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Afrique One-ASPIRE

African Science Partnership
for Intervention Research Excellence

Research Questions on Zoonosis Elimination Pathways in Africa

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AAS/AESA staff

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Nelson Torto, Executive Director, African Academy of Science

Thomas Kariuki, Director, Alliance for Accelerating Excellence in Science in Africa (AESA)

Michael Kilpatrick, Senior Advisor, Good Financial Grant Practice

Elizabeth Marincola, Senior Advisor for Science Communications and Advocacy

Kevin Marsh, Senior Advisor

Paul Munyao, Monitoring and Evaluation Manager

Lilian Mutengu Naigaga, Public and Community Engagement Manager

Evelyn Namubiru-Mwaura, Strategy and Policy Manager

Alphonsus neba, Programme Manager, DELTAS Africa

Deborah-Fay Ndlovu, Communications Manager

Hannah Ngugi, Finance and Grants Manager

Isabel Imbuye, Grants Accountant

Afrique One-ASPIRE Principal Investigators

Kennedy Addo

Bassirou Bonfoh **(Director)**

Joram Buza

John Claxton

Sarah Cleaveland

Wellington Ekaya

Gilbert Fokou

Daniel Haydon

Alain Kamga

Rudovick Kazwala

Godfrey Mbaruku

Sayoki Mfinanga **(Deputy director)**

Blandina Mmbaga

Richard Ngandolo

Jakob Zinsstag

Afrique One Alliance partners

Pius Alibu

Julius Keyyu

Ezekiel Mangi

Enock Matovu

Chacha Mwita

Afrique One-ASPIRE SAB members

Abraham Aseffa

Ayayi Ayih-Akakpo

Eric Fevre

Joachim Frey

James Nokes

Brian Perry **(Chair)**

Christine Thuranira-McKeever

Afrique One-ASPIRE supervisors

- Kennedy Kwasi Addo
- Francis Akindès
- Emile Kou'santa S. Amouzou
- Bukachi S. Atieno
- Josephine Birungi
- Bassirou Bonfoh
- Frank Adae Bonsu
- Joram Buza
- Sarah Cleaveland
- Appolinaire Djikeng
- Mangi J. Ezekiel
- Gilbert Fokou
- Sebastien Gagneux
- Nicodemas Govella
- Jo Halliday
- Katie Hampson
- Daniel T Haydon
- Seven Gudmund Hinderaker
- Shabbar Jaffar
- Neema Kassim
- Jennifer Keiser
- Julius D. Keyyu
- Gibson Kibiki
- Martin Kimanya
- Andrew Y. Kitua
- Philippe S. Kone
- Tiziana Lembo
- Melkizedeck T. Leshabari
- Lucas E. Matemba
- Enock Matovu
- Sayoki G. Mfinanga
- Candida Moshiro
- Stellah Mpagama
- Emmanuel Mpolya
- Phares G.M Mujinja
- Chacha Mwita
- Esther Ngadaya
- Ngandolo Bongo Richard
- Bernard James Ngowi
- Gamba Nkwengulila
- Hezron Emmanuel Nonga
- Constanze Pfeiffer
- Giovanna Raso
- Felix Roth
- Esther Schelling
- Henk L. Smits
- Francesca Stomeo
- Marcel Tanner
- Fabrizio Tediosi
- Jürg Utzinger
- Mark Wamalwa
- Daniel Wight
- Ruth N. Zadoks
- Jakob Zinsstag

Afrique One-ASPIRE fellows

Postdoc	• Mahamat Fayiz Abakar • Angora Rémi Constant Ahoua • Abikpo Clarisse Houngbedji • Gloria Ivy Mensah • Zacharia John Mtema • Coletha Mathew Mteng • Andrée Prisca Ndjoug Ndour • Mbazi Senkoro • Brou Richard Yapi
PhD	• Adiza Abass • Samuel Ofori Addo • Vida Yirenkyiwaa Adjei • James Miser Akoko • Yoro Stéphane Alain Babo • Kawe Patiene Chouop • Helena Dela • Arlette Olaby Dinde • Diakourga Arthur Djibougou • Christian Tetteh Duamor • Gibson Benard Kagaruki • Vessaly Kallo • Aya Lydie Judicaelle Koffi • Bognan Valentin Koné • Didi Lamireou • Ahmed Kambinda Lugelo • Kennedy Selestin Lushasi • Peter Masunga Mbelele • Caroline Mwihaki Mburu • Nicholaus Peter Mnyambwa • Seko Malik Orou • Wilfried Délé Oyetola • Aimé Roland Sanhoun • George Peter Semango • Abdulhamid Lukambagire Settenda • Aifello Wedson Sichalwe • Armel Elysée Yapo
MSc	• Séraphin Alladoumngar Madjadtnan • Ivy Brago Amanor • Abdul Gafar Victoir Coulidiaty • Ester Jacob Diarz • Kossia Debia Thérèse Gboko • Baliet Adama Litié • Togolani Godfrey Maya • Saidi Mwinjuma Mfaume • Raphael Raiton Mwampashi • Mbaïpago Nodjimbadem • Francis Sena Kwaku Nuvey • Rosamystica Mkula Sambu • Lwitiko Elton Sikana • Souleymane Traoré • Akissi Rose Delima N'Guessan • Kouassi Kan Nestor N'dri

Table of contents

Prof Bassirou Bonfoh
Director of
Afrique One-ASPIRE

Foreword

From the Bovine TB network experience in 2007 (WT livestock for life initiative), Afrique One Alliance planned in 2009 (i) to generate a critical mass of internationally-competitive African scientists and research groups with a focus on One-Health and zoonotic diseases; (ii) to strengthen research and training links between African research institutions, particularly between Francophone and Anglophone countries and (iii) to develop more robust research support and research administration infrastructures. These were ambitious goals, but we have demonstrated substantial progress in meeting all three of them.

Since 2009, Afrique One has positioned itself as an African pillar in the research and translation of the One-Health concept with training and support for researchers and practitioners in One Health. A particular feature of Afrique One has been the development of its genuine African leadership, accompanied with the manifest trust and respect of all members of the consortium through both success and adversity.

Afrique One has built a strong network of more than one hundred African researchers effectively engaged in One Health research across East and West Africa, including 20 post-doctoral research

fellows, 18 PhD and 30 Masters students all trained through the consortium. Furthermore, we have established a framework for career progression for the first generation of postdoctoral scientists in African universities trained in the perspectives of One-Health and supported by a strengthening of institutional capacity in partner institutions.

A major transformation will be moving from an equitable resource distribution to one based on merit. The organisation of Afrique One-ASPIRE reflects a more sensitive approach to balancing recruitment of outstanding students and early career researchers (up to 50 fellows) with the rewards of a coherent thematic research training programme that matches the expertise of African institutions and northern partners. Retaining flexibility for resource allocation is critical, and will be determined by the quality of the candidates and their supervision, considering where they wish to undertake their research.

Our consortium recognises that the profound scientific challenges facing Africa will require African-led solutions. Afrique One-ASPIRE will place the highest priority on creating and sustaining this leadership, in addition to supporting it where it currently exists.

Afrique One-ASPIRE Presentation

Afrique One-African Science Partnership for Intervention Research Excellence (ASPIRE) is the continuity of the consortium Afrique One 'Ecosystem and Population health: expanding the frontiers in health'. The focus of Afrique One-ASPIRE (2016-2021) is on endemic zoonotic diseases (diseases that are transmissible between animals and humans) through capacity building. Its aspiration is to harness the unique societal drivers of Africa to build a world-leading Pan-African research capacity in One Health science.

By fostering research partnerships, Afrique One-ASPIRE wants to get the balance right and bridge the gaps between different capacities, languages, disciplines, sectors and geographical regions (East and West Africa). Science excellence and training are built along the disease control-elimination pathway. The leadership is developed with a cohort effect on more than 45 fellows and the supervision and mentorship contribution from European partner institutions.

Afrique One-ASPIRE currently addresses issues in relation to the Sustainable Development Goals (SDGs) in line with the Science, Technology and Innovation Strategy for Africa (STISA-2024) in the area of food security and disease prevention by taking the leadership of global One Health research. The One Health approach produced added value in terms of better health and well-being for humans and animals, financial savings and improved environmental services due to the closer cooperation of human and animal health together with other disciplines and sectors.
The programme will significantly expand research capacity in sub-Saharan Africa through a structured programme of scientific training across five Thematic Training Programmes (TTPs):

- Eliminating canine rabies
- Prevention and control of brucellosis
- Control of mycobacterial infections focusing on zoonotic tuberculosis and Buruli ulcer in humans and livestock
- Foodborne diseases and nutritional illnesses
- Syndromic surveillance-response and integrated One-health systems

The Afrique One-ASPIRE programme will equip African scientists with expertise in planning, monitoring and evaluating interventions of One Health research with the aim of tackling zoonoses. Through this programme, we aim to improve human and animal health and well-being, as well as food security.

Afrique One-ASPIRE is one of the eleven grantees of DELTAS Africa initiative, an independent funding scheme of the Africazn Academy of Sciences (AAS)'s Alliance for Accelerating Excellence in Science in Africa (AESA) and supported by the New Partnership for Africa's Development Planning and Coordinating Agency (NEPAD) with funding from the Wellcome Trust and the UK government.

Coordination team

Bassirou Bonfoh, **Director**

Sayoki Mfinanga **Deputy Director**

Kathrin Heitz-Tokpa, **Programme Manager**

Ibrahim Doukouré, **Financial Officer**

Karim Ouattara, **Senior Monitoring and Evaluation**

Bernard Ngowi, **Senior Monitoring and Evaluation**

Aurélie Cailleau, **Training Coordinator**

Katharina Kreppel, **Training Coordinator**

Emmanuel Dabo, **Communication Officer**

Blandine Adou, **Administrative Assistant**

Support from CSRS

Khady Sall, **Administrative and Financial Management**

Florent Be, **Finance**

Roger Kpon, **IT**

Assibi Bonfoh, **Procurement**

Chrystelle Konan, **Human Resources Management**

Mathieu Kouakou, **Logistic**

Victor Kohi, **Logistic**

Canine Rabies Elimination

Lead

Godfrey Mbaruku
IHI, Tanzania

Co-lead

Alain Kamga
EISMV, Senegal

Collaboration

IHI, Tanzania
EISMV, Senegal
SUA, Tanzania
CSRS, Côte d'Ivoire
NMIMR, Ghana
University of Glasgow, UK
Swiss TPH, Switzerland

The feasibility of canine rabies control and elimination has been demonstrated (Lankester et al. 2014).

