, Malawi

9. Prof Tobias Chirwa, Student projects, Wits School of Public Health, South Africa

10. Dept. of Applied Sciences. Student projects, Malawi University of Science & Technology, Malawi

11. Dept. of Mathematical Sciences. Student projects and staff proposals, University of Malawi, Malawi

12. Dept. of Public Health. Student projects and staff proposals, College of Medicine University of Malawi, Malawi

13. Dr Marc Henrion, Student projects, Liverpool School of Tropical Medicine, UK

14. Professor Trudie Lang, Joint projects in Data Management and Sharing, The Global Health Network, University of Oxford, UK

15. Dr George M. Varghese, Intravenous Treatment for Scrub Typhus (INTREST) Trial Protocol, Christian Medical College (CMC), India

16. Associate Professor Panisadee Avirutnan, Pharmacokinetics and Pharmacodynamics of Ivermectin in Pediatric Dengue Patients (PKIDEN), Siriraj hospital (Division of Dengue Hemorrhagic Fever Research), Faculty of Medicine Siriraj Hospital, Thailand

17. Evelyne Kestelyne, Joint research projects, OUCRU, Viet Nam

18. Department of Clinical Tropical Medicine, Student projects and staff proposals, Faculty of Tropical Medicine, Mahidol University, Bangkok

19. Assoc. Prof. Noppadon Tangpukdee, Ph.D. Department of Clinical Tropical Medicine Faculty of Tropical Medicine, Mahidol University Bangkok, 10400, Thailand

20. Oommen John, Calvin Ho, Lauren Maxwell, Phillippe Guerin, Susi Bull, Laura Merson et al, Data Sharing Working Group Working Group of the COVID-19 Clinical Research Coalition, UK

21. Marianne Munene, Joint research projects, KEMRI-Wellcome Trust Research Programme, Kenya

22. Andrew Schachter, ePRO development COVID-19 study, Axiom Real-Time Metrics, Canada

23. Dr Yaw Anokwa, Open Data Kit Platform development and rollout, GetODK, USA

24. Rhonda Facile, CDISC Standards for Real World Data (RWD Connect Project), Clinical Data Interchange Standards Consortium (CDISC), USA

25. Elliot Zimmerman, Anonymisation of clinical trial data, Real Life Sciences, USA

MORU Units

Shoklo Malaria Research Unit (SMRU)

1. Tim Anderson, Joint research projects, Texas Biomedical Research Institute, USA

2. Aimee Taylor and Daniel Neafsey, Joint research projects, Broad Institute of MIT and Harvard, USA

3. Ric Price, Joint research projects, Global and Tropical Health Division, Menzies School of Health Research and Charles Darwin University, Darwin, Australia

4. Olivo Miotto, Susannah Salter, Joint research projects, Wellcome Trust Sanger Institute, Hinxton, UK

5. Freya Fowkes, Kerryn Moore, Joint research projects, Macfarlane Burnet Institute of Medical Research, Melbourne, Australia

6. Kerryn Moore, Julie Simpson, Joint research projects, Centre for Epidemiology and Biostatistics, University of Melbourne, Melbourne, Australia

7. Gonzalo Domingo, Joint research projects, Diagnostics Program, PATH, Seattle, USA

8. Steven Kennedy, Joint research projects, Nuffield Department of Obstetrics & Gynaecology, University of Oxford, UK

9. Kevin Kain, Joint research project, Canada Research Chair in Molecular Parasitology MaRS Center, Toronto, Ontario, Canada

10. Philippe Guerin, Joint research projects, WWARN, Centre for Tropical Medicine & Global Health, NDM, University of Oxford, UK

11. Manu Vatish, Neva Kandzija, Joint research project, Nuffield Department of Women's & Reproductive Health, University of Oxford, UK

12. Dennis Kyle, Joint research projects, Center for Tropical and Emerging Global Diseases, University of Georgia, Athens, GA, USA

13. Laurent Renia, Joint research projects, Singapore Immunology Network (SIgN) Agency for Science, Technology, and Research (A*STAR), Biopolis, Singapore

14. Bruce Russel, Joint research projects, Department of Microbiology and Immunity, University of Otago, New Zealand

15. Emma Plugge, Gracia Fellmeth, Joint research projects, Nuffield Department of Medicine, Centre for Tropical Medicine and Global Health, University of Oxford, UK

16. Stephan Ehrhardt, Chloe Thio, Joint research project, Johns Hopkins University, Bloomberg School of Public Health, Baltimore, MD, USA

17. Georges Snounou, Joint research projects, Laboratory of Malaria Biology, CEA, France

18. Hal Drakesmith, Joint research project, MRC Human Immunology Unit, University of Oxford, UK

19. Wolfgang Stuetz, Joint research project, University of Hohenheim Institute of Nutritional Sciences, Stuttgart, Germany

20. Damien Chaussabel, Joint research projects, SIDRA Medicine, Doha, Qatar

21. Elke Bergmann-Leitner, Joint research projects, WRAIR, Silver Spring, MD USA

22. Vincent Herbreteau, Joint research projects, IRD, Phnom Penh, Cambodia

23. Jordi Landier, Joint research projects, IRD, Marseille, France

24. Karine Le Roch, Joint research projects, University of California, Riverside, CA USA

25. Julie Reveilaud, Joint research projects, IRD, Montpellier, France

26. Renaud Piarroux, Joint research projects, INSERM, Paris, France

27. Daniel Parker, Joint research projects, University of California, Irvine, CA USA

28. Prof. dr. David Burger, Joint research project, Radboudumc, Nijmegen, The Netherlands

29. Cedric Jo, Joint research projects, SD Biosensor Inc., Gyeonggi-do, Republic of Korea

30. Caterina Fanello, Joint research projects, Kinshasa Research Medical Unit and Kinshasa School of Public Health, Kinshasa, DR Congo

