

2021 ANNUAL REPORT



Groupe
Recherche
Action en
Santé



GRAS 2021 ANNUAL REPORT

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Abbreviations

ASTMH	American society of tropical medicine and hygiene
ACPR	Adequate clinical and parasitological response
AE	Adverse event
AL	Artemether – Lumefantrine
PRIMVAC	Candidate vaccine against placental malaria
CDC	Center for disease control and prevention
CERMEL	Centre de recherches médicales de Lambaréné
HEALTH FACILITY	Centre de santé de promotion sociale
CIDRZ	Centre for infectious disease research in Zambia
MCSU	Medical centre with surgical unit
CMASMK	Centre médical Saint Maximilien Kolbe
CNRST	Centre national de la recherche scientifique et technologique
CISM	Centro de investigação em saúde de Manhiça
ACT	Artemisinin-based combination therapy
CERS	Comité d'éthique pour la recherche en santé
CNLP	Centre national de lutte contre le paludisme
Cmax	Maximum concentration
Cmax of ART	Maximum concentration of Artemether
DGD	Data management department
DPCF	Department of pharmacy and cold chain
DECEE	Department of clinical trials and epidemiological studies
DSBM	Department of biomedical sciences
DCOS	Department of clinical operations sciences
DSS	Department of social sciences
DHA-PQ	Piperaquine Dihydroartemisinin
HD	Health district

EDCTP	European and developing countries clinical trials
EVI	European vaccine initiative
FONRID	Fonds national de la recherche et de l'innovation pour le développement
GSK	GlaxoSmithKline
GRAS	Groupe de recherche action en santé
IgG	Immunoglobulin G
IgM	Immunoglobulin M
IDRC	Infectious diseases research collaboration
IASP	Institut africain de santé publique
IRSS	Institut de recherche en sciences de la santé
INSP	Institut national de santé publique
ISSP	Institut supérieur des sciences de la population
IVI	International vaccine institute
LUMC	Leiden university medical center
LSHTM	London school of hygiene & tropical medicine
LIH	Luxemburg institute of health
COVID-19	Coronavirus disease 2019
NTD	Neglected tropical disease
MMV	Medicine for malaria venture
MESRSI	Ministère de l'enseignement supérieur, de la recherche scientifique et de l'innovation
MSPH	Ministère de la santé et de l'hygiène publique
PK	Pharmacokinetics
PBPK	Physiological based pharmacokinetics
Pyr-AS	Pyronaridine - Artesunate
QMS	Quality management system
REDCap	Research electronic data capture
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
SAE	Serious adverse event

PCT	Parasite clearance time
TBV	Transmission-blocking vaccine
FCT	Fever clearance time
VAR2CSA	Var gene 2 circums sporozoite antigen
WACCBIP	West african centre for cell biology of infectious pathogens
WHO	World health organization

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PREAMBLE

This report of activities of the Groupe de Recherche Action en Santé (GRAS) for the year 2021 presents a range of activities and results acquired, especially in a context of hope with the gradual end of the harmful consequences of COVID-19. Compared to 2020, the volume of this report reflects an increase in the quantity and quality of activities. This is to the credit of GRAS staff, as well as its national and international partners. We will note in terms of innovation, the internal scientific presentations that are held regularly.

In accordance with its vision and mission, the institute, composed of multidisciplinary teams, has worked in synergy to generate research results that, we hope, will contribute a little to inform and/or guide decision-makers more for the improvement of the health of populations in Burkina Faso and why not beyond our borders.

To better fulfil this function, GRAS has embarked on a daily quest for excellence through the deployment of its quality management system (QMS), in order to quickly become a reference centre for biomedical and operational research in West Africa.

By congratulating it, we would like to exhort the entire team to build on the achievements of 2021.

The Chief Executive Officer



Dr Sodiomon B. SIRIMA, MD, BA, PhD

Chevalier de l'Ordre National

INTRODUCTION

The improvement of the health and living conditions of populations, especially those of vulnerable groups, is a major concern for the Groupe de Recherche Action en Santé (GRAS). GRAS is a human health research institute engaged with many national and international partners, to find solutions to the various scourges caused mainly by infectious diseases that reign in mastery especially in sub-Saharan Africa. In the implementation of its programme of activities, GRAS maintains a good collaboration with various structures in Burkina Faso, Africa and the world.



Thus, the Groupe de Recherche Action en Santé conducted a significant number of research activities during 2021.

1. PRESENTATION OF GRAS

Founded in January 2008, the Groupe de Recherche Action en Santé (GRAS) is a private research institute of international reference based in Ouagadougou, Burkina Faso. It has been approved by the Ministère de l'Enseignement Supérieur, de la Recherche Scientifique et de l'Innovation of Burkina Faso, under the authorization number 2020/0000669/MESRSI/SG/DGRSI of 25th June 2020, making it as the pioneer in the field of clinical and biomedical research in the country. With its knowledgeable and experienced research staff, GRAS's main motivation is to boost the contribution of the private sector to health research alongside the public sector. It is a framework for pooling, expressing and exchanging expertise to promote excellence for the benefit of human health. Through this synergistic convergence, the institute conducts quality research studies, meeting international standards, in order to guide the decisions of governments for a continuous improvement of the health of the population.

Since its creation, GRAS aims to become a centre of excellence in biomedical and operational research in West Africa. To achieve this, the Institute's main missions are to contribute to the

resolution of public health problems through innovative health research and, hence, to the improvement of the health of populations and, to contribute to strengthening the skills of health research actors. The GRAS also aims to meet the needs and expectations of relevant customers and stakeholders by implementing a quality approach in line with the standards of ISO 9001 version 2015, to establish itself as a leading institute committed to innovative health research.

1.2 GRAS head office

The GRAS headquarters is located in the Somgandé district (sector 29) of Ouagadougou. It has satellite sites in urban and rural areas. Depending on the volume of activities, some GRAS interventions are carried out in health facilities at the urban level (Kossodo district hospital, Schiphra Hospital, Ouagadougou), semi-urban (Kaya health district) and rural (Saponé health district).

1.3 Satellite sites

The GRAS has satellite sites or research antennas for the conduct of the field activities. We have the research antennas located in the Centre Médical Saint Maximilien Kolbe (CMAMK) in Sabou and at the District Hospital (CM) of Banfora. Satellite sites outside Ouagadougou have the necessary infrastructure, logistic resources and human resources based on site for the conduct of activities. Nevertheless, depending on the needs, these systems can be strengthened.

1.4 GRAS organization

The institute is staffed by a multidisciplinary team, the majority of whom has extensive experience in health research. 2021 was a year of restructuring and strengthening specific staff. The organization chart was improved with more coherent and operational structure.

GRAS has a General Direction, an Administrative and Financial Direction (Human Resources Department, Project Management Department and Capital Department), a Quality Management Department and a Scientific Direction.

The Scientific Direction is the backbone of the institution and has six (06) departments (Figure 1) working on three main axes: research, training and provision of services.