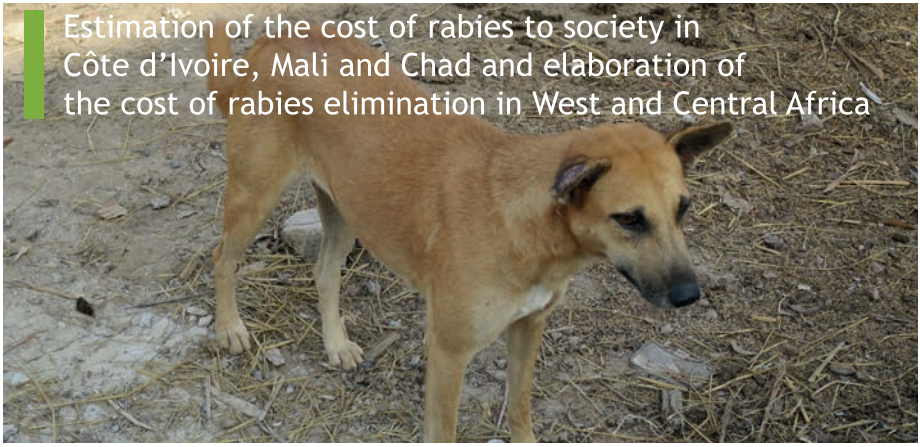
The research consortium Afrique One-ASPIRE incorporated canine rabies elimination into one of its Thematic Training Programs (TTPs) to close research gaps in the understanding of epidemiological, social, political and cultural factors influencing the effectiveness of interventions for the prevention, control and elimination of rabies. There is still a need for:

- Greater understanding of the social, economic and political factors that affect motivation, awareness and responses towards rabies interventions
- Operational research to improve delivery of and participation in rabies intervention strategies
- Research to support the elimination process (Bardosh et al. 2014, Zinsstag 2013)

Rabies elimination is feasible but greater efforts are needed regarding the feedback on exposition to the virus which means a strengthened partnership between the public health sector and the veterinary health systems is needed also including the participation of population and local and administrative authorities. Afrique One-ASPIRE is already on the case by contributing to the setup of a multi-sectoral committee for rabies control and elimination and by training students to use the One Health approach.

Notes

Estimation of the cost of rabies to society in Côte d'Ivoire, Mali and Chad and elaboration of the cost of rabies elimination in West and Central Africa



Andrée Prisca Ndjoug Ndour*[1]

Alain Kamga-Waladjo[1], Godfrey Mbaruku[2], Bassirou Bonfoh[3,4], Monique Lechenne[4], Rianatou Bada Alambedji[1]

[1]Ecole Inter-Etats des Sciences et Médecine Vétérinaires, Dakar, Senegal
[2]Ifakara Health Institute, Dar es Salaam, Tanzania
[3]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire
[4]Swiss Tropical Institute for Public Health, Basel, Switzerland

*Corresponding author: andreeprisca.ndour@gmail.com

Around 99% of rabies infections in humans are due to dog bites and, 3.6 deaths per 100 000 individuals in rural Africa occur yearly. Unfortunately, the relevant and efficient vaccines for humans and animals are frequently inaccessible and non-affordable in low-income countries where the rabies burden is greatest. However, the World Health Organization recognized that human rabies can be controlled by dog mass vaccination.

Studies in Chad and Tanzania show that mass dog vaccination are cost-effective and a sustainable way to control rabies in the long-term. To be able to introduce interventions at a large scale, quantitative data on the economics of rabies are necessary to show its impact on public health and its benefit to animal and human health systems through the control of vector populations. Data of the current Global Alliance for Vaccines and Immunizations (GAVI) project on the estimation of the burden of rabies (dog demography, human and animal incidences, post exposure prophylaxis, several costs) in Mali, Côte d'Ivoire and Chad will be used to parametrize a probabilistic model to evaluate its economics burden and the cost-effectiveness of its elimination.

These studies are conducted according to an integrated One Health and transdisciplinary approach. In West and Central Africa, rabies elimination is feasible and a regional model to evaluate the economics burden of rabies applicable to other diseases will be available to decision makers. Additionally, this study will build capacities of researchers in disease control, increase community awareness for a long-term intersectoral benefit and the sustainability of control programs.

Keywords: Rabies, Cost, Society, Elimination, West and Central Africa

Burden and Rabies elimination in Côte d'Ivoire

Vessaly Kallo[*1,2]

Alambedji Rianatou[2], Monique Lechenne[3], Jakob Zinsstag[3], Bassirou Bonfoh[3,4]

[1]Université Felix Houphouët-Boigny d'Abidjan, Côte d'Ivoire
[2]Ecole Inter Etats des Sciences et de Médecine Vétérinaires de Dakar, Senegal
[3]Swiss Tropical Institute for Public Health, Basel, Switzerland
[4]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire

*Corresponding author: vessalykallo@yahoo.fr

In Côte d'Ivoire, according to Institut National d'Hygiène Publique, during the last three years, an average of 20 people died of rabies each year. Rabies control in Côte d'Ivoire is challenged by low reporting rates for rabid animals and low animal vaccination coverage. Communities are insufficiently sensitized and involved in control activities and theauthorities report inadequate training. There is no global approach to control rabies in Côte d'Ivoire.

To work towards rabies elimination, the study suggests an operational mass dog vaccination.

Rabies burden will be estimated from the incidence of rabies deaths multiplied by the age distribution and the associated years of life years lost (YLL). This will be established with the help of the GAVI project. Vaccination coverage will be achieved using ten teams of three vaccinators each which will be trained in dog vaccination and dog handling. During seven days, nine stationary teams will be placed at posts in areas determined by the local area chiefs and one team will be mobile and move around the areas. We will use a Bayesian capture-mark recapture model to estimate the total number of dogs vaccinated.

During this small scale vaccination campaign, all occurring costs are recorded and summarized as public and private costs of dog vaccination. This study will allow estimating the rabies burden as well as the costs and the effectiveness of mass dog vaccinations in Bouake and San Pedro (rural and urban zone).

Keywords: Rabies, elimination, Côte d'Ivoire

Investigating the potential of a thermostable rabies vaccine to improve strategies for rabies control and elimination in Africa

Ahmed Lugelo*[1]

Katie Hampson[2], Felix Lankester[3], Rudovick Kazwala[1], Sarah Cleaveland[2]

[1]College of Veterinary Medicine and Medical Sciences, Sokoine University of Agriculture, Morogoro, Tanzania
[2]Boyd Orr Centre for Population and Ecosystem Health, Institute for Biodiversity, Animal Health & Comparative Medicine, University of Glasgow, Glasgow, United Kingdom
[3]Paul G. Allen School for Global Animal Health, Washington State University, Pullman, USA

*Corresponding author: ahmedlgl64@gmail.com

Rabies is a deadly zoonosis that kills 59,000 people every year, with most deaths occurring in Asia and Africa. A large body of epidemiological evidence suggests that the global elimination of canine rabies is feasible and it is now a declared objective of the international agencies with a target of zero human deaths from canine-mediated rabies set for 2030. However, gaps remain regarding implementation of cost-effective and sustainable intervention strategies and research translation into effective national, regional and global policies. This study will address these knowledge gaps by conducting an intervention trial in rural Tanzania to investigate: (a) the cost-effectiveness of different delivery strategies, including community-led dog vaccination strategies; (b) dynamics of dog population immunity in communities adopting different delivery models; (c) opportunities for integrating dog rabies vaccination with delivery of other health services. These novel strategies of delivering dog rabies vaccination have been developed based on recent results demonstrating a high thermotolerance of inactivated dog rabies vaccine.

Keywords: Rabies, Cost, Society, Elimination, West and Central Africa

One Health surveillance approaches to guide rabies elimination

Kennedy Lushasi*[1]

Emmanuel Mpolya[2], Godfrey Mbaruku[1], Zacharia Mtema[1], Rudovick Kazwala[3], Gibson Kibiki[4], Bassirou Bonfoh6, Joram Buza[2], Sarah Cleaveland[5], Katie Hampson[5]

[1]Ifakara Health Institute, Dar es Salaam, Tanzania
[2]Nelson Mandela African Institution of Science and Technology, Arusha, Tanzania
[3]Sokoine University of Agriculture, Morogoro, Tanzania
[4]Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania
[5]University of Glasgow, Glasgow, United Kingdom
[6]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire

*Corresponding author: klushasi@ihi.or.tz

Rabies is a neglected zoonotic disease that causes an estimated 59,000 human deaths annually. The main burden lies in Asia and Africa where surveillance capacity is limited in both animal and human health sectors, disease detection is hampered by inadequate laboratory facilities, and there are difficulties of submitting samples from remote areas to laboratories for confirmation. Nevertheless, a target of zero human deaths from dog-mediated rabies has been set for 2030 and large-scale control programs are being rolled out in parts of sub-Saharan Africa. However, there is very limited guidance on integrated rabies surveillance to improve case detection as elimination is approached, or how to manage control programs once progress towards elimination has been made. Active case findings using integrated surveillance systems involving the public health sector and the veterinary sector have the potential to increase case detection. This affordable and practical approach could be used to improve post-exposure prophylaxis administration and strengthen inter-sectorial partnerships and capacity needed for control of emerging zoonoses. Moreover, the need for genomic approaches to guide the strategy and implementation of elimination programs is increasingly recognized to identify sources of incursions and minimize their frequency. This project will involve the pilot implementation of active surveillance approaches including genomic surveillance to: (a) determine case detection in different settings; (b) assess costs of active case finding and feasibility within a One Health framework; (c) evaluate critical criteria to identify and confirm rabies cases; (d) pilot field sequencing approaches to identify sources of incursions and virus diversity. This will strengthen intersectoral partnerships and the capacity for control and elimination of zoonoses.