31. Ian Gassiep, Joint research project, University of Queensland Centre for Clinical Research, Herston, Queensland, Australia

32. Robert Norton, joint research project, Pathology, Townsville Hospital, Townsville, Queensland, Australia and Faculty of Medicine, University of Queensland, Brisbane, Australia
33. Barbara Knust, joint COVID-19 surveillance, Immigrant Refugee & Migrant Health, Division of Global Migration and Quarantine, CDC, USA
34. Nuttapon Wongjindanon, joint COVID-19 surveillance, Immigrant, Refugee and Migrant Health Program, Thailand MOPH - U.S. CDC Collaboration, Thailand
35. Supakit Sirilak, joint COVID-19 surveillance, Department of Medical Sciences, Ministry of Public Health, Thailand
36. Chavalit Kiatvitchukul, joint COVID-19 surveillance, Regional Medical Sciences Center 2 Phitsanulok, MoPH, Thailand

37. Thanat Chookajorn, joint COVID-19 surveillance, Faculty of Tropical Medicine (FTM), Mahidol University, Thailand
38. Jordi Landier, Joint research project (Malaria), France National Research Institute for Sustainable Development (IRD), INSERM, Aix Marseille, France
39. Vincent Herbreteau, Joint research project (Malaria), France National Research Institute for Sustainable Development (IRD), Cambodia
40. Florian Girond, Joint research project (Malaria), France National Research Institute for Sustainable Development (IRD), Cambodia
41. Mallika Imwong, MORU, FTM, Mahidol University, Bangkok, Thailand

Lao-Oxford-Mahosot Hospital-Wellcome Trust Research Unit (LOMWRU)

- | | |
|--|---|
| 1. Department of Communicable Disease Control (DCDC), Ministry of Health, Lao PDR | 13. Savannakhet Provincial Health Office, Lao PDR |
| 2. Department of Health Care and Rehabilitation, Ministry of Health, Lao PDR | 14. WHO Lao Country Office, Vientiane, Lao PDR |
| 3. Centre of Malariology, Parasitology & Entomology, Ministry of Health, Lao PDR | 15. Institut de Recherche pour le Développement, Lao PDR |
| 4. National Centre for Laboratory & Epidemiology, Ministry of Health, Lao PDR | 16. Centre d'Infectiologie Christophe Mérieux du Laos, Lao PDR |
| 5. Food and Drug Department, Ministry of Health, Lao PDR | 17. Institut Pasteur du Laos, Lao PDR |
| 6. University of Health Sciences, Ministry of Health, Lao PDR | 18. Health Frontiers, Vientiane, Lao PDR |
| 7. Provincial Hospitals of Luang Nam Tha, Xieng Khouang, Salavan, Savannakhet, Attapeu & Vientiane, Lao PDR | 19. Dr Cecilia Kato, Rickettsial Zoonoses Branch (RZB), CDC, Atlanta, Georgia, USA |
| 8. Hospital Directors and staff, Joint research projects, Mittaphab, Setthathirat, Childrens', Mother & Child, Police and Army Hospitals, Vientiane, Lao PDR | 20. Dr Mathieu Picardeau, Unité de Biologie des Spirochètes, Institut Pasteur, Paris, France |
| 9. Dr Sengchang Kounnavong, National Institute of Public Health, Vientiane, Lao PDR | 21. Dr Alain Pierret and Dr Anne Pando, Institut de Recherche pour le Développement, Lao PDR |
| 10. Food & Drug Quality Control Laboratory, Ministry of Health, Lao PDR | 22. Dr Olivier Ribolzi, Géosciences Environnement Toulouse, Université de Toulouse, France |
| 11. National Animal Health Laboratory, Lao PDR | 23. Dr Lee Smythe and Dr Scott Craig, Leptospiral Reference Laboratory, Coopers Plains, Australia |
| 12. Bureau of Food and Drug Inspection, Ministry of Health, Lao PDR | 24. London School of Hygiene and Tropical Medicine, London, UK |

25. Prof Bart Currie, Menzies School of Health Research, Australia
26. Prof Al Richards, Rickettsial Diseases Research Program, Naval Medical Research Center, USA
27. Naval Medical Research Centre - Asia, Singapore
28. Prof David Relman and Dr Stephen Popper, Department of Microbiology and Immunology, Stanford University, California, USA
29. Swiss Tropical and Public Health Institute, Basel/University of Basel, Switzerland
30. Dr Tim Barkham, Tan Tock Seng Hospital, Singapore
31. Dr Kate Bond, Dr Souly Phanouvong, Dr Jude Nwokike, Dr Victor Pribluda and Dr Mustapha Hajjou, United States Pharmacopeia, Rockville, Virginia, USA
32. Dr Todd French and Philip Bulterys, University of California - Los Angeles, USA
33. Dr Daniel Parker, University of California - Irvine, USA
34. Prof Fiona Russell, Murdoch Childrens Research Institute (MCRI), University of Melbourne, Victoria, Australia
35. Prof John Crump, University of Otago, NZ
36. Prof Nicole Zitzmann and Dr Bevin Gangadharan Department of Biochemistry, University of Oxford, UK