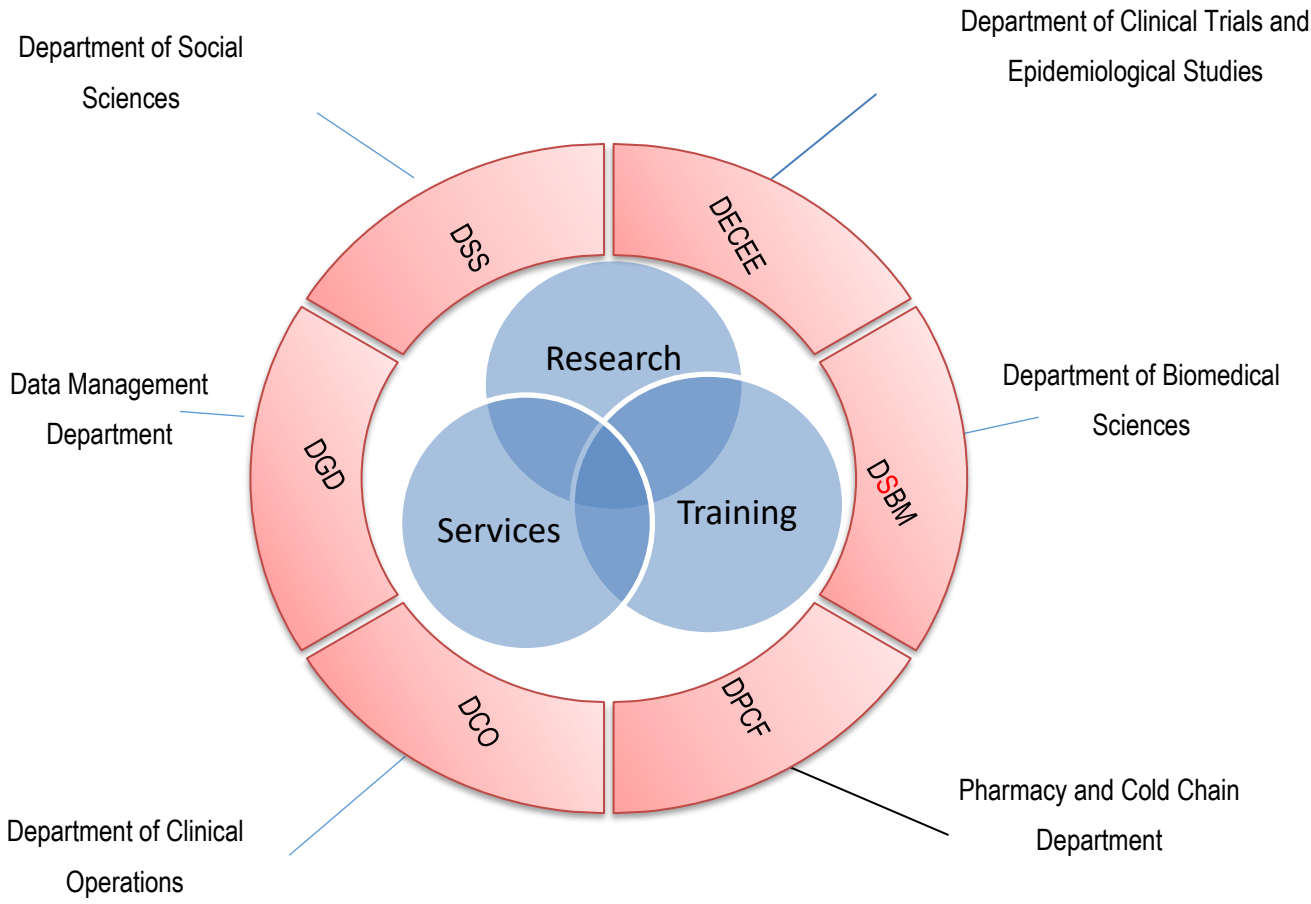


Figure 1: Organization of the scientific direction of GRAS

- **Department of Clinical trials and Epidemiological studies (DECEE):** It is responsible for the design and conduct of clinical studies. It is also committed to the capacity building of health research teams and junior researchers training in Burkina Faso and elsewhere. This department is composed of epidemiologists, clinical trial specialists, clinical research coordinators, doctors and clinical study nurses.

- **Department of Biomedical Sciences (DSBM):** It participates in the design and implementation of both fundamental and interventional studies. It is responsible for biological assessments by ensuring the pre-analytic, analytical and post-analytical assessment. It provides training for biomedical personnel (biomedical technicians, biologists, nurses, etc.), as well as student and the monitoring and supervision of laboratory activities. It has a technical platform with the latest equipment in molecular biology, immunology, bacteriology, virology, parasitology, biochemistry and haematology. This includes, among other things, a sequencer for the identification of variants of SARS-CoV2, *falciparum* malaria with the possibility to explore

gene variants of other infectious pathogens and a Luminex platform allowingsimultaneous determination of numerous protein and nucleic targets.

A quality management system has been set up to control performance and quality in order to meet the needs and requirements of users. The department is enrolled in external quality programs (Blood parasites, Haematology and Biochemistry) with the College of American Pathologist (CAP), based in the United States of America and with Clinical Laboratory Services (CLS) for blood parasites, based in Johannesburg in South Africa.

The team is certified for the management of hazardous biological samples according to IATA rules. It is composed of biologists, pharmacists and biomedical technologists.

- **Department of Pharmacy and Cold chain (DPCF):** The cold chain and the management of products under investigation are crucial in the implementation of clinical research projects. Ths edepartment is composed mainly of pharmacists, state pharmaceutical preparers and biologists. It is responsible for:
    - managing the receipt and storage, of investigational products in accordance with applicable rules and manufacturer's requirements;
    - shipment of investigational products across study sites in accordance with manufacturer's requirements
    - preparing and administering the investigational drug to clinical trial participants;
    - the destruction of investigational products in accordance with study protocol requirement and international regulations
    - ensuring the maintenance and proper functioning of the cold chain for the preservation of investigational products and biological samples.

- **Department of Clinical Operations (DCO):** This is an internal support group for clinical research activities. It is composed of physicians, biologists, epidemiologists, clinical researchers and project managers. This group is oriented towards production of quality services for any clinical study sponsored in Africa, according to international standards, the clinical trial sponsor's standard operating procedures and regulatory requirements.

- **Data Management Department (DGD):** With solid experience in the use of several data management software such as Epi Info, Dbase, File Maker Pro, Microsoft Access, KoboCollect, RedCap Open Clinica and, Df Explorer etc., This department has a real-time clinical study data management system through a system network and high-speed Internet access, a data archiving system, according to good clinical practices. It is also experienced in the electronic data capture system with a daily data security procedure. The team is ready to provide this expertise to clinical research promoters in Africa for the development,

maintenance and cleaning of databases, according to good clinical practices. This department consists of data managers and data entry officers.

- **Department of Social Sciences (DSS):** It is responsible for the design, conduct of socio-anthropological studies and is strongly involved in the design and conduct of operational studies. It constitutes a support group in the conduct of clinical trials, research studies based on demographic and health surveillance systems. This department is composed of socio-anthropologists, demographers, field workers, etc.

2. GRAS COOPERATION AGREEMENT

2.1. Cooperation agreement with the Ministry of Health

GRAS, through a collaboration agreement between the Ministry of Health, is authorized to operate throughout the country. In return, the GRAS has committed to respect the health policy, to send annual reports of health activities to the districts and regional health directorates of its intervention areas, provide to the Ministry of Health an annual report on health activities and also the annual program of its activities.

2.2. Other collaboration agreements

In addition to the Ministry of Health, GRAS has also signed collaboration agreements with public and private structures working in the field of human health. These are, among others:

- ✓ le Centre National de la Recherche Scientifique et Technologique ;
- ✓ Saint Maximilian Kolbe medical center of Sabou;
- ✓ Sabou health district;
- ✓ Banfora health district;
- ✓ Schiphra Hospital in Ouagadougou ;
- ✓ l'Institut Supérieur des Sciences de la Population.



3. PHYSICAL ASSESSMENT 2021

3.1 GRAS Staff

The GRAS team is multidisciplinary and includes epidemiologists, clinical trial specialists, physicians, pharmacists, biologists, sociologists, data managers, research assistants, administrative staff, nurses and support staff (Table 1).



***Table 1**: Situation of permanent GRAS staff*

Designation	Number of officers	Percentage
Researchers	20	31.7%
Technicians	27	42.9%
Administrative staff	16	25.4%
TOTAL	**63**	**100%**

3.2 Update on research projects and training carried out in 2021

3.2.1 Research Activities

In 2021, GRAS implemented 14 research and training projects (Tables 2 and 3) focused primarily on malaria and diarrheal diseases.

- In the fight against malaria, the following activities were carried out:
  - malaria vaccines trials assessment: two vaccine trials were implemented: two baseline studies to prepare sites for malaria vaccine trials, and one study for theselection of future vaccine trial sites;



- antimalarial treatments: studies on new antimalarials and optimization of the use of current antimalarial treatments to strengthen the health system in malaria management have been conducted;
- basic research focused on seasonal malaria chemo prevention, interaction between COVID-19 disease and malaria, surveillance of malaria resistance markers;

❖ Vaccines against diarrheal diseases and urinary schistosomiasis: the release of data from the Typhoid fever vaccine trial and the start of the baseline study on Shigellosis to generate important data on the disease with a view of preparing a vaccine trial. Preparation activities for a vaccine trial against schistosomiasis were also conducted.





❖ Training on good data and student management practices.

Table 2: *Progress Report of Research Projects in AP 2021*

	Number of projects planned	Number of projects carried out	Rate of completion
Research projects	15	12	80%

Table 3: Summary of projets conducted by GRAS during 2021.