Keywords: Rabies, elimination, Côte d'Ivoire

Evaluation of community-directed rabies elimination strategies: towards sustained, increased vaccine coverage

Christian Tetteh Duamor[*1]

Katie Hampson[2], Sally Wyke[2], Sarah Cleaveland[2], Felix Lankester[3], Godfrey Mbaruku[4], Bassirou Bonfoh6, Emmanuel Mpolya[5]

[1]Accra School of Hygiene, Accra, Ghana.
[2]University of Glasgow, Glasgow, United Kingdom
[3]Washington State University, Pullman, USA
[4]Ifakara Health Institute, Dar es Salaam, Tanzania
[5]Nelson Mandela African Institute of Science and Technology, Arusha, Tanzania
[6]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire

*Corresponding author: duamort@gmail.com

Canine-mediated rabies is the leading viral zoonosis with almost 100% case fatality rate in the absence of timely medical intervention. The global case-specific death rate for rabies is estimated at 59,000 (Tanzania, approximately 1,500) annually, with 3.9 billion people at risk. Elimination of rabies has been described to be feasible with increased dog vaccination coverage as determined by its transmission dynamics. The main challenge has been accessibility to vaccines by vulnerable and remote populations, due to limited infrastructure, and a lack of large-scale implementation of dog vaccination programs because of their associated costs. The objective of this study is to investigate whether dog rabies vaccination delivered by a community-led approach will result in improved and sustained coverage in a cost-effective manner as opposed to a team-led (vertical) approach. A randomized trial study design will be used. Villages (120) will be randomized to receive vaccination either by the community-led or team-led approach. Coverage and cost-per-dog will be evaluated for each arm. Barriers and facilitators to the effective delivery of dog vaccination campaigns and community perceptions relating to dog vaccination will be documented. A logic model will be developed to describe the expected outcome chain. A mixed methods approach with an embedded process evaluation will be used to analyse the trial outcomes and processes. Through a comprehensive evaluation, we will generate recommendations for best practice to implement cost-effective high coverage vaccination programmes in East Africa.

Keywords: Zoonosis, elimination, coverage, team-led, community-led

Preliminary research on family aspects of dog care in rural Tanzania to inform rabies prevention interventions

Lwitiko Elton Sikana*[1]

Godfrey Mbaruku[1], Emmanuel Mpolya[2], Danny Wight[3], Tiziana Lembo[3], Katie Hampson[3]

[1]Ifakara Health Institute, Dar es Salaam, Tanzania
[2]Nelson Mandela African Institution of Science and Technology, Arusha, Tanzania
[3]University of Glasgow, Institut of Biodiversity, Animal Health and Comparative Medicine, Glasgow, United Kingdom

*Corresponding author: lwsikana@ihi.or.tz

Rabies is a fatal zoonosis transmitted through animal bites. In rural Africa, domestic dogs are the main source of rabies and children are the most vulnerable group. Deaths can be prevented through: (a) timely post-exposure prophylaxis of people bitten by suspected rabid dogs, and (b) mass dog vaccination. Successful zoonosis interventions not only raise awareness of the disease, but also motivate people to prevent the disease. Yetprogrammes tend to draw on approaches from developed countries, which are often unsuitable for rural Africa. This study will be conducted in Kilosa district in southern Tanzania. It will: (1) explore relationships between villagers and dogs, children's exposure to dogs, and their role in caring for them and how this is affected by parent-child relationships; (2) investigate factors affecting parents' response to children's exposure to rabies and explore villagers' engagement in rabies prevention.

The study will use quantitative and qualitative approaches, including household-level questionnaire data, in-depth interviews and group discussions involving children and their care givers. The study takes a One Health approach, where a range of stakeholders work together to develop appropriate rabies prevention interventions in their community. Stakeholders include health, veterinary and education professionals, religious and village leaders, children and young people. The findings will inform the design of interventions relevant to rabies and other public health issues. Workshops with a steering group of regional and district-level policy-makers will help incorporate the findings into policy.

Keywords: Rabies, community, interventions, stakeholders, workshops, One health, policy-making, steering group

Brucellosis Control and Prevention

Lead

Rudovick Kazwala
SUA, Tanzania

Co-lead

Gilbert Fokou
CSRS, Côte d'Ivoire

Collaboration

SUA, Tanzania
MUHAS, Tanzania
KCRI-KCMC, Tanzania
TAWIRI, Tanzania
BecA-ILRI, Tanzania
University of Glasgow, UK
Swiss-TPH, Switzerland

Brucellosis is a bacterial infection that systemically affects a wide variety of mammals worldwide. It is endemic in Africa and one of the leading zoonoses affecting humans. Various studies conducted in both, East and West Africa have concentrated on the burden of the disease and the transmission and distribution of several Brucella agents across populations in various ecosystems. However, appropriate and successful intervention strategies are yet to be implemented.

The bold aim of the Brucellosis Control and Prevention Thematic Training Program is not only to assess at varying scales the burden, brucella species distribution and zoonotic transmission routes but also to develop diagnostic tools and intervention approaches appropriate to the African context. The specific objectives includes:

- to identify species of brucellosis causing infections in human and animals in Africa
- to develop appropriate protocols for intervention of brucellosis in humans and animals (include the aspects of social science – knowledge, perception and behaviour)
- to identify policy gaps and drivers for intervention of brucellosis in humans and animals
- to develop and complement capacity in diagnosis of brucellosis in human, wildlife and livestock in East and West Africa

Notes

Priorities for brucellosis control in Sub-Saharan Africa context

Coletha Mathew*[1]

Bassirou Bonfoh[2], Sarah Cleaveland[3], Rudovick Kazwala[1]

[1]College of Veterinary Medicine and Biomedical Sciences, Sokoine University of Agriculture, Morogoro, Tanzania
[2]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[3]University of Glasgow, Institut for Biodiversity, Animal Health and Comparative Medicine, Glasgow, United Kingdom

*Corresponding author: colethamat@yahoo.com

Brucellosis is a complex disease that has a wide range of impacts worldwide on animals and humans. The disease burden is particularly severe in sub-Saharan Africa, yet it is a neglected disease in this region. Brucellosis control and eradication require detailed information on transmission dynamics especially in areas with more than one host species and more than one *Brucella* species is circulating. In Africa, where almost all known domestic and wild hosts for Brucella are present detailed information on the agent's subspecies and strains is scarce. Most studies in Africa are serology based and mainly restricted to cattle with few looking into bacteriological and molecular aspects and other host species. Integration between serology, bacteriology and molecular typing is necessary to fully understand the epidemiology and transmission dynamics of this complex multispecies pathogen in sub-Saharan Africa. The aim of this study is to describe the transmission dynamics of Brucella spp. in animals and humans in order to develop a protocol for an appropriate control strategy. Available literature will be reviewed and subjected to a meta-analysis. Biological materials from animals and humans will be collected and subjected to *Brucella* culture and isolation. The isolates will be identified, characterized and their phenotypic and genetic relatedness established. This project is expected to build capacity for the isolation of Brucella spp. from different hosts. The current status of brucellosis and source of human infection will be elucidated which will enable the design and execution of an appropriate control and elimination strategy.

Keywords: Culture, Isolation, Genotyping, Phenotyping, Brucella spp., Transmission-dynamics

Dynamic of brucellosis transmission in sub-Saharan Africa: generating evidence for action

Richard Yapi*[1]

Gilbert Fokou[1], Daniel Haydon[2], Giovanna Raso[3], Bassirou Bonfoh[1,3], Rudovick Kazwala[4]

[1]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[2]University of Glasgow, United Kingdom
[3]Swiss Tropical and Public Health Institute, Basel, Switzerland
[4]Department of Veterinary Medicine and Public Health, Sokoine University of Agriculture, Morogoro, Tanzania

*Corresponding author: richard.yapi@csrs.ci

Brucellosis is listed among the most common zoonoses and is more rampant in developing countries. The consequences of the disease are manifold. It rarely causes death in humans, but it is very debilitating and disabling. *Brucella* species cause disabilities in an estimated 15% of cases for chronic and localized brucellosis and in 19% of cases of acute brucellosis infections. The long-term impact of mass-livestock immunization against *Brucella* species could be a major intervention benefitting both, the public health sector and the livestock industry. An integrated, one Health approach, in resource-constrained countries, for the control of brucellosis epidemics is essential. In the proposed study, we aim to provide diseases estimates and quantify parameters that drive the transmission dynamic of *Brucella spp* in endemic settings that would be informative to design control intervention.

Keywords: Brucellosis, sub-Saharan Africa, one health

Evaluation of Novel Diagnostic Tests for Human and Animal Brucellosis

Abdul-Hamid Lukambagire*[1,2]

Jo Halliday[3], John McGiven[4], Blandina Mmbaga[5], Gabriel Shirima[6], Rudovick Kazwala[1]

[1]College of Veterinary and Medical Sciences, Sokoine
[2]University of Agriculture, Morogoro, Tanzania
[3]Kilimanjaro Christian Medical University College, Moshi, Tanzania
[4]The University of Glasgow, Scotland, United Kingdom
[5]Animal and Plant Health Agency, England, United Kingdom
[6]Kilimanjaro Clinical Research Institute, Moshi, Tanzania
[7]The Nelson Mandela African Institution for Science and Technology, Arusha, Tanzania

*Corresponding author: lukhamid@gmail.com

Brucellosis is a zoonosis of veterinary and public health importance due to its widespread distribution, difficulty to control, poor clinical understanding and limited diagnostic capacity in many high risk populations. In Tanzania, there is no clear and consistent diagnostic policy on brucellosis and therefore, an inaccurate picture of the actual disease distribution and burden in humans as well as livestock. Challenges include variable access to diagnostic supplies, poor implementation and lack of robust data on available diagnostic tools.

This study will seek to trial and evaluate a number of novel diagnostic tests for brucellosis on human and livestock samples collected during field projects in East and West Africa. Diagnostic performance will be evaluated on the ability to distinguish true and false seropositive samples in agreement with confirmatory serology, culture and PCR based tests. Further in vitro proteomics characterizing the human T and B-cell immune response to a novel, synthetic antigen will be done following a procedure of immortal white cell culture from febrile cases in high risk areas, to stage the disease pathology.

A rapid field application test kit for speciation of infectious pathogen will also be tested for application on human and livestock samples. The overall benefit of this project will be the evaluation and field testing of novel diagnostic tests poised to inform development of evidence based strategies for better diagnosis, management and control of brucellosis in human and livestock populations in sub-Saharan Africa.