Cambodia-Oxford Medical Research Unit (COMRU)

- | | |
|--|--|
| 1. Prof Jukka Corander, Joint research projects, University of Oslo, Norway | 6. Dr Jason Hinds, Joint research projects, BUGS Bioscience, St. George's, University of London, UK |
| 2. Dr Patricia Kingori, Joint research projects, ETHOX Centre, UK | 7. Dr James Heffelfinger, Joint research projects, WHO, WPRO, The Philippines and Centers for Disease Control, USA |
| 3. Prof Stephen Bentley, Joint research projects, Wellcome Trust Sanger Institute, UK | 8. Dr Li Yang Hsu, Joint research projects, National University of Singapore, Singapore |
| 4. Dr Nick Croucher, Joint research projects, Imperial College London, UK | 9. Prof Susie Dunachie, Joint research projects, Global Research on AntiMicrobial Resistance (GRAM) Project, UK |
| 5. Dr Florian Marks, Joint research projects, International Vaccine Institute, South Korea | 10. Dr Sakib Burza, Joint research projects, Médecins sans Frontières, Spain |

37. Prof Philippe Guérin and the Infectious Diseases Data Observatory (IDDO), Centre for Tropical Medicine & Global Health, University of Oxford, UK
38. Dr Anders Omsland, Washington State University Paul G Allen School for Global Animal Health, USA
39. Dr John Pettersson, University of Uppsala, Sweden
40. PATH, Seattle, USA
41. Sabine Dittrich, Deggendorf Institute of Technology, Germany
42. Foundation for Innovative New Diagnostics (FIND), Geneva, Switzerland
43. Mathieu Pruvot and Amanda Fine, Wildlife Conservation Society, Wildlife Health Program, Bronx, New York, USA
44. Wildlife Conservation Society, Lao PDR Program, Vientiane, Lao PDR
45. Philippe Dussart and Paul Horwood, Institut Pasteur du Cambodge, Phnom Penh, Cambodia (now at Institut Pasteur du Madagascar, Antananarivo, Madagascar, and Australian Institute of Tropical Health and Medicine, James Cook University, Cairns, Australia, respectively)
46. Xavier de Lamballerie, Unité des Virus Émergents, Aix-Marseille Université, Institut National de la Santé Et de la Recherche Médicale (INSERM), Institut de Recherche pour le Développement (IRD)

Myanmar-Oxford Clinical Research Unit (MOCRU)

1. Dr Mo Mo Win, Melioidosis soil study, Department of Medical Research, Ministry of Health and Sports, Myanmar	7. National Malaria Control Programme, Malaria immunity project & DeTACT multi-centre trial, Myanmar
2. Dr Hayley MacGregor, Dr Ayako Ebata, Myanmar Pig Partnership collaboration, Institute of Development Studies (IDS), a joint project between IDS and OUCRU-VN	8. Dr Khin Cho Aye, University of Community Health Magway, Myanmar
3. Prof. Kyaw Linn, A study on the aetiology of CNS infections, University of Medicine 1, Myanmar/ Yangon Children's Hospital, Myanmar	9. Prof. Moe Wint Aung, Rickets study, Department of Endocrinology, Yangon General Hospital, Myanmar
4. Dr Khin Pyone Kyi, Hepatitis C treatment study, Myanmar Liver Foundation	10. Prof. Lut Lynen, HIV related studies, Institute of Tropical Medicine, Antwerpen, Belgium
5. Prof. Dan Tucker, Zoonoses and emerging livestock systems - ZELS project, University of Cambridge, UK	11. Prof Job v Woensel, Rickets related studies, University of Amsterdam, the Netherlands
6. Dr Kay Thwe Han, Malaria immunity study & DeTACT multi-centre trial, Department of Medical Research, Myanmar	12. Prof Min Zaw Ooo, Thinkankyun Sanpya General Hospital, and Prof David Warrell, Antivenom studies, Myanmar

Medicine Quality Research Group

1. Jayasree Iyer, Access to Medicine Foundation, Haarlem, The Netherlands	11. Christa Cepuch & Alain Alsalhani, MSF Access Campaign, Geneva, Switzerland
2. Dr Mike Green, CDC, Atlanta, Georgia, USA	12. Food and Drug Department, Ministry of Health, Lao PDR
3. Professor Veronika Wirtz, School of Public Health, Boston University, Boston, USA	13. University of Health Sciences, Ministry of Health, Lao PDR
4. Professor Muhammad Zaman, Department of Biomedical Engineering, Boston University, Boston, USA	14. Bureau of Food and Drug Inspection, Ministry of Health, Lao PDR
5. Dr Jennifer Young and Professor Adrian Linacre, Flinders University, Australia	15. National Center of Food and Drug Analysis (NCFDA), Ministry of Health, Lao PDR
6. Aline Plançon, FMEDS, Paris, France	16. Dr Souly Phanouvong, Dr Jude Nwokike, Dr Victor Pribluda, United States Pharmacopeia, Rockville, Virginia, USA
7. Professor Clark Freifeld, Boston Children's Hospital, Harvard University, Boston, USA	17. Dr Pierre-Yves Sacré, University of Liège, Belgium
8. Professor Facundo Fernandez, Georgia Institute of Technology, Atlanta, Georgia, USA	18. Professor Marya Lieberman, Department of Chemistry and Biochemistry, University of Notre Dame, USA
9. Dr Raffaella Ravinetto, Institute of Tropical Medicine, Antwerp, Belgium	19. Professor Nicole Zitzmann & Dr Bevin Gangadharan, Department of Biochemistry, University of Oxford, UK
10. Professor David Mabey, Dr Heidi Hopkins, Dr Shunmay Yeung and Dr Harparkash Kaur, London School of Hygiene and Tropical Medicine, London, UK	20. Professor Lutz Heide, University of Tübingen, Germany