(See the following pages)

Table 3: list of projects conducted in 2021

N°	Title of the project	Collaborators / Partners	Sources of financing
Projects started or still in progress in 2021			
1	Evaluation of the safety and immunogenicity of the BK-SE36/CpG malaria vaccine candidate in healthy African adults and children exposed to malaria and residing in Burkina Faso (SEMALVAC 2).	Nobel Pharma, University of Osaka ; European Vaccine Initiative (EVI) en Allemagne; Institut de Recherche en Science de la Santé (IRSS), Schiphra Hospital in Ouagadougou.	Global Health Innovative Technology (GHIT) Nobelpharma Co.
2	Preparatory to conduct phase II of the candidate NPC-SE36/CpG malaria vaccine (SEMALVAC 4).	Nobel Pharma, University of Osaka. European Vaccine Initiative (EVI) en Allemagne; Research Institute for microbial diseases.	Global Health Innovative Technology (GHIT)
3	Baseline cohort study to assess malaria-related morbidity in children living in future trial sites of malaria candidate vaccines - MIMVaC- Africa (BLOOMY).	Ifakara Health Institute Trust (IHI), Tanzania; Centre de Recherches Médicales de Lambaréné (CERMEL), Gabon ; Fundação Manhiça (FM), Mozambique ; Eberhard Karls Universität Tübingen (EKUT), Germany ; University of Oxford, England ; EVI, Germany ; Academisch Ziekenhuis Leiden (LUMC), Netherlands ; Luxembourg Institute of Health (LIH), Luxembourg ; Osaka University, Japan, Banfora Health District.	European and Developing Countries Clinical Trials Partnership (EDCTP) 2
4	Community dynamics of malaria transmission and mosquito blood feeding in Sabou region, Burkina Faso (CODYMAT).	Université des Sciences, des Techniques et des Technologies de Bamako (USTTB), Mali; Statens Serum Institut, Copenhagen, Denmark ; Centre National de Formation et de Recherche en Santé Rurale Jean SENECAL de Maferinyah, Guinea ; National Public Health Institute of Liberia, Liberia ; Stichting Katholieke Universiteit, Netherlands ; PATH, United States, National Institute of Allergy and Infectious Diseases, United States ; Sabou Health District .	European and Developing Countries Clinical Trials Partnership (EDCTP) 2

5	Phase 2 and 3 trial to evaluate the safety, efficacy and transmission blocking properties of the new antimalarial formula KAF156 and lumefantrine (WANECAM 2).	Université des Sciences, des Techniques et des Technologies de Bamako (USTTB), Mali ; Centre de Recherches Médicales de Lambaréné (CERMEL), GABON : Institut des Sciences et Techniques de Bobo (INSTech-Bobo), Burkina Faso ; Universite Abdou-Mounouni in Niamey, Niger ; London School of Hygiene & Tropical Medicine, UK ; University of Tübingen, Germany; Karolinska Institutet Stockholm County, Sweden; Amsterdam UMC, Holland; Université Claude Bernard Lyon1, France.	European and Developing Countries Clinical Trials Partnership (EDCTP) 2
6	Portfolio approach to developing the next generation of malaria treatments for Africa (PAMAfrica).	Novartis ; Medicines for Malaria Venture (MMV) Institut de Recherche en Science de la Santé (IRSS) : Fundação Manhiça (FM), Mozambique ; Eberhard Karls Universität Tübingen (EKUT), Barcelona Institute for Global Health. Lambaréné Medical Research Center (CERMEL): Infectious Diseases Research Collaboration (IDRC).	European and Developing Countries Clinical Trials Partnership (EDCTP) 2
7	Feasibility, acceptability and cost of the implementation of a multiple first line treatment strategy using artemisinin-based therapeutic combinations for the treatment of uncomplicated malaria: a pilot study in the Kaya health district in Burkina Faso (MFT).	Medicines for Malaria Venture (MMV), Geneva, Switzerland ; Programme National de Lutte contre le Paludisme (PNLP), Burkina Faso; IRSS, Burkina Faso.	Medicines for Malaria Venture (MMV)
8	Impact of seasonal malaria chemoprevention on the development of protective immunity and protection against clinical malaria in Burkina Faso (ISCHEMIC).	Kemri-Welcome Trust research program, Kilifi, Kenya; Karolinska Institut, Sweden; Stockholm University, Sweden; Sabou Health District.	European and Developing Countries Clinical Trials Partnership (EDCTP) 2
9	Tracking COVID-19 infection in West Africa to inform public health interventions (COVI-AO)	Institut de Recherche en Sciences de la Santé (IRSS), Burkina Faso ; Centre d'Excellence Africain en Innovations Biotechnologiques pour l'Elimination des Maladies à Transmission Vectorielle (CEA/ITECH-MTV), Université Nazi BONI, Bobo-Dioulasso, Burkina Faso.	Rockefeller Fondation

10	Malaria as a risk factor for COVID-19 in Western Kenya and Burkina Faso (MALCOV)	École de médecine tropicale de Liverpool (LSTM), Royaume-Uni London School of Hygiene & Tropical Medicine (LSHTM) Kemri-Welcome Trust research programme, Kilifi.	Bill and Melinda Gates Fondation
11	Long-term follow-up of the immunological profile and pregnancy outcomes of women previously enrolled in the phase 1b clinical trial of the candidate vaccine PRIMVAC against malaria during pregnancy.	Institut national de la santé et de la recherche médicale (INSERM), France ; European Vaccine Initiative (EVI), Germany	Global Health Innovative Technology (GHIT), Japan
12	Evaluation of *Plasmodium falciparum* genotypes and resistance markers in malaria-infected patients living in two health districts as part of molecular malaria surveillance at sentinel sites of the National Malaria Programme malaria in Burkina Faso (BMG-GC).	Programme National de Lutte contre le Paludisme (PNLP), Burkina Faso	Bill and Melinda Gates Fondation
13	Evaluation of the long-term immunity of subjects who participated in the randomized, double-blind, controlled trial on the safety and immunogenicity of the conjugate typhoid vaccine (Vi-TCV) in children under 2 years of age in Ouagadougou, Burkina Faso (TYVAC2)	University of Maryland-Baltimore; Centre de développement des vaccins et santé globale.	Bill and Melinda Gates Fondation
14	A baseline study for clinical evaluation of an Oral vaccine candidate against Shigellosis. (SHIGORAVAX).	European Vaccine Initiative (EVI), Germany; University of Gothenburg (UGOT) Gothenburg, Sweden; Leiden University Medical Centre, Netherlands; Centre for Infectious Disease Research in Zambia (CIDRZ), Lusaka, Zambia ; MSD Wellcome Trust Hilleman Laboratories, India.	European and Developing Countries Clinical Trials Partnership (EDCTP) 2
15	Schistosomiasis Vaccine for Africa: A Phase 1 Study of Shistosomiasis Vaccine SchistoShield® in Adults in Endemic Areas in Sub-Saharan Africa (VASA).	The Chancellor Masters and Scholars of the University of Cambridge, UK; Academisch Ziekenhuis Leiden, Hollande; Goeteborgs Universitet, Sweden; Eberhard Karls Universitaet Tuebingen, Allemagne ; University of Antananarivo, Madagascar; Université de Ouagadougou, Burkina Faso ; Texas Tech University, Etats-Unis d'Amérique ; PAI Life Sciences Inc, USA ; International Vaccine Institute, South Korea.	European Union (EU)

3.2.1.1. Development of antimalarial vaccine trials

3.2.1.1.1. SEmalvac 2 Study

SEmalvac 2 : Evaluation of the safety and immunogenicity of the BK-SE36/CpG malaria vaccine candidate in healthy African adults and children exposed to malaria and residing in Burkina Faso (SEmalvac2)

As part of the development of effective malaria vaccines, a phase Ib clinical study that was underway was completed by GRAS in 2020. This is a clinical trial of decreasing age to evaluate the safety and immunogenicity of the blood-phase recombinant malaria vaccine candidate, BK-SE36.



The purpose of the study was to evaluate the safety and reactogenicity of 3 doses of the candidate BK-SE36 malaria vaccine (100µg SE36 protein + aluminum hydroxide gel).

The study took place at the Schiphra hospital from 2018 to 2020, where 135 participants in 3 different cohorts were vaccinated according to the study procedures. It was a phase Ib controlled, double-blind randomized trial with participants of decreasing age.

Cohort 1 consisted of adults aged 21 to 45 (n=45), Cohort 2 of children aged 5 to 10 (n=45) and Cohort 3 of children aged 12 to 24 months (n=45). Recruitment and follow-up of study participants was completed in 2019.

During 2021, the main activities related to this research project were the management of study data and the processing of biological samples.

3.2.1.1.2. SEMALVAC 4 Study

SEmalvac 4 : Preparation of the implementation of a phase II malaria vaccine candidate : NPC-SE36/CpG

2021 for SEmalvac4 was a preparatory step to conduct phase 2 trial. BKSE36 is a blood stage vaccine candidate that showed promising results in a phase Ia trial in Japanese adults not exposed to malaria, as well as in phase 1b trials of healthy subjects residing in malaria endemic regions such as Burkina Faso. The promising results of this trial justified the selection of study sites in Africa to conduct a large phase 2 efficacy study. This study will evaluate the efficacy of the SE36 vaccine candidate in healthy children (less than 5 years , age group where the burden of malaria is high) living in Africa.