Keywords : Brucellosis, diagnostics, development, novel tests

Brucella host-pathogen association and transmission framework in Sub-Saharan Africa

James Miser Akoko[*1,2]
Collins Ouma[2], Gabriel Shirima[3]

[1]International Livestock Research Institute, Nairobi, Kenya,
[2]Maseno University, Nairobi, Kenya,
[3]Nelson Mandela African Institute of Science and Technology, Arusha, Tanzania

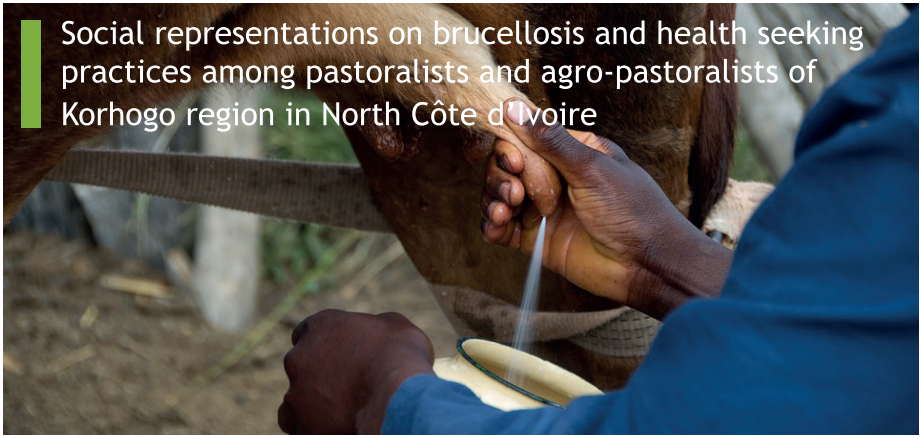
*Corresponding author: j.akoko@cgiar.org

Brucella is a genus of a zoonotic bacterial organism, with several species, affecting humans and a wide range of livestock and wildlife hosts worldwide. Several serological studies in Sub-Saharan Africa (SSA) indicate that it is widespread. However, information on host-pathogen association in SSA is insufficient. Therefore, we are conducting this study (i) to investigate *Brucella* transmission dynamics among different livestock and wildlife hosts, (ii) to identify and characterize *Brucella* species present in different livestock, wildlife and human populations in SSA and (iii) to identify the animal host(s) acting as a reservoir for human infection and the *Brucella* species primarily responsible for human disease in SSA.

A random selection of 10 administrative villages will be carried out within the Mara and Trans-Mara regions of Tanzania and Kenya respectively, 6 villages will be identified in areas that border game reserves. A systematic random sampling method will be used to select herds and a total of 1550 cattle, sheep and goats for collection of blood samples. Any aborted material available during the sampling period will also be sampled. About 200 blood samples will be obtained from consenting clients testing sero-positive for Brucellosis at the medical facilities within the study site, and a further 250 archived wildlife and livestock samples approximated to have been obtained within SSA region. Samples will be screened using ELISA and subsequently all positives are subjected to PCR and sequencing. A structured questionnaire will be administered to get information on the risk factors for *Brucella* transmission in village communities.

Keywords: Brucella, transmission, livestock, sub-saharan, Africa

Social representations on brucellosis and health seeking practices among pastoralists and agro-pastoralists of Korhogo region in North Côte d'Ivoire



Yoro Stéphane-Alain Babo[*1,2]

Zoguéhi Arnaud Kevin Dayoro[1], Gilbert Fokou[2], Bassirou Bonfoh[1], Rudovick Kazwala[3]

[1]Université Félix Houphouët-Boigny d'Abidjan, Abidjan, Côte d'Ivoire
[2]Centre Suisse de Recherche Scientifique en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[3]Sokoine University of Agriculture, Morogoro, Tanzania

*Corresponding author: stephane.babo@csrs.ci

Brucellosis, a highly contagious zoonotic disease is endemic in many low-income countries, with impacts on wildlife, livestock and humans. Staff of slaughterhouses, veterinarians, farmers, shepherds, breeders and their families are known to be most at risk of contracting the disease. In Cote d'Ivoire, several strategies of disease control have been implemented since the 1970s with livestock vaccination campaigns against brucellosis being one of them. This contributed to a decrease in abortions and mortality rates in livestock of more than 37%. Despite those efforts, the disease stills exist in this country and brucellosis has been recently listed as one of the five prioritized zoonotic diseases to be controlled in the country. Strategies for controlling this disease entail preventive and curative measures necessitating the involvement of targeted communities.

To achieve this, it is paramount to understand knowledge, beliefs and practices of most at risk communities on brucellosis. However, there is a knowledge gap regarding the beliefs and practices of pastoral and agro-pastoral communities of North Côte d'Ivoire who are central to this research. This study will conduct a socio-anthropological survey with questionnaires, interviews and participatory photography and by using the One Health approach: (i) assess community knowledge and beliefs on brucellosis; (ii) describe health seeking behaviors; (iii) define practices putting people at risk of brucellosis and finding integrated strategies for better control. This interdisciplinary research will contribute to design better integrated interventions for brucellosis control among humans and animals in Côte d'Ivoire through awareness, vaccination and adequate treatments.

Keywords: Brucellosis, pastoralists, agro-pastoralists, One Health, Côte d'Ivoire

Cultural drivers and treatment pathways related to human Brucellosis in the Morogoro region of Tanzania

Caroline Mwihaki Ng'ang'a*[1]

Salome Bukachi[1], Isaac Nyamongo[1], Ezekiel Mangi[2], Bassirou Bonfoh[3,4], Constanze Pfeiffer[3]

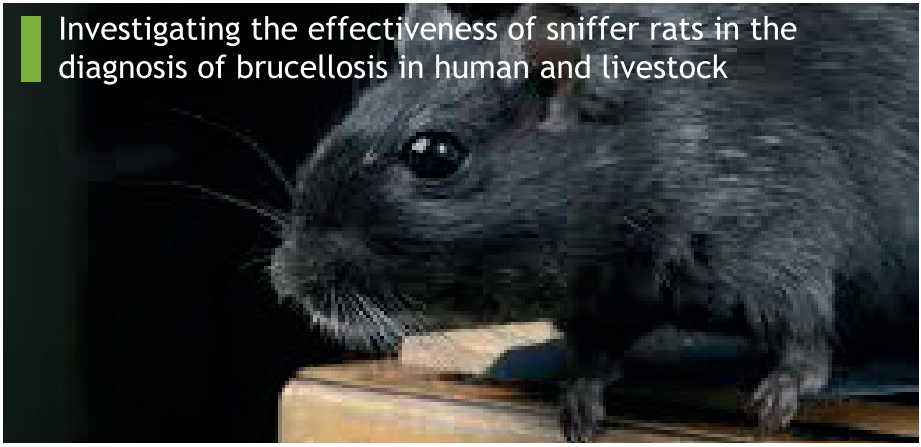
[1]Institute of Anthropology, Gender and African Studies, University of Nairobi, Nairobi, Kenya
[2]Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania
[3]Swiss Tropical and Public Health Institute, Basel, Switzerland
[4]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire

*Corresponding author: mwihakicarol@gmail.com

Brucellosis which is a highly contagious zoonotic disease is endemic in many countries in Africa. In Tanzania, this disease is a major problem especially in pastoral systems because of consumption practices, low awareness and difficulty in implementing livestock control measures. Human behavioural factors have therefore been found to be central in the transmission of brucellosis. The control and prevention of brucellosis partly depends on a holistic approach to understand the interaction of factors such as lay perceptions of the local communities, attitudes and practices of the human and animal health experts as well as the risk factors for brucellosis associated with animal husbandry practices. This understanding would contribute to the development of suitable mitigation strategies. This study proposes that the grounded theory approach serves as the guiding theoretical framework for this research, utilizing the socio ecological model to collect and analyse the data. This will be done using ethnographic methods through participant observation, focus group discussions, key informant interviews, structured interviews and in depth narratives of personal lived experiences. This study will provide detailed knowledge on the communities' awareness, risk perception and health seeking behaviour. This will help policy makers develop appropriate interventions that take into consideration these lay perceptions of risk factors for this disease and communities' livelihood strategies.

Keywords: Cultural drivers, One Health, Treatment Pathways, Ethnography, Zoonotic disease, Tanzania

Investigating the effectiveness of sniffer rats in the diagnosis of brucellosis in human and livestock



Raphael Mwampashi*[1]

Rudovick Kazwala[1], Jo Halliday[2]

[1]College of Veterinary Medicine and Biomedical Sciences, Sokoine University of Agriculture, Morogoro, Tanzania

[2]University of Glasgow, Institut for Biodiversity, Animal Health and Comparative Medicine, Glasgow, United Kingdom

*Corresponding author: rmwampashi@yahoo.com

Brucellosis, also known as, enzootic abortion or undulant fever is a bacterial disease caused by members of the genus *Brucella*, an important zoonosis and a significant cause of reproductive losses in animals. Brucellosis occurs worldwide, both endemically and zoonotically to varying degrees, particularly in Africa. Currently, diagnostics for brucellosis for both humans and animals have several constrains which impact on planning and delivering effective control programmes.

This study aims to improve and support the diagnosis of brucellosis by using sniffer rats.

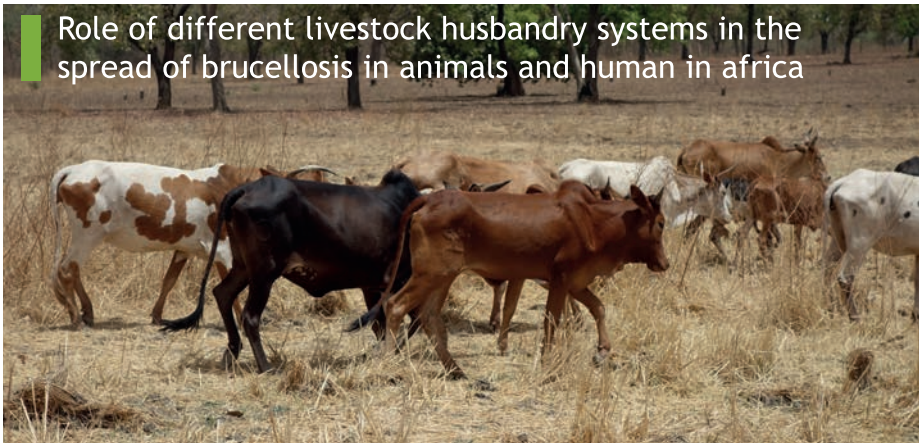
An experimental study design will be employed in which sniffer rats which have an accurate sense of smell will be trained to recognise livestock species infected with Brucella species. The study will be conducted using Hero Rats which are kept at Apopo-SUA and have successfully been trained to diagnose TB in humans. Using operative conditioning based on a reward system, sniffer rats will be trained to detect Brucella in dung samples of livestock.

After training the rats, the diagnostic potential of using trained rats will be tested through a small scale prevalence survey on local livestock herds.

Utilizing trained sniffer rats for *Brucella* detection is a potentially faster screening method. This method could therefore be suitable for active case finding, especially where large numbers of samples are to be analysed in resource-limited settings, to complement existing diagnostic techniques.

Keywords: Sniffer rats, diagnosis, brucellosis, human, livestock

Role of different livestock husbandry systems in the spread of brucellosis in animals and human in africa



Souleymane Traoré*[1]

Rianatou Bada Alembedji[1], Bassirou Bonfoh[2]

[1]Ecole Inter-Etats des Sciences Medicales Vétérinaires, Dakar, Senegal
[2]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire

*Corresponding author: souleymanot@yahoo.fr

The farming systems which currently exist in sub-Saharan Africa are the traditional systems (Pastoral and agro pastoral) and the commercial systems (dairy production and feeder). Studies done in Africa have attempted to determine the prevalence as well as the risk factors implicated in the maintenance of brucellosis, a highly infectious zoonosis, in farms as well as in the human population. It should be noted that most of these studies carried out in Africa related to cattle.