21. EUROPOL, The Hague, The Netherlands	33. Stanislas Barro, Theophile Segbo, Rachel Hinder, Global Head Anti-counterfeiting, Novartis Business Assurance & Advisory, Global Security, Basel, Switzerland
22. Drs Lesley Chesson and Jim Ehleringer, IsoForensics Inc., and Dr Thure Cerling, University of Utah, USA	34. INTERPOL, Lyon, France
23. Rutendo Kuwana, Pernelle Bourdillon-Esteves, Diana Lee, Babatunde Jayeola, Fatima Guiet Mati, Naseem, Hudroge, Substandard and Falsified Medical Products Group, World Health Organisation, Geneva, Switzerland	35. UNODC, Vienna, Austria
24. Professor James McCullagh and Dr John Walsby-Tickle, Department of Chemistry, University of Oxford, UK	36. Dr Simon Kelley, International Atomic Energy Authority, Vienna, Austria
25. Professor Pavel Matousek, STFC Rutherford Appleton Laboratory, Harwell, Oxon, UK	37. Professor Robert Ogden, Director of Conservation Science, The Royal (Dick) School of Veterinary Studies and The Roslin Institute, Edinburgh, UK
26. Dr Stephen Kigera, MEDS, Nairobi, Kenya	38. Professor Heather Hamill & Professor Federico Varese, Department of Sociology, University of Oxford, UK
27. Professor Heiman Wertheim & Dr Annelie Monnier, Department of Medical Microbiology, Radboud University Medical Center, Nijmegen, The Netherlands	39. Dr Luana Bontempo, Food Quality and Nutrition Dept. Traceability Unit, Fondazione Edmund Mach, Trento, Italy
28. Catherine Dujardin, Ministry of Foreign Affairs, Brussels, Belgium	40. National Institute for Biological Standards and Control, Potters Bar, UK
29. Dr Elizabeth Pisani, London, UK	41. Medicines and Healthcare Products Regulatory Agency, London, UK
30. Dr Sachiko Ozawa, University of North Carolina, Eshelman School of Pharmacy, Chapel Hill, USA	42. Professor Philippe Guérin and the Infectious Diseases Data Observatory (IDDO), Centre for Tropical Medicine & Global Health, University of Oxford, UK
31. Drs Benjamin Wilson, Matthew Keller, GH Labs, Seattle, Washington, USA	43. National Agency for Food and Drug Administration and Control, Abuja, Nigeria
32. Dr Carine Baxerres, Institut de Recherche pour le Développement, Marseille, France	

KIMORU Study Site, Kinshasa, DRC

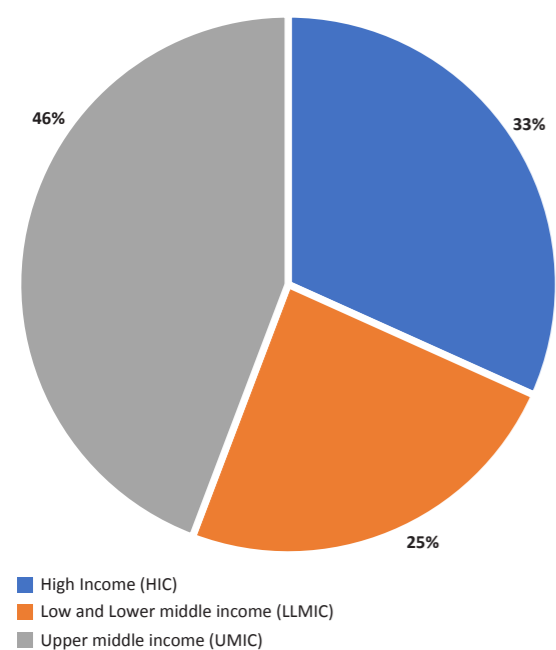
1. Kinshasa School of Public Health, DRC	7. Dr K. Plewes, Joint research projects, University of British Columbia, Canada
2. National Malaria Control Program Kinshasa, DRC	8. Dr A. Walden, Department of Intensive Care, Royal Berkshire Hospital, Reading, UK
3. Ministry of Health, DRC	9. Prof A. Goffi, Critical Care and Medicine Departments University of Toronto, Canada
4. Dr G. Bancone, Joint research projects, SMRU	10. Prof D. De Luca, Service de Pédiatrie, Hospital Antoine Béclère, France
5. Prof D. Kwiatkowski, Wellcome Trust Sanger Institute, Hinxton, UK	11. Dr F. Tshibusu Tshienda, Radiology University of Kinshasa Clinics, Kinshasa DRC
6. Prof O. Miotto, Joint research projects, University of Oxford, Wellcome Trust Sanger Institute, Hinxton, UK	12. FOSUN Pharmaceutical Company, PRC