The study could not start in 2020 due to the Covid-19 pandemic. The major activities during 2021 wee the finalization of the questionnaires for the evaluation of the sites, the finalization of the synopsis of the protocol and the continuation of the search for funds.

3.2.1.1.3. BLOOMY Study

BLOOMY: Baseline cohort study to assess malaria morbidity in children living in a future trial site for malaria vaccine candidates assessment in Burkina Faso

Immune responses to malaria vaccine candidates may be altered by malaria-induced immunosuppression itself before vaccination (with vaccine candidates under study). Therefore, pre-treatment of individuals prior vaccination in malaria endemic areas deserves great attention. In preparation for phase 2b clinical trials of malaria vaccines, this baseline study was conducted to determine the incidence of malaria after a radical cure with effective antimalarial drugs in a population of 1,5 to 12 years for which these critical data are missing. The study was conducted in the Banfora Health District, located in the



Cascades Health Region. The sites of the study concerned the Health facilities of Bounouna and Nafona. Started in 2020, the study included a cohort of 464 participants, previously treated against malaria with Artesunate in monotherapy for 7 days or Dihydroartemisinin-Piperaquine for 3 consecutive days, and follow-up during 6 months. The study participants were actively followed every two weeks at home or passively at any time the child was sick and seeking care at the health facility. Data collection ended in April 28, 2021. The data collection was carried out in a participatory manner with a good involvement of the agents of the two health facilities. Implementation of the study was considered as satisfactory.

As the site characterization data is obtained, 2022 should be the start of implementation of the MIMVaC-Africa vaccine trials.

3.2.1.1.4. CODYMAT Study

CODYMAT : Community dynamics of malaria transmission in humans and mosquitoes in the Sabou region of Burkina Faso

The Community-Based Dynamic Study of Malaria Transmission in Humans and Mosquitoes in the Sabou Region, Burkina Faso, in Acronym CODYMAT is a prospective longitudinal study of a cohort of infants, healthy children and adults to examine the natural and the dynamics of malaria infection and transmission over several seasons (high and low malaria transmission seasons) at a site where a transmission-blocking vaccine (TBV) will be tested. This study was approved by Burkina Faso's Comité d'Ethique pour la Recherche en Santé (CERS) before its implementation.

The purpose of the study is to estimate the rate of malaria transmission measured by live capturing of wild mosquito , by location, year and season. The study is being conducted in the Sabou Health District in the Central West Region of Burkina Faso.



Recruitment and follow-up of participants were carried out in the villages of Ipendo and

Ouezzendougou. The meetings held with the various actors of the health system in the region and members of the community made it possible to present the protocol and the procedures of the study, in order to obtain the support and involvement of all the actors concerned. Participant recruitment began in June 2021 with research teams consisting of study physicians and nurse investigators.

A total of 598 participants were included in the follow-up cohort. The first subject was enrolled on July 1 and the last participant on July 29, 2021. All participants were actively follow up monthly according to the study procedures.

In collaboration with the agents of the Health Facility of Ipendo a program of permanence has been established in order to contribute to the management of the participants who will consult in these heath facilities for any health problem.



An insectarium and a dissection room have been set up in the Sabou Medical Centre to carry out studies related to entomology activities.

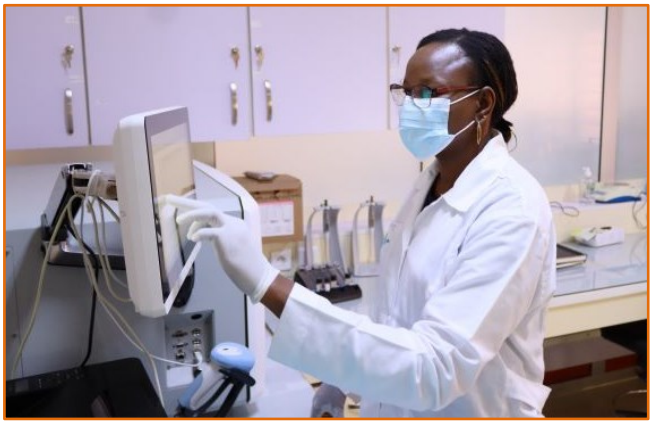
CODYMAT is a specific research study on malaria. It will help in the design of the type of vaccine called "Transmission-Blocking Vaccine", (TBV).

3.2.1.2. Antimalarial drug development

3.2.1.2.1. WANECAM 2 Study

KALUMI :. A Phase 2, multicentre, randomized, open-label interventional study of three age cohorts to assess the efficacy, safety and tolerability of KAF156-Lumefantrin SDF in the treatment of uncomplicated acute malaria with *Plasmodium falciparum* in a pediatric population.

Artemisinin-based combination therapies (ACTs) are the cornerstone of the malaria control and elimination strategy. However, increasing resistance to artemisinin derivatives is now a growing problem in Southeast Asia. In Africa, although artemisinin remains effective, the rate failure of ACTs due to resistance to associated drugs is also a concern. Therefore, it is important to develop new antimalarials of new generation that can stop resistance. KAF156, an imidazolepiperozine, is one of the main antimalarial candidates being developed. This is a new drug developed by Novartis. Its structure and mode of action are different from the currently marketed antimalarials drugs and other antimalarial drugs candidate. The new combination of KAF156 with LUM-SDF is told to be fast-acting and fully curative, improving patient adherence and potentially reducing malaria transmission.



The purpose of this study is to determine the efficacy, safety and tolerability of the experimental drug in patients aged 6 months to < 18 years with uncomplicated *P. falciparum* malaria. The activities to obtain regulatory authorizations for the conduct of the study, training and equipment were conducted during the year 2020. The study is implemented on the site of the Schiphra Hospital, Nongr Massom Health District (Centre). After information meetings and especially training, recruitment of study participants began in the last quarter of 2021. Data collection will continue in 2022 with the support of all stakeholders. Ultimately, this study will help eliminate malaria through effective case treatment.

3.2.1.2.2. PAMAFRICA Study (CALINA)

PAMAfrica : Portfolio approach for developing the next generation of malaria treatments for Africa

Recent World Health Organization reports on malaria eradication have made it clear that defeating malaria will require new tools, including new and better medicines. The WHO Global Malaria Report 2019 indicates that global malaria deaths are declining at a slower pace compared to recent years and highlights the need to improve interventions to treat the most vulnerable populations, including babies. The goal of this first study (CALINA) is the development of the first new malaria treatment for babies under 5 kg, a new formulation of Coartem®. The presentation of the currently available combination of Arteemether - Lumefantrin (20/120mg) seems to be inappropriate for children of low weight (<5kg).



This will be a single-group, multi-centre, open-ended, age-descending, sequential, adaptive study of infants and new-borns < 5 kg body weight with uncomplicated *P. falciparum* acute malaria.

The primary objective of this study is to assess the main PK endpoint, Cmax of Artemether (Art-Cmax); to identify the highest concentration between the 1-hour and 2-hour concentrations after the first dose in infants and new-born, infants of body weight < 5 kg treated with the new formulation of the dispersible artemether - lumefantrine tablet.

This study will include male and female patients with body weight < 5 kg with uncomplicated *P. falciparum* acute malaria. Cohort 1: infants > 28 days of age and Cohort 2: 28 days of term

infants. The plan is to recruit and treat a minimum of 44 patients (22 in each cohort). During the year 2021 the study received all the regulatory ethical authorizations to its implementation. A project team was set up to conduct the study.

The study is being conducted at the Schiphra Hospital in Ouagadougou in the Nongr Massom Health District. All members of the project team, including members of the Schiphra Hospital Pediatric Unit, were trained on the study protocol and procedures.

3.2.1.2.3. MFT Study

MFT: Feasibility, acceptability and cost of the implementation of a multiple first line treatment strategy using artemisinin-based therapeutic combinations for the treatment of uncomplicated malaria: a pilot study in the Kaya health district in Burkina Faso

As part of the strengthening of the health system in Burkina Faso, a study on the optimization of the use of current antimalarial drugs was conducted in the health district of Kaya. This is a simultaneous deployment of several front-line treatments against uncomplicated malaria using combination therapies based on artemisinin derivatives.

Theoretical models have shown that this strategy can extend the useful life of current ACTs by reducing drug pressure and slowing the spread of resistance without putting patients' lives at risk. Thus, a simultaneous deployment of three ACTs, Artemether – Lumefantrine (AL), Pyronaridine – Artesunate (Pyr-AS) and Dihydroartemisinin-Piperaquine (DHA-PQ), targeted three segments of the population.