Unfortunately, there is not enough data on the prevalence of brucellosis in the population of small ruminants in sub-Saharan Africa. Thus, we proposed to determine the role of different farming systemsin the spread of brucellosis as well as the risk factors implicated in the infection of humans. This study will be conducted in Mali in the major areas of livestock rearing (Bamako, Sikasso, and Mopti). Samples of blood sera will be analyzed with the Rose Bengale test for preliminary diagnosis of *Brucella* infection. Positive samples will be submitted to the cELISA for confirmation. Furthermore, questionnaires will be administered to different actors such as breeders, veterinarians and doctors. The data collected will be entered with the Epidata® and treated with the software Epidata Analysis® and Epi Info®. This study will be a perfect model of the «One Health» approach. It will enable inter-sectoral and interdisciplinary collaboration to strengthen the capacities of "One Health» professionals for the prevention, early detection and response against brucellosis and other zoonoses.

Through the results that we will get, it will be possible to act at the level of the different factors contributing to the spread of brucellosis in Africa in order to curb its spread.

Keywords: Brucellosis, livestock systems, One Health, Africa, Mali

The role of wildlife in the transmission of brucellosis in humans and animals

Rosamystica Mkula Sambu[*1]

Hezron Nonga[1] et al.

[1]College of Veterinary Medicine and Biomedical Sciences, Sokoine University of Agriculture, Morogoro, Tanzania

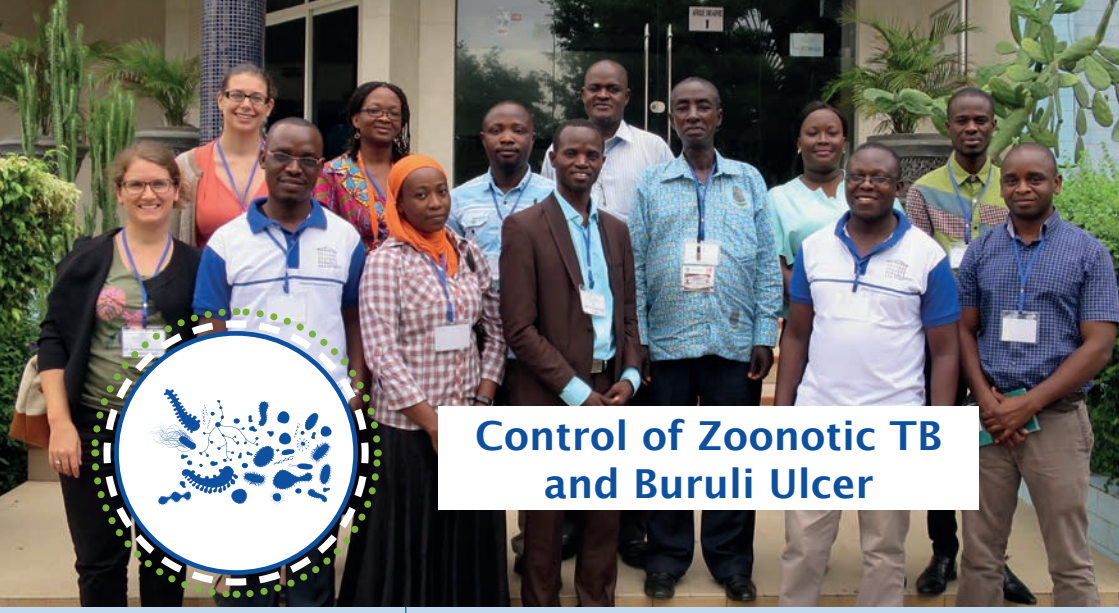
*Corresponding author: mkula1969@yahoo.com

Brucellosis is a zoonotic disease which mostly affects pastoral and agro-pastoral communities in Africa. The infection circulates in domesticated and wild animals, but little is known about the prevalence and strains of *Brucella* in sub-Saharan Africa, especially in areas where livestock and wildlife live in close proximity. To further brucellosis control and elimination, this study aims (i) to elucidate the prevalence of brucellosis in wild animals in the Serengeti ecosystem in Tanzania, (ii) to determine the strains of *Brucella* species in wild animals, cattle and humans, (iii) to investigate the genetic relatedness of *Brucella spp* detected in cattle, wild animals and humans.

A cross-sectional study will be carried out involving samples collected from wild animals, cattle and humans from the Serengeti ecosystem. Sampling of wild animals will invasive and opportunistic. Blood samples from immobilized wild animals and cattle will be collected. Analytical techniques to be used are Polymerase chain reaction and, for genetic relatedness tests of *Brucella* species Geneious software for phylogenetic tree building. This study will establish the molecular prevalence of brucellosis hosts and humans of the Serengeti ecosystem; characterize *Brucella* species detected and determine genetic relatedness of *Brucella spp.* detected in wild animals, cattle and humans. The study will contribute towards identifying local strains of *Brucella* in Tanzania which can be used in vaccine development. New approaches to control measures can be devised especially in the wildlife-livestock-human interface areas. After knowing the status of brucellosis in the interface areas, new policies on control of brucellosis can be put in place.

Keywords: Brucellosis, wild animals, cattle, humans, molecular identification

Notes



Control of Zoonotic TB and Buruli Ulcer

Lead

Kennedy Addo
NMIMR, Ghana

Co-lead

Rudovick Kazwala
SUA, Tanzania

Collaboration

NMIMR, Ghana
SUA, Tanzania
IRED, Chad
BecA-ILRI Hub, Kenya
NIMR, Tanzania
KCRI-KCMC, Tanzania
CSRS, Côte d'Ivoire

The objectives of the Thematic Training Programme on control of zoonotic TB and Buruli ulcer are the following:

- To differentiate *Mycobacterium tuberculosis* complex (MTBC) isolates to the species level from TB disease prevalence surveys, selected clinics including MDR clinics and animal sources using GenoType MTBC (Hain Lifescience GmbH, Nehren, Germany) and Spoligotyping
- To differentiate Non-Tuberculous Mycobacteria (NTM) isolates to the species levelfrom TB disease prevalence surveys, selected clinics including MDR clinics and animal sources using GenoType CM/AS (Hain Lifescience GmbH, Nehren, Germany)
- To determine the first and second line drug susceptibility patterns of MTBC isolates using BD BACTEC MGIT 960 SIRE test kit (Becton Dickinson, Sparks, MD, USA)
- To determine the drug susceptibility patterns of NTM isolates
- To determine the presence of mutations associated with drug resistance by sequencing

Childhood tuberculosis in Ghana: using immunodiagnostics to improve detection and monitoring of response to anti-tuberculosis therapy

Gloria Ivy Mensah*[1]
Dolly Jackson-Sillah[2], Joram Buza[3], Rudovick Kazwala[4], Christoff Geldmacher[5], Bassirou Bonfoh6, Kennedy Addo[1]

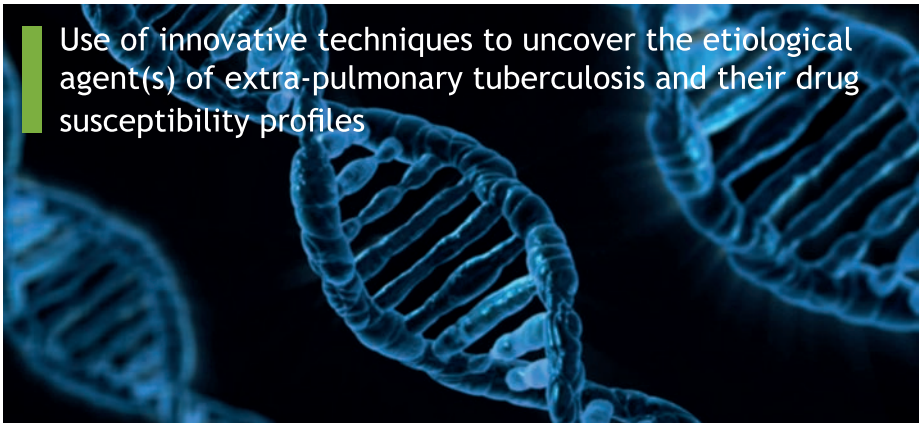
[1]Noguchi Memorial Institute for Medical Research, Accra, Ghana
[2]London School of Hygiene and Tropical Medicine, London, United Kingdom
[3]Nelson Mandela African Institution of Science and Technology, Arusha, Tanzania
[4]Sokoine University of Agriculture, Morogoro, Tanzania
[5]German Center for Infection Research & Department for Infectious Diseases and Tropical Medicine, Medical Center of the University of Munich, Germany
[6]Centre Suisse de recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire

*Corresponding author: gmensah@noguchi.ug.edu.gh

In 2014, of 728 children diagnosed with tuberculosis (TB) in Ghana, only 13% were smear-positive. For about 35% of these pediatric TB cases, smear microscopy was not done at all because sputum could not be obtained. In the absence of sputum, TB diagnosis is based on clinical signs, symptoms and history. This often results in over or under-diagnosis as this has not been validated against the gold standard sputum-culture. This prospective longitudinal study seeks to provide a realistic diagnostic algorithm for TB in children using a combination of existing tools including sputum-independent immunodiagnostic assays. Children under 15 years of age, newly diagnosed with TB will be recruited from selected health facilities in Accra. Peripheral blood (7mls) will be obtained (pretreatment initiation); 4mls for the Quantiferon® TB test and 3mls for whole blood and serum assays. Multiple cytokine levels in serum and harvested culture supernatant will be measured at 3 time points before and during anti-TB treatment. In a subset of children, an additional 5mls of blood will be taken to assess the diagnostic potential of the TAM-TB assay®. For children able to produce sputum, microscopy, culture (LJ and BACTEC MGIT 960), and Xpert MTB/RIF® assay will be done to isolate Mycobacterium tuberculosis complex and detect Multidrug resistance (MDR) respectively. This study will provide a tool for confirming a clinical diagnosis of childhood TB and reduce cases of over or under-diagnosis. In addition, associated risk factors and etiological agents of childhood TB will be uncovered.