Annex D

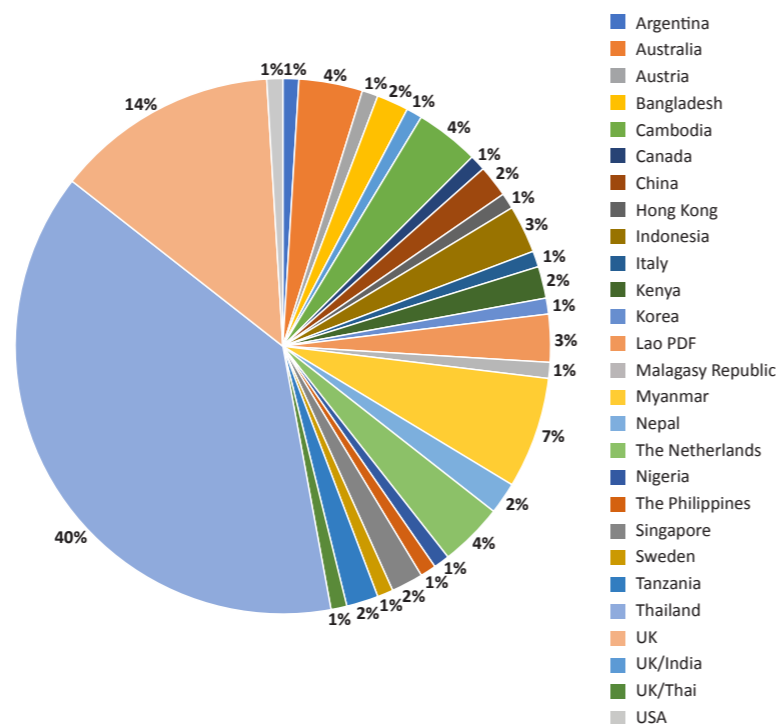
Postgraduate Students, Active or Graduated in 2021



Postgrads, active or graduated in 2021, by country income



Postgrads, active or graduated in 2021, by country



MORU Bangkok-based Departments

Malaria & Critical Illness

James Callery, UK, University of Oxford, The safety and tolerability of Triple Artemisinin-based Combination Therapies (TACTs), 2021, DPhil, Active, Malaria & Critical Illness and Clinical Pharmacology

Cintia Cruz, Argentina, University of Oxford, Pharmacometric determinants of efficacy in the treatment of Chagas disease, 2021, DPhil, Active, Malaria & Critical Illness and Clinical Pharmacology

Freek de Haan, Netherlands, University of Utrecht, The market positioning of Triple Artemisinin-based Combination Therapies in Southeast Asia and Africa, 2019, PhD, Active, Malaria & Critical Illness

Jureporn Duanguppama, Thailand, Mahidol University, Thesis title: Pending, 2019, PhD, Active, Malaria & Critical Illness

Rebecca Inglis, UK, University of Oxford, A mixed methods study to develop and evaluate a training course for doctors and nurses caring for critically ill patients in a low resource environment, 2017, PhD, Active, Clinical Researcher MORU, Malaria & Critical Illness, LOMWRU and University of Oxford

Kriangkrai Karnchaisri, Thailand, Mahidol University, Thesis title: Pending, 2019, PhD, Active, Malaria & Critical Illness

Chanon Kunasol, Thailand, Mahidol University, Genotyping in the field isolates of Plasmodium falciparum in endemic areas, 2016, PhD, Active, Malaria & Critical Illness

Salum Ahmed Mshamu, Tanzania, University of Oxford, Evaluation of the impact of novel house design on prevention of diseases, 2019, DPhil, Active, Malaria & Critical Illness

Puritrat Sinjanakhom, Thailand, Mahidol University, thesis title: Pending, 2019, PhD, Active, Malaria & Critical Illness

Rob van der Pluijm, Netherlands, University of Amsterdam, Artemisinin resistant malaria, 2015, PhD, Graduated 2021, Malaria & Critical Illness

Achaporn Yipsirimetee, Thailand, Mahidol University, Effects of ivermectin and its metabolites on sexual and asexual development of *Plasmodium falciparum*, 2016, PhD, Active, Malaria & Critical Illness

Microbiology

Sandra Adele, Nigeria, University of Oxford, Characterising the T cell responses to SARS-CoV-2 including variants of concern induced by natural infection and vaccines, 2021, DPhil student, active, Microbiology and University of Oxford

Mohammad Ali, Bangladesh, University of Oxford, The Impact of diabetes mellitus on immune responses to SARS-CoV-2 in acute and convalescent COVID-19 patients in Bangladesh, 2019, DPhil student, active, Microbiology and University of Oxford

Chawitar Arayanuphum, Thailand, Mahidol University, Prospective validation of diagnostic accuracy of Hcp-1 Ict as a point-of-care test for rapid detection of melioidosis using whole blood samples, 2017, PhD, Active, Microbiology

Piyaorn Chornchoem, Thailand, Mahidol University, Isolation and characterization of probiotic bacteria with antibacterial and immunomodulatory activities, 2018, PhD, Active, Microbiology

Suthida Chuenklin, Thailand, University of Oxford, Developing genetic tools to study the host-pathogen cell biology of *Orientia tsutsugamushi*, 2021, DPhil, Active, Microbiology

Witchayoot Huangsuranun, Thailand, University of Oxford, Developing multiplex molecular diagnostics for tropical pathogens, 2021, DPhil, Active, Microbiology

Thomas Hughes, UK, Open University, Studying the impact of zoonotic disease surveillance in the Orang Asli (indigenous population) communities of Peninsular Malaysia on reducing the risk of zoonotic disease emergence, 2016, PhD, Active, Microbiology

Manutsanun Inthawong, Thailand, Mahidol University, Rapid biomolecular-based identification for salmonella species using matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS), 2018, PhD, Active, Microbiology