The purpose of this study is to assess the feasibility, acceptability, costs and effects of the MFTs pilot study on the treatment of Uncomplicated malaria in the Kaya Health District.

The study is divided into four phases: the formative phase, the deployment phase, the monitoring/evaluation phase and the post-evaluation phase. The formative phase consisted of training sessions in cascades of all actors involved.

A total of 253 health workers in the Kaya District were trained on the study procedures. Implementation of the strategy with the deployment of the three (3) ACTs took place from December 02th, 2019 to December 1, 2020. The M&E phase collected data for the evaluation of program indicators. The programme as a whole covered 40 out of 43 health facilities.



A total of 183,800 malaria cases were diagnosed in 2020 in the district's health facilities and 182,247 malaria episodes were treated with ACT. For the treatment of malaria by ACTs, 44.5%, 49.1% and 6.4% of uncomplicated malaria episodes were treated with Pyr-AS, DHA-PQ and AL, respectively. The compliance rate of health workers with the guidelines of the MFT strategy was 74.2% (patients diagnosed positive for malaria and treated according to the drug allocated with a correct dosage.

The Quantitative Household Survey was conducted with 1,036 households to assess care seeking practices and attitudes and the acceptability of ACTs during the implementation of the program. Under the qualitative surveys, 33 focus groups interviews and 28 in-depth individual interviews were conducted with all health system stakeholders.

The results showed a good adherence to the strategy of treatment with a very good acceptability of the drugs used.

3.2.1.3. Basic malaria research

3.2.1.3.1. ISCHEMIC Study

ISCHEMIC: Impact of Seasonal Malaria Chemoprevention on the acquisition of protective immunity and protection against clinical malaria in Burkina Faso

Fundamental research was one of the GRAS's main activities during 2020. A study on seasonal malaria chemoprevention (SMC) called ISCHEMIC was conducted in the Sabou Health District.



The SMC consists of administered one full dose of sulfadoxine-Pyrimethamine plus amodiaquine treatment each month to children aged 6 to 59 months for 4 months from July to October, corresponding to the high malaria transmission season. However, it is not clear that there is a cumulative effect of SMC over time on the acquisition of immunity against the malaria parasite.

This pilot study was conducted to establish the key elements for understanding the potential role of SMC in enhancing immunity and protection against clinical malaria. It was a cohort study following the national SMC policy in Burkina Faso.

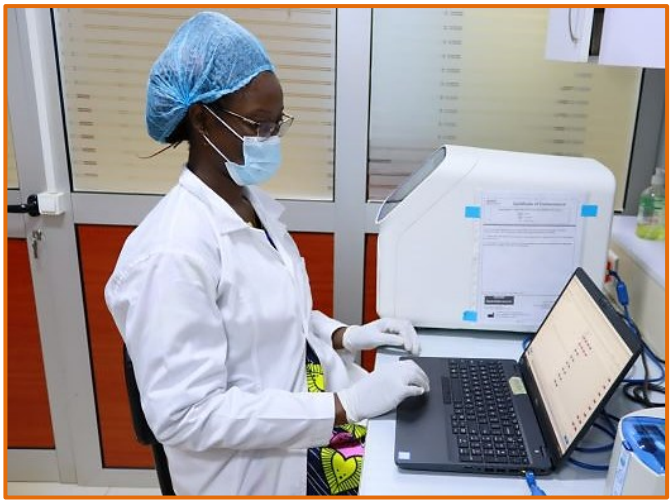
The study took place in several phases: community meetings, recruitment phase and monitoring of participants. Children included in the study were followed for six (6) months covering the cross-sectional survey periods.

In fact, five (5) cross-sectional surveys were conducted with one-month interval in-between from July to December 2020. Year 2021 activities are mainly laboratory analysis and data processing.

3.2.1.3.2. MALCOV Study

MALCOV: Malaria as a risk factor for COVID-19 in western Kenya and Burkina Faso.

While knowledge about COVID-19 risk factors is changing rapidly in developed countries, less is known about risk factors in countries where malaria is endemic. It is not known whether malaria worsens COVID-19, affects the acquisition of protective antibodies against the SARS-CoV-2 virus, or contributes to its subsequent spread by causing higher viral load and longer duration of viral shedding.



The relationship can be complex, as chronic malaria can lead to a hypo-response of the immune system, which in some cases, could be protective if it mitigates some of the potentially life-threatening excessive immune responses associated with severe COVID-19.

It is also unclear whether effective malaria treatment changes any of these potential associations.

The purpose of this study is to determine whether malaria infection is a positive or negative risk factor for the severe form of COVID-19 or its transmission. More specifically, it seeks to determine whether:

• Malaria infection is predictive of the prevalence of SARS-CoV-2, adjusted for other risk factors for SARS-CoV-2 infection;

• Malaria infection affects the severity of COVID-19;

• Pyronaridine-artesunate, compared to artemether-lumefantrine, reduces early excretion of SARS-CoV-2 virus.

After obtaining the favourable opinion of the Health Research Ethics Committee on 07 October 2020 and the authorisation of the Agence Nationale de la Régulation Pharmaceutique (ANRP)

on 04th March 2021, Recruitment of study participants began on April 19, 2021 at the Nongr-Massom Health District (Kossodo). Prior to the recruitment phase, a series of information meetings and presentations of the study protocol were conducted with the health authorities of the Health District of Nongr Massom and Bogodogo in Ouagadougou the Capital city.

The recruitment of study participants was carried out in two health districts (HD) of the Central Health Region: HD Nongr Massom and Bogodogo. At the health district of Nongr Massom, the sites study were represented by the district hospital of Kossodo (main site of the study), the Health facility of Wayalghin and sector 19. At the Bogodogo HD, rural and peri-urban sites including the Saaba Medical Centre, the Tanlarghin, Gampela and Nioko 2 Health facilities contributed to the recruitment of participants in the MALCOV study.

In 2021, 1,302 volunteers were screened for SARS-CoV-2 disease (suspect, contact or voluntary) and malaria, 120 participants were included in a cohort study and 4 subjects in nested clinical trial. The positivity rate was 12.9% and 6.07% for SARS-CoV-2 and malaria, respectively. For the nested clinical trial, no serious adverse events were reported during the implementation of the study in 2021. In order to limit the transmission of SARS-CoV-2, national directives have been complied with, in particular regardless of the use of personal protective equipment and individual barrier measures. Ultimately, the MALCOV study will provide important data on the evolution of COVID-19 disease in the presence or not of malaria infection.

3.2.1.3.3. COVI-AO Study

COVI-AO : Tracking COVID-19 infection in West Africa to inform public health interventions.

Despite the extraordinary progress made in the development of the COVID-19 vaccine, the pandemic will likely remain a significant challenge for years to come. Effective disease surveillance requires real-time information on the characteristics of the pathogen, as well as its burden on the population and the associated risk in vulnerable groups. That is why, since the beginning of the COVID-19 pandemic in Ghana, scientists at the University of Ghana have taken

the initiative to conduct research to provide vital information about SARS-CoV-2 and the spread of the disease in Ghana and now in Burkina Faso a near sharing border country.

The general objective of this study is to monitor the evolution of SARS-CoV-2 and the dynamics of transmission in Ghana, Nigeria and Burkina Faso in order to better guide public health interventions, including infection control measures and potential vaccine deployment.



The Ethics Committee's approval was obtained before the start of the study in 2021. The data was collected in the city of Ouagadougou. The collection sites concerned public procurement (Dassasgho, Zone One and Katr-yaar markets) and bus stations (Eastern and Ouagarinter markets) for general screening, while targeted screening was carried out at treatment sites, including COVID-19 testing centres and hospitals (Pogbi, Bogodogo, Yalgado, CMA Kossodo). Serologic tests were performed on site using a TDR coated for 2019-nCoV IgG/IgM specifics antibodies.

It was a multicentre cross-sectional survey in which the target population of the study concerned all individuals from 10 years of age and over, living in the geographical areas selected for the study in the city of Ouagadougou whether exposed or not to SARS-CoV-2. The survey therefore took place between September and October 2021. A total of 1,009 participants were recruited ; The average age was 36.4 14.92 years and 56.89% were women. The proportion of participants positive for IgG was 16.17% and those positive for IgM was 1.80%. Of 411 participants tested for antigen, only 19 (4.62%) were positive for SARS-CoV-2 antigens.

Analysis of the preliminary serological test results revealed that participants in this study in the city of Ouagadougou were exposed to COVID-19 infection. Although small, these data highlighted the spatial distribution of exposed participants during the survey period.

3.2.1.3.4. PRIMALVAC 2 Study (VAC4PM)

PRIMALVAC 2: Long-term follow-up of the immunological profile and pregnancy outcomes of women previously enrolled in a phase 1b clinical trial of malaria vaccine candidate PRIMVAC during pregnancy.