Keywords: TB, children, diagnosis, blood, TAM TB assay, Ghana

Use of innovative techniques to uncover the etiological agent(s) of extra-pulmonary tuberculosis and their drug susceptibility profiles



Samuel Ofori Addo*[1]

Lydia Mosi[2], Gloria Ivy Mensah[1], Rudovick Kazwala[3], Bassirou Bonfoh[5], Jakob Zinsstag[4]

[1]Department of Bacteriology, Noguchi Memorial Institute for Medical Research, Legon, Ghana
[2]Department of Biochemistry, Cell and Molecular Biology, University of Ghana, Legon, Ghana
[3]Sokoine University of Agriculture, Morogoro, Tanzania
[4]Swiss Tropical and Public Health Institute, Basel, Switzerland
[5]Centre Suisse de recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire

*Corresponding author: soaddo@noguchi.ug.edu.gh

Tuberculosis (TB) can affect almost any organ of the body and although the most common presentation is pulmonary, extra-pulmonary TB (EPTB) forms about 10-15 % of all reported TB cases globally. In Ghana, about 1, 212 (2.7%) of all TB cases reported in 2015 were EPTB. However, this figure may not reflect the actual EPTB incidence due to diagnostic challenges. Absence of typical clinical features and often negative conventional diagnostic tests (smear microscopy and culture) due to paucibacillary nature of samples contribute to delay in diagnosis and appropriate drug therapy. This study seeks to use novel tools which offer prospects for rapidity, high sensitivity and specificity in determining the etiology of EPTB and their drug susceptibility test (DST) patterns from ante- and post-mortem samples. A cross-sectional study will be conducted in ten hospitals located across coastal, middle and northern pastoral areas in Ghana. Appropriate extra-pulmonary samples will be collected consecutively from all presumptive EPTB patients. Line Probe Assays, Spoligotyping and sequencing will be done after extracting DNA from samples. Sensitivities and specificities of each tool will be calculated. It is expected that risk factors for EPTB as well as usefulness of molecular techniques in detecting etiological agents of EPTB and DST patterns would be demonstrated. In addition, relevant information will be generated to support efforts by government and other stakeholders in public health activities in formulating new or reviewing existing policies on diagnostic algorithms and treatment options for extra-pulmonary TB in Ghana.

Keywords: Extra-pulmonary TB, Molecular techniques, DST, post-mortem, Ghana

Molecular Characterization and Monitoring of *Mycobacterium tuberculosis* Complex for Clinical Management of Multidrug-resistant Tuberculosis: "A Strategy to Optimize Favorable Treatment Outcomes in Tanzania"

Peter Mbelele[*1,2]

Elingarami Nkya[2], Emmanuel Mpolya[2], Sayoki Mfinanga[3], Kennedy Addo[4], Stellah Mpagama[1]

[1]NKibong'oto Infectious Diseases Hospital, Sanya Juu, Tanzania
[2]Nelson Mandela African Institute of Science and Technology, Arusha, Tanzania
[3]National Institute for Medical Research-Muhimbili, Dar es Salaam, Tanzania
[4]Noguchi Memorial Institute For Medical Research, Accra, Ghana

*Corresponding author: mbelelepeter@yahoo.com

Multidrug resistance-tuberculosis (MDR-TB), caused by *M. tuberculosis* complex (MTBC) harboring mutations on genes encoding rifampicin and isoniazid, is a result of tuberculosis and human immunodeficiency virus (TB/HIV) co-epidemics. Treatment of MDR-TB is lengthy (9-24 months) with less efficacious regimen, accounting for high mortality and morbidity. This study aims to apply molecular diagnostics to characterize MTBC and monitor MDR-TB treatment response.

Consented 70 MDR-TB participants enrolled at Kibong'oto Infectious Diseases Hospital will provide pre-treatment sputum. The direct sputum will be tested to differentiate MTBC species by GenoType MTBC Version 1.X (HAIN LifeSciences) and processed sputum will be cultured on Lowenstein-Jensen media for susceptibility on TaqMan® array card-high resolution melts and phenotypic method such as minimum inhibitory concentration (MIC). Discordant results will be tie-broken by whole genome sequencing. Furthermore, pre-treatment and subsequently 10 sputa collected during the first 4 months of intensive phase will be processed on molecular bacterial load assay to quantify clearance of MTBC 16S rRNA, a proxy for treatment response. Cohen-Kappa and Cox-hazard proportion models will calculate agreement of susceptibility test results and clearance of MTBC respectively. A difference of results at $p \leq 0.05$ will be considered significant.

The MTBC species: *M. tuberculosis*, *M. bovis*, *M. africanum* etc., susceptibility of second line anti-TB drugs (Kanamycin, Capreomycin, moxifloxacin, isoniaziad, Ethionamide, Cycloserine, pyrazinamide, clofazimine, ethambutol) and MTBC Clearance rate during MDR-TB treatment will be elucidated.

These findings will guide in designing strategies for optimizing MDR-TB regimens that will improve favorable treatment outcomes.

Keywords: Multidrug-resistance, tuberculosis, M. tuberculosis complex, susceptibility, anti-TB drugs, treatment-response, Kibong'oto, Tanzania

The genetic basis of drug-resistant patterns in *Mycobacterium tuberculosis* complex: clinical isolates from tuberculosis patients in Tanzania

Nicholaus Peter Mnyambwa[*1,2]

Dong-Jin Kim[1], Esther Ngadaya[2], Rudovick Kazwala[3], Pammla Petrucka[1,4], Kennedy Addo[5], Sayoki Mfinanga[2]

[1]School of Life Sciences and Bioengineering, Nelson Mandela African Institution of Science and Technology, Arusha, Tanzania.
[2]National Institute for Medical Research, Muhimbili Medical Research Centre, Dar es Salaam, Tanzania
[3]Faculty of Veterinary Medicine, Sokoine University of Agriculture, Morogoro, Tanzania.
[4]College of Nursing, University of Saskatchewan, Saskatoon, Canada.
[5]Bacteriology Department, Noguchi Memorial Institute for Medical Research, Accra, Ghana

*Corresponding author: lodnicho@gmail.com

Evolving novel and/or unfamiliar mutations are revolutionizing the pathways of antibiotic resistance of clinical tuberculosis (TB). Accumulation and interactions of these poorly characterized mutations fuel the complexity of resistant pathogenic strains and raise public health concerns. Although known mutations explain much resistance in TB, several causative mutations in clinically resistant isolates are unknown and, even where such mutations have been identified, there may be additional mutants that nurture drug resistance. It is estimated that between 10 and 40% of causative mutations in clinically resistant isolates have not yet been identified. Consensus is growing that mycobacterial genotype may be strongly interconnected with a specific human population in a narrow geographical region, which reframes global TB pandemic as a totality of genetically diverse outbreaks. Thus, well-defined localized programs are necessary for a holistic, responsive and meaningful global solution. Tanzania is ranked amongst the 20 countries with the highest TB burden, but minimal information on resistant TB further complicates building effective management strategies. This study employs High-Throughput genotyping and whole genome sequencing methods to characterize genetics of drug resistance and transmission dynamics amongst TB strains circulating in Tanzania. The study utilizes TB samples routinely received at the National Reference TB Laboratory as a part of national TB surveillance. Additionally, the study employs qualitative and quantitative methods to assess factors associated with pre-treatment loss among multi-drug resistant TB patients in the country. This genetic and pre-treatment loss data is critical for effective TB control interventions in the country.

Keywords: Tuberculosis (TB), Multi-drug resistant TB (MDR-TB), Mutation

One Health Approach for Tuberculosis control in Burkina Faso: molecular characterization, drug resistance profiles and human susceptibility to etiological agents of zoonotic tuberculosis

Diakourga Arthur Djibougou[*1,2]
Serge Diagbouga[2], Adrien Marie-Gaston Belem[1], Roch Kounbobr Dabiré[2], Gloria Ivy Mensah[3], Matthieu Perreau[4], Adama Sanou[1,2], Hervé Hien[1], Rudovick Kazwala[5], Kennedy Addo[3], Bassirou Bonfoh[6,7,8], Sebastien Gagneux[7,8]

[1]Université Polytechnique de Bobo-Dioulasso, Bobo-Dioulasso, Burkina Faso
[2]IRSS/Centre MURAZ, Bobo-Dioulasso, Burkina Faso
[3]Noguchi Memorial Center for Medical Research, University of Ghana, Accra, Ghana
[4]Université de Lausanne, Lausanne, Switzerland
[5]Sokoine University of Agriculture, Morogoro, Tanzania
[6]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[7]Swiss Tropical and Public Health Institute, Basel, Switzerland
[8]University of Basel, Basel, Switzerland

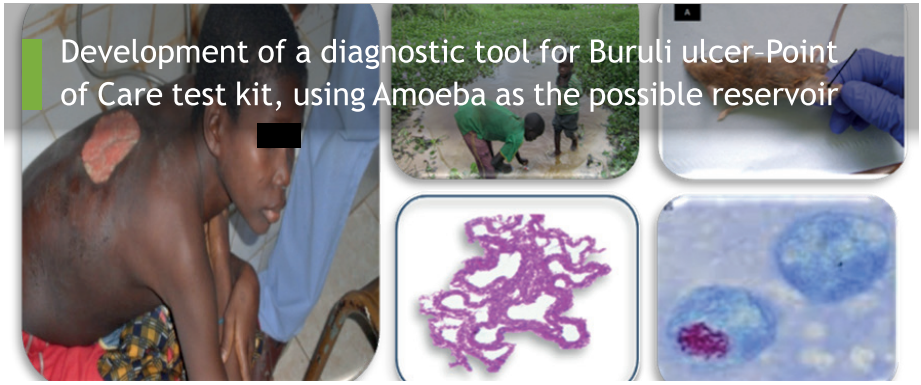
*Corresponding author: lynndjibougou@gmail.com

Zoonotic tuberculosis (TB) is responsible for huge economic losses in the veterinary field and represents a global threat to public health. In Burkina Faso (BF), TB is considered a major zoonosis and as such there are policies for monitoring and control activities in slaughterhouses to ensure that infected carcasses are not put on the market for human consumption. Despite these efforts, there is ample evidence that many communities are still highly exposed to TB-infected cattle directly or through consumption of unpasteurized milk and dairy products. Prevalence of bovine tuberculosis in cattle is estimated at 6.05% in BF, but the proportion of human TB cases due to zoonotic mycobacteria species is unknown. Despite mass drug distributions, intestinal parasitic infections and under-nutrition remain considerable health issues in BF.

Helminthes infections are mediated by a Th2 immune response in contrast to Th1-mediated response to TB. A shift in the immune response to Th2 following a helminthic infection coupled with under-nutrition can lead to a weakened response to renewed TB infection or reactivation. We aim to determine (i) the prevalence of zoonotic mycobacteria in humans and cattle using current molecular tools, (ii) drug sensitivity profile of zoonotic mycobacterial isolates, (iii) impact of helminths co-infection and under-nutrition on the immune response to TB, (iv) and to evaluate the impact of an integrated "One Health Approach" on health system policies for improving TB control in BF. The study will provide information on the burden and appropriate drug therapy for zoonotic TB.