Cherry Lim, Philippines, University of Oxford, Epidemiology and burden of AMR infections in South/ Southeast Asia and the effect of AMU on patient outcome, 2017, DPhil, Active, Microbiology

Suthee Mangmee, Thailand, Mahidol University, Dynamics of the immune responses to scrub typhus in non-human primate (Rhesus Macaque) model and in human studies, 2018, PhD, Graduated 2021, Microbiology

Nina Matsumoto, Australian, University of Sydney, Pig diseases in a transitioning economy: The epidemiology and socioeconomic effects of high-impact and zoonotic pig diseases in Lao PDR, 2019, PhD, Active, Microbiology (Co-supervision)

Isabel Neale, UK, University of Oxford, Defining immune correlates of protection against SARS-CoV-2 from a prospective study of vaccine breakthrough infections, 2021, DPhil student, active, Microbiology and University of Oxford

Carlo Perrone, Italy, Open University, Scrub typhus in Northern Thailand: exploring preventive, diagnostic and therapeutic challenges in the field, 2021, PhD, Active, Microbiology (CCRU) and Bioethics & Engagement

Anucha Preechanukul, Thailand, Mahidol University, Role of CD160 on NK cells in melioidosis, 2018, PhD, Active, Microbiology

Patpong Rongkard, Thailand, University of Oxford, thesis title pending, 2018, DPhil, Active, Microbiology and University of Oxford

Kartika Saraswati, Indonesia, University of Oxford, Scrub typhus in Indonesia, 2017, DPhil, Graduated 2022, Microbiology

Rathanin Seng, Thailand, Mahidol University, Molecular epidemiology and genetic mutation of *Burkholderia Pseudomallei* in clinical melioidosis in Thailand, 2018, PhD, Active, Microbiology

Ampai Tanganuchitcharnchai, Thailand, Mahidol University, Development of recombinant antigens to improve rickettsial diagnostics, 2019, PhD, Active, Microbiology

Epidemiology

Yalda Jafari, Canada, University of Oxford, Understanding transmission dynamics of dengue in Thailand to support real-time decisions on intervention targeting, 2021, DPhil, Active, Epidemiology

Monnaphat Jongdeepaisal, Thailand, University of Oxford, Sustaining village malaria worker programs with expanded roles in the Greater Mekong Subregion: a mixed-method study in Cambodia, Thailand and Vietnam, 2021, DPhil, Active, Epidemiology

Frank Kagoro, Tanzania, University of Cape Town, Impactful maps and associated visualisations on antimalarial drug resistance for malaria programmes and policymakers in Southern Africa and Southeast Asia, 2017, PhD, Active, Epidemiology

Mohammad Jariul Karim, Bangladesh, Open University, Epidemiological analysis and mathematical modelling for elimination of malaria in Bangladesh, 2016, PhD, Active, Epidemiology and MAEMOD

Pengby Ngor, Cambodia, Open University, Informatics for integrated malaria elimination strategy in Cambodia, 2014, PhD, Active, Epidemiology and MAEMOD

Ipsita Sinha, UK, University of Oxford, Mapping and predicting the potential spread of malaria in Southeast Asia and Bangladesh to better inform targeting of malaria control and elimination interventions, 2017, DPhil, Active, Epidemiology

Ratchaneewan Sinitkul, Thailand, University of Oxford, Does urban chemical exposure influence biomarkers of immune development in infants born in Thailand?, 2017, DPhil, Active, Epidemiology

Greta Tam, Hong Kong, University of Hong Kong, Thesis title: Pending, 2019, PhD, Active, Epidemiology

Qian Wang, China, University of Oxford, Spatiotemporal dynamics of dengue and scrub typhus in China, 2021, DPhil, Active, Epidemiology

Clinical Pharmacology

James Callery, UK, University of Oxford, The safety and tolerability of triple artemisinin-based combination therapies (TACTs), 2021, DPhil, Active, Malaria & Critical Illness and Clinical Pharmacology

Cintia Cruz, Argentina, University of Oxford, Pharmacometric determinants of efficacy in the treatment of Chagas disease, 2021, DPhil, Active, Malaria & Critical Illness and Clinical Pharmacology

Yamin Granberg, Sweden, Karolinska Institute, Function and quality of life after extremity trauma, 2015, PhD, Active, Clinical Pharmacology and Department of Molecular Medicine and Surgery (Co-supervision)

Bioethics & Engagement

Rachel Claire Greer, UK, Open University, Evaluation of C-reactive protein point of care testing, and associated research challenges, to improve the quality of antibiotic prescribing in the community in North Thailand, 2017, PhD, Active, Bioethics & Engagement, CCRU (Microbiology) and MAEMOD

Carlo Perrone, Italy, Clinical Tropical Medicine, Open University, UK, Scrub typhus in Northern Thailand: exploring preventive, diagnostic and therapeutic challenges in the field, 2021, PhD, Active, CCRU (Microbiology) and Bioethics & Engagement

Naomi Waithira, Kenya, University of Oxford, Promoting reuse of clinical research data, 2020, DPhil, Active, CTSG and Bioethics & Engagement

MAEMOD

Toby Bonvoisin, UK, University of Oxford, Evaluating interventions to reduce transmission of respiratory pathogens in hospitals, 2021, DPhil, Active

Arjun Chanda, UK, University of Oxford, Prediction of disease severity in patients with febrile illness in resource-limited settings, 2019, DPhil, Active, COMRU and MAEMOD