Children under 5 and pregnant women are the most vulnerable groups affected by malaria. Indeed, during their first pregnancy, women become again sensitive to the serious clinical consequences associated with malaria infection of the placenta.



It is assumed that vaccinating women before their first pregnancy with a subunit of the malaria vaccine candidate based on the VAR2CSA protein, induce a specific immune response to this parasite that will later protect the mother and foetus from the deleterious consequences of placental malaria. For this reason, the candidate placental malaria vaccine (PRIMVAC) was developed and tested in Burkina Faso in a phase 1b trial. This trial left key unanswered questions that are essential for the future development of this vaccine candidate: 1) How long does this artificial immunity last? 2) Is there a natural improvement in vaccine-induced immunity after pregnancy and in case of placental malaria infection? 3) Does natural exposure during pregnancy expand the recognition and inhibitory activity of heterologous variants of VAR2CSA expressed by *P. falciparum* parasites? 4) Is there protection associated with PRIMVAC vaccination? 5) Are there any safety issues during pregnancy? It is to answer these different questions that this study was designed.

This is a long-term observational follow-up study, comparing the immunological response trend of antibodies against malaria in three (3) groups of (i) women who previously received the PRIMVAC vaccine candidate or placebo in the phase 1b trial in Burkina Faso; ii) women of the same age and nulligests who did not participate in the phase 1b trial iii) women of the same age and primigests who did not participate in the phase 1b trial.

Follow-up is 12 months if pregnancy does not occur; any pregnancy occurring during the study will be followed to term. The study is being conducted in Burkina Faso in the Saponé Health District, which is located in the Centre-Sud region 47 kilometres south of Ouagadougou. The activities carried out during 2021 include the submission and obtaining of authorizations from the Ethics Committee and other regulatory authorizations for its implementation.

In the perspective for the year 2022, several activities including training of all stakeholders on the protocol and procedures of the study, meetings with the health authorities of HD of Saponé, community mobilization, Participant recruitment and 12-month follow-up will be implemented.

3.2.1.3.5. BMG-GC Study

BMG-GC : Evaluation of *Plasmodium falciparum* genotypes and resistance markers in malaria-infected patients living in two health districts as part of molecular malaria surveillance at sentinel sites of the National Malaria Control Program in Burkina Faso.

This surveillance study is a cross-sectional study on two sentinel sites of the National Malaria Control Program (which, at each site, will include any febrile subject diagnosed with positive malaria (through the rapid malaria diagnostic test). Subjects enrolled after consent and assent (for subjects aged 10-19) will be asked to collect additional demographic, clinical and biological data.



The purpose of the study is to provide a "near real-time" platform for genotyping *P. falciparum* and monitoring resistance by the National Malaria Control Program in Burkina Faso. This should allow for rapid and appropriate decision-making. The objective is to assess the prevalence of

Plasmodium falciparum genotypes and resistance markers in malaria-infected patients living in two health districts as part of the National Malaria Control Program's sentinel site for malaria surveillance. The study is being conducted in the Kaya health district in the centre-north of the country and in the Banfora district in the Cascades region of Burkina Faso.

During the course of 2021, activities consisted of preparing the study protocol for submission to the Ethics Committee, training stakeholders on the study protocol and procedures and launching the enrolment of study participants at the Banfora site.

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3.2.1.4. Control of diarrheal diseases and schistosomiasis

3.2.1.4.1. SHIGORAVAX Study

SHIGORAVAX: Clinical development of an oral vaccine against Shigella through a phase II study in Africa

As part of the fight against diarrheal diseases, a large program called ShigOraVax, involving several countries, aimed at establishing an effective and well-tolerated vaccine against shigellosis (bacillary dysentery) in children under five (5) was initiated in 2020 in Burkina Faso and Zambia. The first phase of the program was a basic epidemiological study with the main objective of generating data on the burden of shigellosis and circulating of shigelles strains in the areas where future clinical trials will be conducted.

The study took place in the health district of Nongr-Massom, located in the Central Region on two sites (Nioko and Polesgo). It consists of two phases: Phase I consisting of household identification, recruitment of participants and collection of basic data; and Phase II consisting of active and passive follow up of participants included.

The study recruited a total of 750 children at both sites. The first subject was recruited on December 17, 2020 and the last on March 2, 2021. Enrolled children were actively followed

(monthly home visits and cross-sectional visits at M0, M6 and M12) and passively (visits to health centres at each episode of diarrhoea) for 12 months. During passive surveillance, in addition to routine care provided in accordance with standard treatment guidelines in Burkina Faso, a stool sample was taken at each episode of diarrhoea and tested for the presence of Shigella.



Positive cases of Shigella were actively monitored on days 3, 5, 7 and 9 to investigate the disease and to collect blood and stool samples. No saddle was collected during monthly home visits. At these home visits, children with episodes of diarrhea were encouraged to seek medical attention in designated health facilities. In addition, asymptomatic Shigella infections were also assessed during the cross-sectional enrolment surveys conducted 6 months and 12 months after study initiation.

The one-year monitoring started in December 2020 and should end in March 2022. During this surveillance, 251 episodes of moderate to severe diarrhea (MDS) were identified at the health facility level.

The pathogens associated with the highest number of moderate to severe cases of diarrhea in children under 5 years of age were Shigella (33 cases), E. coli (26 cases), respectively. A total of 80 cases of all follow-up Shigella infections (cross-sectional and passive) were diagnosed.

3.2.1.4.2. TyVAC2 Study

TyVAC2 : Evaluation of the long-term immunity of subjects who participated in the randomized, double-blind, controlled trial on the safety and immunogenicity of the conjugate typhoid vaccine (Vi-TCV) in children under 2 years of age in Ouagadougou, Burkina Faso

The World Health Organization (WHO) pre-qualified a single-dose Vi-typhoid conjugate vaccine (Typbar TCV®, Bharat Biotech International) in 2018 and identified co-administration as a research priority.



We conducted a co-administration trial of Typbar TCV® with measles-rubella and yellow fever vaccines at nine (9) months; and measles-rubella and meningococcal group A (MCV-A) vaccines administered at 15 months in Burkina Faso.

Children in the cohort in which Vi-TCV was administered with EPI vaccines at 15 months of age were followed for longer-term immune responses assessment.

This will help to guide decisions about vaccination programs, including whether a booster Vi-TCV vaccination is required after an initial dose and when a booster dose could be suitable.

3.2.1.4.3. VASA Study

VASA : Schistosomiasis vaccine for Africa: a phase 1 clinical study of SchistoShield® anti-schistosomiasis vaccine in adults in endemic areas in sub-Saharan Africa

Schistosomiasis is a neglected tropical disease linked to poverty, affecting one billion people in 74 countries. Medical treatment is the current method available to combat schistosomiasis; but the effectiveness of mass treatment programs is compromised by re-infection requiring regular treatment.



An effective vaccine, with lasting protection against all forms of schistosomiasis, would have an impact on the fight against the disease.

The purpose of this study is to evaluate the safety/immunogenicity of the SchistoShield® vaccine (Sm-p80 antigen + GLA-SE adjuvant) in a Phase 1 clinical study in healthy African adults.

The 2021 activities consisted of preparatory meetings and equipment acquisition.

3.2.2. Strengthening the quality management system (QMS)

In order to build a reference research structure, GRAS has embarked on the implementation of a quality management system (QMS) for certification according to ISO 9001V2015.

In 2020, a quality diagnosis process was carried out by the Association Burkinabè pour le Management de la Quality (ABMAQ) in order to set the bases of the implementation of the QMS in 2021.



The ultimate goal is to implement and maintain a quality management system, following the recommendations of ISO 9001V2015. ISO 9001V2015 is an international standard that sets the requirements for a QMS. The past year has been marked with activities around the following points:

- The further development of the GRAS Quality Management System (QMS) with the support of ABMAQ experts to obtain certification on the ISO 9001 version 2015 standard. The working group composed of GRAS officers and experts was able to carry out the following activities:

  - Drafting of the GRAS vision, values, objectives, quality policy and environmental analysis,

  - Finalization of the description and mapping of the identified process: eleven (11) process were identified and detailed in a process identification sheet by the working group. This description specifying the missions, activities/steps, actors, input elements, output data and their clients, the necessary resources, objectives and indicators, external stakeholders, links with other process, potential risks and regulatory and legal requirements.

- Obtaining process validation and the appointment of pilots and co-pilots: the identified scope of process and their description were presented to the GRAS General Direction and then submitted for validation. After the validation of the process, the General Direction assigned to each process a pilot and a co-pilot.