Keywords: Zoonotic mycobacteria, Drug resistance, Helminthiasis and Undernutrition, Immune response, One Health, Burkina Faso

Development of a diagnostic tool for Buruli ulcer–Point of Care test kit, using Amoeba as the possible reservoir



Adiza Abbas*[1]

Kennedy Addo[2], Juerg Utzinger[3], Bassirou Bonfoh[4], Lydia Mosi[1]

[1]Department of Biochemistry, Cell and Molecular Biology, University of Ghana, Ghana
[2]Noguchi Memorial Institute for Medical Research, legon, University of Ghana, Ghana
[3]Swiss Tropical and Public Health Institute, Basel, Switzerland
[4]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire

*Corresponding author: abass_adiza@yahoo.com

Buruli ulcer, caused by *Mycobacterium ulcerans* (*M. ulcerans*), is a cutaneous infection which affects both sexes and age groups in humans. The mode of transmission has been shown to be multifactorial with high correlation between disease incidence, environmental disturbance and slow moving water bodies. Previous research done under the Afrique One phase one program identified *M. ulcerans* in humans and small mammals in the same endemic environment. Interestingly, biofilms which are known to harbour amoeba, have in various MU transmission studies been shown to contain significantly higher M. ulcerans DNA. What is more, research also suggests that *Acanthamoeba* have a symbiotic relationship with mycobacteria. The virulence and transmissibility of M. ulcerans when associated with *amoeba* is directly proportional.

Our work is based on the One Health's concept which highlights the importance of considering the environment of both humans and animals in order to develop novel diagnostics for early detection of *M. ulcerans* infection. This is in line with the WHO's mandate of identifying novel biomarkers for early diagnostic tests to be used at the point of care.

Keywords: Buruli ulcer, Mycobacterium ulcerans, Amoeba, Diagnostic

Determination of mycobacterium species and their drug susceptibility pattern on samples collected during DR-TB surveillance in the Northern Tanzania

Togolani Godfrey Maya*[1]

Peter Mbelele[1,2], Esther Ngadaya[3], Sayoki Mfinanga[3], Kennedy Addo[4]

[1]NKibong'oto Infectious Diseases Hospital, Sanya Juu, Tanzania
[2]Nelson Mandela African Institute of Science and Technology, Arusha, Tanzania
[3]National Institute for Medical Research, Muhimbili Medical Research Centre, Dar es Salaam, Tanzania
[4]Bacteriology Department, Noguchi Memorial Institute for Medical Research, Ghana

*Corresponding author: tmaya2009@gmail.com

Tuberculosis control strategies are challenged by emergence of Mycobacterium strains that are resistant to anti-tuberculosis drugs. Out of estimated 730 MDR-TB cases in Tanzania, only 178 had bacteriological confirmation, of which 12% were notified from Northern Tanzania. This low bacteriological confirmation which mostly relates to limited laboratory infrastructure depends on TB culture and Xpert® MTB/Rif assay which not only they delay results but also fail to provide a full spectrum of anti-TB drugs. Advanced molecular tests such as Taqman Array Card (TAC-HRM) which reports all first line anti-TB drugs and most of second line anti-TB drugs has potential to widen the spectrum of DR-TB and minimize test turn-around time. This study will identify Mycobacterium species and their drug susceptibility pattern. In addition it will determine cost of using TAC-HRM for surveillance in comparison to culture method in use.

This is a cross-sectional study that will include a total of 175 isolates from sputa samples collected from the main TB clinics during DR-TB surveillance in Northern Tanzania.

Expected outcomes: This study will build knowledge and expertise on research paper publication, build foundation for career development in molecular diagnostics and lastly the findings will help in guiding decision making in selection of appropriate methods for DR-TB surveillance.

Use of advanced molecular methods such as TAC-HRM, GenoType® CM/AS, GenoType® MTBC and GenoType® NTM-DR during DR-TB surveillance can widen the spectrum drug tested, improve baseline characterization of infecting mycobacterium species and thus provide quality surveillance data for TB epidemic control.

Keywords: Mycobacteria species, One Health, drug susceptibility, Taqman Array Card – High Resolution Melt applicability

Enhanced detection of active tuberculosis infections in Ghana: Cost effectiveness of the interferon gamma release assays

Ivy Drago Amanor*[1]
Gloria Ivy Mensah[1], Sayoki Mfinanga[2], Rudovick Kazwala[3], Bassirou Bonfoh[4], Jakob Zinnstag[5], Kennedy Addo[1]

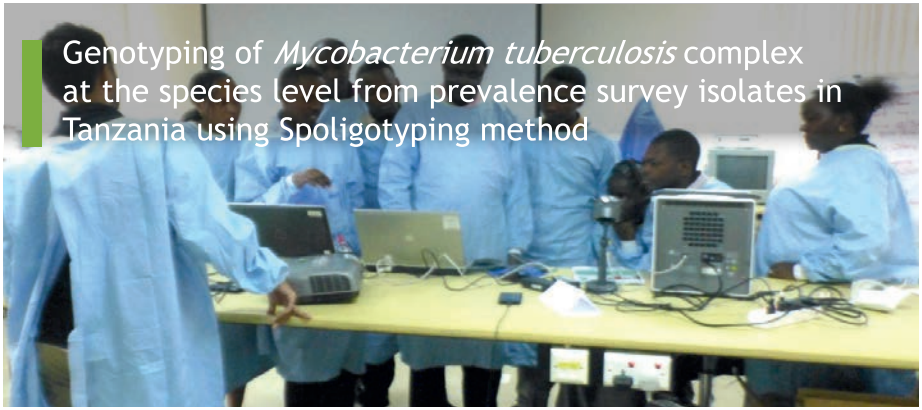
[1]Bacteriology Department, Noguchi Memorial Institute for Medical Research, Ghana
[2]Muhimbili Research Centre of the National Institute for Medical Research, Dar es Salaam, Tanzania
[3]Sokoine University of Agriculture, Morogoro, Tanzania
[4]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[5]Swiss Tropical and Public Health Institute, Basel, Switzerland

*Corresponding author: iamanor92@yahoo.com

In humans and cattle, two tuberculosis (TB) conditions caused by the *Mycobacterium tuberculosis* complex, exist; latent TB infection (LTBI) and active TB disease. While data on active TB is readily available, information on LTBI in humans and cattle is not notifiable. However, because LTBI can develop into active TB, LTBI testing serves as basis for further screening to detect already active TB or take precautionary measures. The introduction of the interferon gamma release assays (IGRAs) made testing for both humans and cattle easier. Currently, the commercially available IGRAs are the 'T SPOT TB' and the Quantiferon TB gold in tube test '(QFT-GIT)' for humans as well as the 'Bovigam test' for cattle .The purpose of this study is to determine the cost effectiveness of each IGRAs for detecting TB infection .The study will be conducted in selected hospitals and abattoirs in Accra, Ghana. Blood samples from household contacts of smear-positive TB patients and cattle will be screened with the IGRAs, Concordantly; early morning sputum from the contacts and suspected lesions from cattle will be subjected to GeneXpert MTB/RIF analysis as a definitive test for TB disease. Factors such as cost per test, equipment and technical skills needed as well as time spent and accuracy of the test will be compared. The study will not only provide an estimate of the burden of LTBI among household contacts of TB patients and cattle but also inform policy on usage of IGRA in Ghana.

Keywords: Latent TB, Household contact, IGRA, Abattoir, cost effectiveness, Ghana

Genotyping of *Mycobacterium tuberculosis* complex at the species level from prevalence survey isolates in Tanzania using Spoligotyping method



Saidi Mwinjuma Mfaume*[1]
Kennedy Addo[2], Sayoki Mfinanga[1]

[1]National Institute for Medical Research, Dar es Salaam, Tanzania
[2]Noguchi Memorial Institute for Medical Research, Accra, Ghana

*Corresponding author: mfaume.saidi45@gmail.com

Tuberculosis (TB) which is caused by *Mycobacterium tuberculosis* complex (MTC) is one of the major causes of death from infectious diseases worldwide. Mycobacterium tuberculosis is considered to be the most common causative agent of human TB and *Mycobacterium bovis* is the causative agent for TB in cattle. TB epidemic is larger than previously estimated. The global estimation of the number of new and previously treated TB cases for 2015 was 10.4 million. Several studies have already been carried out on the characterization of *Mycobacterium tuberculosis* to species level. However, these studies were conducted with samples originating from small geographic areas. The objective of this study is to characterize *Mycobacterium tuberculosis* complex (MTBC) isolates collected from the National TB prevalence survey in Tanzania (PST) covering a much wider geographical area. These isolates were obtained from sputum specimen collected from 62 clusters which were included in the Prevalence Survey of Tanzania. The clusters were randomly selected from all over the country. The sputum specimens were collected at the community level and processed at the Central Tuberculosis Reference Laboratory (CTRL). A total of 100 isolates from PST, stored at the CTRL, Dar es Salaam, will be used for the study. DNA will be extracted from the isolates and tested at the BecA-ILRI Hub in Nairobi, Kenya, using Spoligotyping method. The sequences will be compared with those available in the SpolDB4 database. Data will be double entered into EpiData and analyzed using SPSS. Both Genotypic and demographic records of the patients will be analyzed. It is expected that at the results obtained from this study will help to differentiate the species causing TB in Tanzania and shed light on their geographical distribution. This will help to optimize treatment and interventions.

Keywords: Genotyping, Prevalence Survey, Tanzania

Foodborne Diseases and Nutritional Illnesses

Lead

Bassirou Bonfoh
CSRS, Côte d'Ivoire

Co-lead

Sayoki Mfinanga
NIMR, Tanzania

Collaboration

CSRS, Côte d'Ivoire
NIMR, Tanzania
NM-AIST, Tanzania
SUA, Tanzania
TAWIRI, Tanzania
KCRI-KCMC, Tanzania
MUHAS, Tanzania
UDSM, Tanzania
BecA-ILRI Hub, Kenya
EISMV, Senegal
Swiss-TPH, Switzerland

Foodborne zoonoses are taking a massive toll in the world's poorest communities in sub Saharan Africa. According to the WHO, neglected zoonosis affects majority of poor and marginalized people worldwide every year. Viral, parasitic and bacterial diseases, known to be neglected, are among some of the most common infections affecting about 2.7 billion people who live below the poverty line of less than 2 US$ a day (WHO 2006). Poverty and food insecurity are the main determinants of endemic and emerging zoonotic diseases.