Chris (Rusheng) Chew, Australia, University of Oxford, Development of dynamic algorithms for empirical antibiotic treatment in the rural tropics, 2021, DPhil, Active, MAEMOD

Pavadee Chuaicharoen, Thailand, Mahidol University, Thesis title: Pending, 2020, PhD, Active, MAEMOD

Rachel Claire Greer, UK, Open University, Evaluation of C-reactive protein point of care testing, and associated research challenges, to improve the quality of antibiotic prescribing in the community in north Thailand, 2017, PhD, Active, Bioethics & Engagement, CCRU (Microbiology) and MAEMOD

Pengby Ngor, Cambodia, Open University, Informatics for integrated malaria elimination strategy in Cambodia, 2014, PhD, Active, Epidemiology and MAEMOD

Mathupanee Oonsivilai, Thailand, University of Oxford, Using mechanistic models to understand the impact of spatiotemporal heterogeneity in patterns of antimicrobial use in Southeast Asia on antimicrobial resistance, 2019, DPhil, Active, MAEMOD and University of Oxford

Mark Pritchard, UK, University of Oxford, Modelling the role of hospitals and hospital referral networks in the transmission of emerging and re-emerging pathogens, YEAR, DPhil, Active

Myo Maung Maung Swe, Myanmar, University of Oxford, Defining the epidemiology of fever and generating new treatment algorithms for febrile illness in rural Myanmar, 2018, DPhil, Active, MOCRUC and MAEMOD

Weerakorn Thichumpa, Thailand, Mahidol University, Modeling of rabies infection dynamics (pet dogs), 2019, PhD, Active, MAEMOD

Sai Thein Than Tun, Myanmar, University of Oxford, Modelling of malaria elimination in dynamic populations, 2019, DPhil, Active, MAEMOD and University of Oxford

Mo Yin, Singapore, University of Oxford, Defining antibiotic treatment duration and its impact on antimicrobial resistance, 2017, DPhil, Active, MAEMOD and University of Oxford

Meiwen Zhang, China, University of Oxford, Defining the hidden burden of disease in rural communities in South and Southeast Asia, 2021, DPhil, Active, MAEMOD

Clinical Therapeutics Unit (CTU)

Cintia Cruz, Argentina, University of Oxford, Pharmacometric determinants of efficacy in the treatment of Chagas disease, 2021, DPhil, Active, Malaria & Critical Illness, Clinical Pharmacology and CTU

William Schilling, UK, University of Oxford, COVID-19, 2020, DPhil, Active, CTU

Clinical Trials Support Group (CTSG)

Naomi Waithira, Kenya, University of Oxford, Promoting reuse of clinical research data, 2020, DPhil, Active, CTSG and Bioethics & Engagement

MORU Units

Chiangrai Clinical Research Unit (CCRU)

Rachel Claire Greer, UK, Open University, Can Testing for C-reactive protein improve the targeting of antibiotics in the community, 2017, PhD, Active, Bioethics & Engagement, CCRU (Microbiology) and MAEMOD

Carlo Perrone, Italy, Clinical Tropical Medicine, Open University, Scrub typhus in northern Thailand: exploring preventive, diagnostic and therapeutic challenges in the field, 2021, PhD, Active, CCRU (Microbiology) and Bioethics & Engagement

Tri Wangrangsimakul, UK, University of Oxford, Scrub typhus in northern Thailand, 2017, DPhil, Active, CCRU (Microbiology) and University of Oxford

Shoklo Malaria Research Unit (SMRU)

Marieke Bierhoff, Netherlands, University of Amsterdam, New strategies for prevention of mother to child transmission of hepatitis B in a resource poor setting, 2017, PhD, Graduated 2021, SMRU

Tobias Brummaier, Germany, Swiss Tropical Institute, Molecular signature in infectious diseases, 2016, PhD, Active, SMRU

Ellen Kearney, Australian, The University of Melbourne, Anopheles' salivary antigens as biomarkers for mosquito and malarial exposure in the Greater Mekong Subregion, 2019, PhD, Active, SMRU (Co-supervision)

Aung Myat Min (Aye Min), Myanmar, University of Oxford, Optimising material and fetal outcomes along Thai Myanmar border, 2019, DPhil, Active, SMRU

Jade Rae, Australia, Open University, Optimising surveillance and intervention delivery to achieve *P. falciparum* elimination in Kayin State, Myanmar, 2019, PhD, Active, SMRU

Lao-Oxford-Mahosot Hospital-Wellcome Trust Research Unit (LOMWRU)

Tehmina Bharucha, UK, University of Oxford, Identification of diagnostic protein biomarkers of neurological infections, 2018, DPhil, Active, University of Oxford and LOMWRU

Vilada Chansamouth, Lao PDR, University of Oxford, Evaluating the impact of a Lao language mobile phone antimicrobial use guideline application on antimicrobial prescribing in Laos, 2019, DPhil, Active, LOMWRU

Rebecca Inglis, UK, University of Oxford, ICU performance in Lao PDR, 2016, DPhil, Active, Malaria & Critical Illness, LOMWRU and University of Oxford

Cambodia-Oxford Medical Research Unit (COMRU)

Arjun Chanda, UK, University of Oxford, Prediction of disease severity in patients with febrile illness in resource-limited settings, 2019, DPhil, Active, COMRU and MAEMOD

Bahar Holly Kashef Hamadani, USA, University of Oxford, The global burden and geospatial distribution of antimicrobial resistance in selected Gram-negative bacterial infections, 2018, DPhil, Active, COMRU and Oxford Big Data Institute