- The further development of the GRAS QMS with the support of NOVARTIS: as part of a clinical trial protocol, NOVARTIS initiated a collaboration agreement with the GRAS whose QMS was the subject of an external audit in November 2021. This audit initiated by NOVARTIS was accompanied by a corrective and preventive action plan with the implementation of new information documented in the GRAS QMS.
- Continuing the routine activities of the GRAS QMS:

  - Checking and updating existing documented information
  - Production of new documented information

Table 4 shows the number of Standard Operating Policies, Directives and Procedures (SOPs) approved and available in GRAS.

Table 4 : Implementation of the QMS since 2019

Existing documented information	≤2020	2021	TOTAL
Policies and directives	2	4	**6**
Standard operating procedures	55	43	**98**
Administrative and Financial Manual Procedures	1	0	**1**

3.2.3. Training activities

As part of the implementation of its missions, GRAS provides continuous training for its staff in Burkina Faso and elsewhere in the world where necessary. These are diploma courses (short or long-term), short-term training/retraining workshops, which lead to certificates (Table 5).

GRAS also welcomes national and international internship. In 2021, a total of 12 trainees benefited from the support of GRAS at the level of technical platforms through the Departments of Social Sciences, the Department of Clinical Trials and Epidemiological Studies and the Department of Biomedical Sciences (Table 5).

In addition, the GRAS organises bi-monthly scientific presentations with the frameworks of sharing scientific knowledge between staff. Other training opportunities such as webinar or in-person exchange with internal or external partners occurred.

Table 5 : summary of training activities

Titled	**2019**	**2020**	**2021**
Training of GRAS staff			
Master's degree	0	3	4
PhD	1	1	2
Training session			
Department of Biomedical Sciences	-	-	10
Department of Clinical Trials and Epidemiological Studies	-	-	1

3.2.4. Other activities



These are:

- publications in relevant scientific journals;
- participation in scientific conferences and congresses;
- participation in experts and scientific committees;
- Participation as member in the review boards of national or international scientific journals.

3.2.4.1. Scientific publications of GRAS in 2021

2021 was a successful year in terms of scientific production for all GRAS researchers. A total of twenty(20) and seven (27) peer-reviewed scientific productions including one ebook versus eight and seven in 2019, 2020 respectively (Figure 2). The scientific publication list is given in Appendix 1.

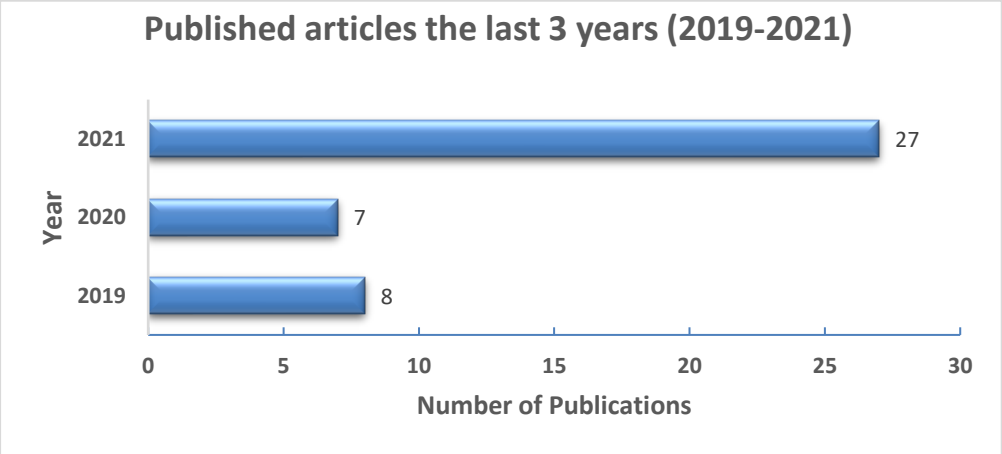


Figure 2: Evolution of GRAS scientific publications since 2019

3.2.4.2. Communications during Conferences

GRAS also distinguished itself in 2021 in the dissemination of its researchers' research results nationally and internationally by participating in scientific communications (Figure 2).

The list of submissions is summarized in Appendix 3.

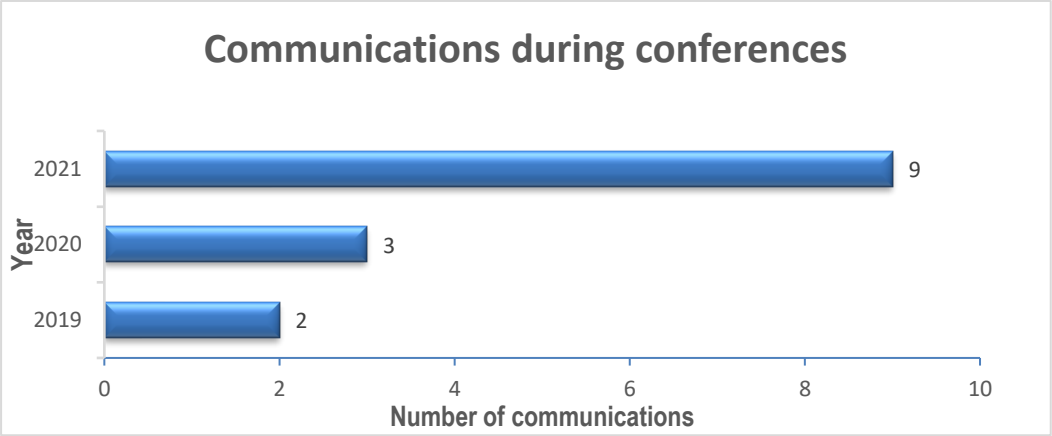


Figure 2: GRAS Science Communications since 2019

CONCLUSION

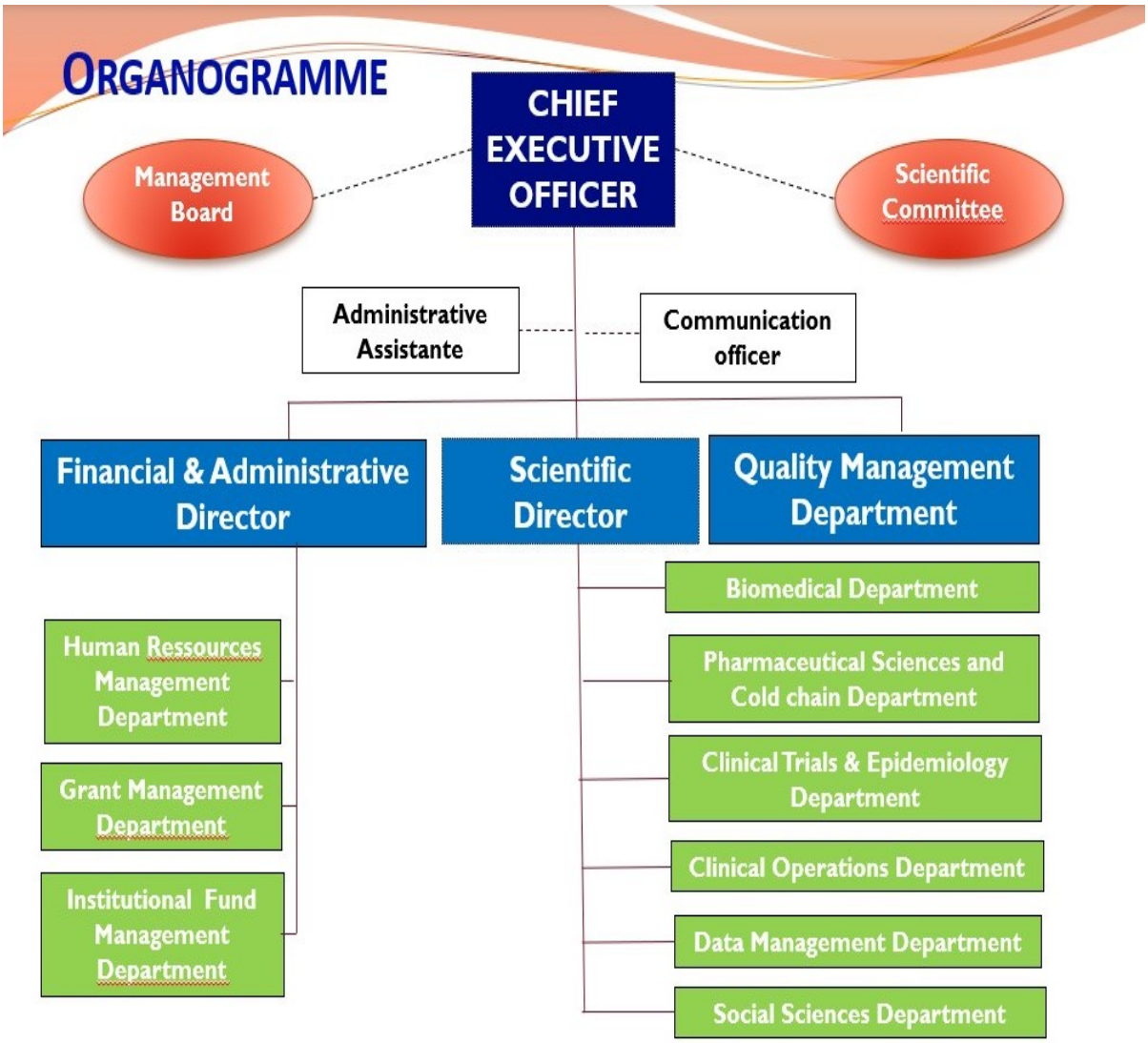
The Groupe de Recherche Action en Santé (GRAS), as a human health research institute with target goal of excellence in clinical research in disease control and well-being, is committed to becoming an essential instrument of the burkinabè government to accompanied and guide the Ministère de l'Enseignement supérieur et de la Recherche et de l 'Innovation (MESRI) and the Ministère de la Santé et de l'Hygiène Publique (MSHP).