Justin Im, Korea, University of Oxford, Aspects of disease burden and risk factors for invasive bacterial disease in low- and middle-income countries, 2017, DPhil, Active; COMRU, OUCRU and International Vaccine Institute (IVI)

Kaajal Patel, UK, Open University, The evaluation of a mentorship programme to improve healthcare provision in rural Cambodia, 2020, PhD, Active, COMRU

Myanamr-Oxford Clinical Research Unit (MOCRU)

Hein Aung, Myanmar, University of Amsterdam, Aetiological factors and options for prevention and treatment for children with rickets in Nagaland, North-West Myanmar, 2021, PhD, Active, MOCRU

Thomas Lamb, UK, University of Oxford, Determining optimal dose of antivenom for *Daboia siamensis* envenoming, 2020, DPhil, On hold, MOCRU

Myo Maung Maung Swe, Myanmar, University of Oxford, Defining the epidemiology of fever and generating new treatment algorithms for febrile illness in rural Myanmar, 2018, DPhil, Active, MOCRU and MAEMOD

Ni Ni Tun, Myanmar, University of Antwerp, Management of HIV and co-infections in Myanmar, 2021, PhD, Active, MOCRU

EOCRU Indonesia (OUCRU network)

Kartika Saraswati, Indonesia, University of Oxford, Scrub typhus in Indonesia, 2018, DPhil, Active, EOCRU

Robert Sinto, Indonesia, University of Oxford, Associations between blood culture utilization, antimicrobial use, and antimicrobial-resistant infections in Indonesian national referral hospital, 2021, DPhil, Active, EOCRU

Faculty of Tropical Medicine, Mahidol University

Nabaraj Adhikari, Nepal, Mahidol University, Bacterial etiology of acute undifferentiated febrile illness among patients visiting three selected hospitals in Nepal, 2021, PhD, Active, Clinical Tropical Medicine

Abigail Hui En Chan, Singapore, Mahidol University, Development and evaluation of a DNA metabarcoding approach for molecular identification of parasitic helminths, 2021, PhD, Active, Department of Helminthology

Atthasit Rabiabok, Thailand, Mahidol University, Thesis title: Pending, 2017, PhD, Active, Clinical Tropical Medicine

Dora Murielle Rajonhson, Malagasy Republic, Mahidol University, Mosquito vector - mosquito specific virus interactions: *Aedes aegypti* - cell fusing agent virus, 2017, PhD, Active, Medical Entomology

Upendra Thapa, Nepal, Mahidol University, The aetiology of viral infections in acute febrile illness at three tertiary care hospitals in Nepal, 2020, PhD, Active, Clinical Tropical Medicine

MSc Students

Microbiology

Phumrapee Boonklang Thailand, University of Cambridge, Defining gene expression signatures for fatal and non-fatal melioidosis from Thailand, 2022, MPhil, preparation, Microbiology-Bioinformatics (Sanger MPhil scholarship)

Chalita Chomkatekaew Thailand, Imperial College London, Evolution of *Burkholderia pseudomallei* antibiotic synthesis and resistance genes, 2021, MPhil, Active, Microbiology-Bioinformatics (Wellcome International Master Fellowship)

Epidemiology

Nutcha Nontarak, Thailand, Asian Institute of Technology, Deriving climate measures from remote sensing for predicting vector-borne disease incidence, 2020, MSc, Active, Epidemiology

Kunlathida Sranam, Thailand, Asian Institute of Technology, Association of land use change with dengue incidence, 2020, MSc, Active, Epidemiology

Bioethics & Engagement / Chiangrai Clinical Research Unit (CCRU)

Nipaphan Kanthawang, Thailand, Major Border Health Management, Mae Fah Luang University, Thailand, 2019, MPH, Active, Bioethics & Engagement and CCRU (Microbiology)

SMRU

Humayra Bashir, UK, University of Oxford, The impact of antenatal corticosteroids on early neonatal death, neonatal death and neurodevelopment in preterms in a limited resource setting on the Thailand- Myanmar border, MSc IHTM, Graduated 2021 (Co-supervision from SMRU)

Tabitha Ashley-Norman, UK, University of Leeds, The use of structured clinical interviews for DSM-4 (SCID) to inform future practice for supporting the mental health of pregnant refugee and migrant women living along the Thai-Myanmar border, Intercalated BSc in International Health, Graduated 2021 (Co-supervision from SMRU)

Janna Thecla Prüst, The Netherlands, Vrije Universiteit Amsterdam, MSc International Public Health, Evaluation of gestational diabetes screening policy: an observational cohort study among migrants on the Myanmar-Thai border, Graduated 2021 (Co-supervision from SMRU)

LOMWRU

Vilayouth Phimolsarnnousith, Lao PDR, London School of Hygiene & Tropical Medicine, 2021, MSc in Medical Microbiology, Active

Vanheuang Phommadeeck, Lao PDR, Mahidol University, 2019, MSc in Tropical Medicine, Medical Entomology, Active, LOMWRU

COMRU

Soputhy Chansovannara, Cambodia, National Institute of Public Health, 2021, MSc in Epidemiology, Active

MOCRU

Dr Ni Ni Tun, Myanmar, Tropical Institute of Antwerp, 2019, MSc Tropical Medicine and Research, Graduated 2021, MOCRU

Mahidol-Oxford Tropical Medicine Research Unit (MORU)

Faculty of Tropical Medicine
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420/6 Ratchawithi Rd., Ratchathewi District
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