While the year 2021 has enabled GRAS to consolidate its achievements and continue to strengthen its human resources, the year 2022 is set to begin with the finalization and official application for ISO 9001/2005 certification, in order to permanently commit the entire GRAS structure for the building of the quality management system.

The enormous potential in terms of human resources and infrastructure offered by the GRAS can only be expected to be retained and exploited with a clear motivation of the staff. It is a compendium of national expertise for clinical research available at the service of the Burkinabè nation and the international, a guarantee of a source of development and poverty reduction in Burkina Faso.



Annexe 1 : GRAS Institution flowshart



Appendix 2: List of GRAS publications in 2021

1. *Malaria is a cause of iron deficiency in African children.* Muriuki JM, Mentzer AJ, Mitchell R, Webb EL, Etyang AO, Kyobutungi C, Morovat A, Kimita W, Ndungu FM, Macharia AW, Ngetsa CJ, Makale J, Lule SA, Musani SK, Raffield LM, Cutland CL, **Sirima SB**, **Diarra A, Tiono AB**, Fried M, Gwamaka M, Adu-Afarwuah S, Wirth JP, Wegmüller R, Madhi SA, Snow RW, Hill AVS, Rockett KA, Sandhu MS, Kwiatkowski DP, Prentice AM, Byrd KA, Ndjebayi A, Stewart CP, Engle-Stone R, Green TJ, Karakochuk CD, Suchdev PS, Bejon P, Duffy PE, Davey Smith G, Elliott AM, Williams TN, Atkinson SH. Nat Med. 2021 Apr;27(4):653-658.
2. *Extended follow-up of children in a phase2b trial of the GMZ2 malaria vaccine.* Dassah S, Adu B, **Sirima SB**, Mordmüller B, Ngoa UA, Atuguba F, Arthur FKN, Mensah BA, Kaddumukasa M, Bang P, Kremsner PG, Mategula D, Flach C, Milligan P, Theisen M. Vaccine. 2021 Jul 13;39(31):4314-4319.
3. *Higher gametocyte production and mosquito infectivity in chronic compared to incident Plasmodium falciparum infections.* **Barry A**, Bradley J, Stone W, Guelbeogo MW, Lanke K, **Ouedraogo A, Soulama I, Nébié I, Serme SS**, Grignard L, Patterson C, Wu L, Briggs JJ, Janson O, Awandu SS, Ouedraogo M, Tarama CW, Kargougou D, Zongo S, **Sirima SB**, Marti M, Drakeley C, **Tiono AB**, Bousema T. Nat Commun. 2021 Apr 26;12(1):2443.
4. *Risk factors for Plasmodium falciparum infection in pregnant women in Burkina Faso: a community-based cross-sectional survey*. **Yaro JB**, **Ouedraogo A, Diarra A,** Sombié S, **Ouedraogo ZA, Nébié I**, Drakeley C, **Sirima SB, Tiono AB**, Lindsay SW, Wilson AL. Malar J. 2021 Sep 6;20(1):362.
5. *Accelerated phase Ia/b evaluation of the malaria vaccine candidate PfAMA1 DiCo demonstrates broadening of humoral immune responses.* Remarque EJ, Faber BW, Rodriguez Garcia R, Oostermeijer H, **Sirima SB, Nebie Ouedraogo** I, Kara L, Launay O, Houard S, Leroy O, Kocken CHM. NPJ Vaccines. 2021 Apr 14;6(1):55.
6. *G6PD polymorphisms and hemolysis after antimalarial treatment with low single-dose Primaquine:* a pooled analysis of six african clinical trials. Sepúlveda N, Grignard L, Curry J, Mahey L, Bastiaens GJH, **Tiono AB**, Okebe J, **Coulibaly SA**, Gonçalves BP, Affara M, **Ouédraogo A, Bougouma EC**, Sanou GS, **Nébié I**, Lanke K, **Sirima SB**, Dicko A, d'Alessandro U, Clark TG, Campino S, Chen I, Eziefula AC, Gosling R, Bousema T, Drakeley C. Front Genet. 2021 Apr 9;12:645688.
7. *Persistent Submicroscopic Plasmodium falciparum Parasitemia 72 Hours after Treatment with Artemether-Lumefantrine Predicts 42-Day Treatment Failure in Mali and Burkina Faso.*

Beshir KB, Diallo N, Somé FA, Sombie S, Zongo I, Fofana B, Traore A, Dama S, Bamadio A, Traore OB, Coulibaly SA, Maurice OS, **Diarra A**, Kaboré JM, Kodio A, Togo AH, Dara N, Coulibaly M, Dao F, Nikiema F, Compaore YD, Kabore NT, **Barry N, Soulama I**, Sagara I, **Sirima SB**, Ouédraogo JB, Djimde A, Sutherland CJ. Antimicrob Agents Chemother. 2021 Jul 16;65(8): e0087321.

8. *Protocol for a quasi-experimental study to assess the feasibility, acceptability and costs of multiple first-lines artemisinin-based combination therapies for uncomplicated malaria in the Kaya health district, Burkina Faso.* Siribie M, Tchouatieu AM, **Soulama I, Kaboré JMT,** Nombré Y, **Hien D**, Kiba Koumaré A, **Barry N**, Baguiya A, **Héma A**, Dianda F, Savadogo Y, Kouanda S, **Tiono AB, Sirima SB**. BMJ Open. 2021 Feb 15;11(2):e040220.
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Appendix 3: List of communications in 2021

Title of the presentation	Type of presentation	Location	Date
Assessing the feasibility of a strategy deploying multiple first-line artemisinin-based combination therapies for uncomplicated malaria in the health district of Kaya, Burkina Faso.	Oral presentation	ASTMH Annual Meeting, On line	19.11.2021
Access to drinking water and basic sanitation in two peri-urban areas of Ouagadougou: a quantitative study in households in Polesgo and Nioko 2	Oral presentation	4th edition of the Symposium International sur la Science et la Technologie (SIST) face-to-face in Ouagadougou	November 15-19, 2021
Diarrheal diseases and access to basic sanitary facilities in two peri-urban districts of Ouagadougou	Oral presentation	10th International Congress of the Société Africaine de Parasitologie (SoAP) on line	December 1-3, 2021
The necessity of establishing a Quality Management System (QMS) in Clinical Research Centers (CRC)	Oral presentation	Tenth EDCTP Forum on line	October 17-21, 2021
Prevalence and diversity of entero-pathogenic bacteria in children under five living in a community setting in Ouagadougou, Burkina Faso	Poster presentation	Tenth EDCTP Forum on line	October 17-21, 2021
Prevalence of Plasmodium falciparum after radical antimalarial treatment of children living in peri-urban areas in Burkina Faso	Poster presentation	SIST	November 15-19, 2021
Prevalence of Plasmodium falciparum after radical antimalarial treatment of children living in an area of high malaria transmission in Burkina Faso	Poster presentation	SOAP on line	01.12.2021
Safety & immunogenicity of typhoid conjugate vaccine co-administration with routine 9- & 15-month vaccination in Burkina Faso: A randomized controlled phase 2 trial	Oral presentation	12th International Conference on Typhoid & Other Invasive Salmonelloses (on line)	06.12.2021
Extended anti-Vi IgG responses in 15-month-old children vaccinated with a typhoid conjugate vaccine in Burkina Faso	Poster presentation	12th International Conference on Typhoid & Other Invasive Salmonelloses (on line)	06.12.2021

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