The Foodborne diseases and nutritional illness TTP address the epidemiological links between food and human health including infectious and non infectious diseases, and show how these factors will influence the effectiveness of control interventions based on risk.

The countries covered by this TTP are: Burkina Faso, Côte d'Ivoire, Ghana, Senegal and Tanzania.

Notes

Livestock and human health: Risks and burden of foodborne diseases and non-communicable diseases in pastoralist communities in Tanzania and Côte d'Ivoire

Mbazi Senkoro*[1]

Sayoki Mfinanga[1], Daniel Haydon[2], Esther Ngadaya[1], Bonfoh Bassirou[3]

[1]National Institute for Medical Research – Muhimbili Medical Research Centre, Dar es Salaam, Tanzania
[2]University of Glasgow, Institute for Biodiversity, Animal Health and Comparative Medicine, Glasgow, United Kingdom
[3]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire

*Corresponding author: senkorombazi@gmail.com

Foodborne diseases (FBDs) are taking a massive toll on the world. Non-communicable diseases (NCDs) have also been identified as high priority, and currently are the leading cause of death worldwide. Livestock can have multiple impacts on human health, but the interactions and potential trade-offs between health benefits and risks of livestock-keeping are poorly understood. Pastoralists' communities in Tanzania and Côte d'Ivoire are experiencing a rapid increase in the incidence of FBDs and NCDs. However, knowledge gaps remain regarding the effect of factors like food handling, food preparation, storage of food, etc. on FBDs and NCDs risks. We are going to develop an innovative surveillance tool for predicting and evaluating the risks and burden of FBDs and NCDs in pastoralist communities in Tanzania and Côte d'Ivoire. This will be a cross-sectional study in Tchologo (Côte d'Ivoire) and Manyara (Tanzania) regions. We will employ quantitative and qualitative data collection techniquesto study various stages of the food chain to identify risk factors for FBDs. We will test for enteropathogens in people with symptoms suggestive of FBDs to determine the burden of FBDs. For NCDs, we will use a WHO-stepwise approach for identification of risk factors and to determine the burden. Descriptive and analytical statistics will be presented and the risk factors and burden of FBDs and NCDs will be assessed. Studying the dynamics of interaction of these factors will allow modelling and prediction of risks and the burden of the two diseases and thus allow good plans for control and prevention.

Keywords: Foodborne diseases, Non-communicable diseases, Pastoralists' communities, Tanzania, Côte d'Ivoire

Epidemiology of Salmonella spp at Human-Animal interface and options for mitigating gastrointestinal disorder

Clarisse Abikpo Houngbedji*[1]

Gilbert Fokou[1], Daniel Haydon[2], Andrew Yona Kitua[3], Sayoki Mfinanga[3], Giovanna Raso[4], Bassirou Bonfoh[1,4]

[1]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[2]University of Glasgow, United Kingdom
[3]National Institut of Medical Research, Dar es-Salaam, Tanzania
[4]Swiss Tropical and Public Health Institute, Basel, Switzerland

*Corresponding author: clarisse.houngbedji@csrs.ci

Salmonella is one of the major foodborne pathogens responsible for gastrointestinal disorders (diarrhea and constipation) threatening lives of people of all ages. Gastroenteritis illnesses and Typhoid fever are most common in developing countries, but there is little data available on *Salmonella spp* infection, particularly in Côte d'Ivoire. Most of the studies done focused on the description of hazards related to foods and their pathogens without assessing their real effect on population health. The aim of this study is to assess the actual burden of foodborne diseases due to *Salmonella spp* by quantifying self-reported diarrhea and constipation and associated risk factors, at the household level. Using a One Health concept, humans, animal source food and the surrounding environment will all be investigated. We will use a cross-sectional study approach at the household level. Furthermore, we will investigate street food vendors in three localities in Côte d'Ivoire (Korhogo, Toumodi and Abidjan). A transdisciplinary approach combining sociology, microbiology, molecular biology, and epidemiology will allow the understanding and perception of gastrointestinal disorders in people. We will also determine the prevalence of *Salmonella spp* and its associated risk factors within the household to develop a surveillance tool based on the predicted risk of infection. This will help to adapt control intervention strategies for risk mitigation.

Keywords: *Salmonella spp*, self-reported diarrhea and constipation, One Health, risk factors, prediction

Constant Rémi Angora Ahoua*[1,2]
Mamidou Koné[1,2], Bassirou Bonfoh[2]

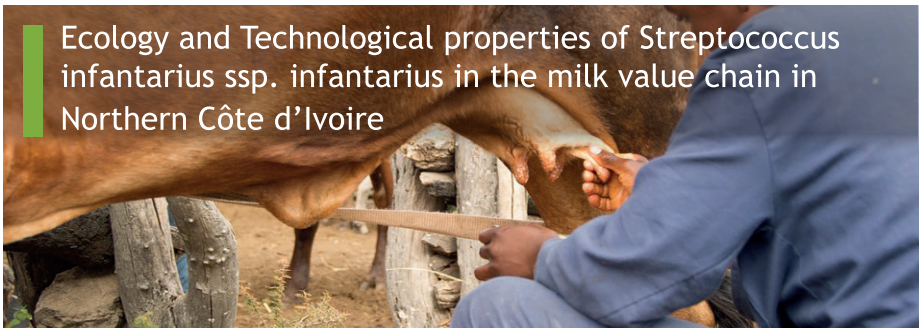
[1]Nangui Abrogoua University, Abidjan, Côte d'Ivoire
[2]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire

*Corresponding author: constant.ahoua@csrs.ci

Côte d'Ivoire, like most tropical countries, has abundant flora, rich in species. This flora offers a large choice of plants with active substances, whose curative or toxic properties offer nutrition and the preparation of remedies for the treatment of many diseases in all parts of the country. Among these plant species, there are those which are consumed by great apes. A study carried out on plants consumed by chimpanzees on the biological, nutritional and phytochemical aspects, showed that some of these plants inhibit bacterial, fungal and cancer development and have high antioxidant and nutritional properties. Compounds with high therapeutic potential have been identified and seven have been isolated; Among them, two new compounds with anticancer potential. Most of the Ivorian medicinal plants have also been studied. In the interest of contributing to the well-being of the population, it is important to develop functional foods or nutraceuticals. Based on the results, Ivorian medicinal plants and those consumed by chimpanzees will be screened to select certain plant species. The aim of this study will be to identify in the Ivorian flora, plants with high therapeutic potential to develop drugs. Based on a bio-cultural approach, plant species will be selected for functional foods and nutraceutical development. In this study, the focus will be on remedies for non-communicable diseases (NCDs) including diabetes, hypertension, cancer and infectious diseases (bacterial infections). Plant species concerned include thoses whose activities have already been demonstrated.

Keywords: Plants, Nutraceuticals, Infectious diseases, NCDs, Drugs, Côte d'Ivoire

Ecology and Technological properties of Streptococcus infantarius ssp. infantarius in the milk value chain in Northern Côte d'Ivoire



Aimé Roland Sanhoun*[1]

Clarisse Abikpo Houngbedji[2], Sylvain Gnamien Traoré[3,2], Christoph Jans[4], Francesca Stomeo[5], Pierre Renault[6], Lydia Mosi[7], Mbazi Senkoro[8], Sayoki Mfinanga[8], Marina Koussemon[1], Bassirou Bonfoh[2,9,10]

[1]Université Nangui Abrogoua, Abidjan, Côte d'Ivoire
[2]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[3]Université Péléforo Gon Coulibaly, Korhogo, Côte d'Ivoire
[4]ETH Zurich, Zurich, Switzerland
[5]BecA/ILRI-Hub, Nairobi, Kenya
[6]Institut National de la Recherche Agronomique, Jouy-en-Josas, France
[7]West African Centre for Cell Biology of Infectious Pathogens, Accra, Ghana
[8]National Institute for Medical Research, Dar es Salaam, Tanzania
[9]Swiss Tropical and Public Health Institute, Basel, Switzerland
[10]University of Basel, Basel, Switzerland

*Corresponding author: aime.sanhoun@csrs.ci

In Africa, milk is an important source of income and nutrients. Due to its traditional production, milk is subject to rapid deterioration and zoonoses' transmission. The novel *Streptococcus infantarius ssp. infantarius (Sii)*, a lactic acid bacterium of the *Streptococcus bovis/Streptococcus equinus* complex (SBSEC), is predominantly isolated from spontaneous fermented milk across Africa. However, Sii has never been isolated from raw milk. Thus, sources of contamination of milk by *Sii*, their moments of intrusion into the milk and factors favoring their emergence remain unknown. The ecology of Sii in the dairy environment is also unstudied. Moreover, the greater adaptation of Sii to milk metabolism, the absence of virulence factors in Sii and their ability to inhibit certain food pathogens point to *Sii*'s potential to be an excellent starter culture. Through a cross-sectional study with collection and analysis of samples from human, animals and environment, (i) Origins of *Sii* in milk will be determined by sampling milkers' hands, cows' udders, calves' tongues, soil, air, water, utensils and raw milk directly sampled from cows' udders; (ii) Moments of introduction of Sii in the milk and factors of their predominance will be determined by monitoring spontaneous fermentation of raw milk to determine emergence parameters of Sii (titratable acidity, pH, temperature, duration, evolution of microflora etc.); (iii) Technological properties of *Sii* will be evaluated (acidification rates, flavor compounds production etc.) and a stabilized starter culture will be developed targeting improvement of traditional dairy products quality and the livelihoods of milk dependent populations.

Keywords: Milk, Streptococcus infantarius, Fermentation, SBSEC, Starter culture

Development of an innovative surveillance tool for predicting and estimating the burden of Non-typhoidal Salmonellosis in Ghana

Vida Yirenkyiwaa Adjei*[1]

Tanu Debrah[1], Bassirou Bonfoh[2], Kennedy Addo[3]

[1]University of Ghana, Legon, Ghana
[2]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[3]Noguchi Memorial Institute for Medical Research, legon, University of Ghana, Ghana

*Corresponding author: vyadjei@gmail.com

Salmonellosis caused by non-typhoidal *Salmonella* species is the leading cause of foodborne mortality and morbidity worldwide. Estimation of the true burden of foodborne diseases is difficult and complex. In Ghana and most developing countries, incidences of foodborne diseases (FBD) are not reported because of non-existence of awareness and/or public health surveillance systems and partly because affected persons do not always seek medical care and submit a stool sample for testing. Additionally, risk factors for Salmonellosis outbreaks are understudied and therefore predicting an outbreak is very difficult. The proposed study will identify environmental as well as source-to-consumption risk factors for *Salmonella* Infection in both rural and urban communities. Predictive Models such as Bayesian inference and Monte Carlo simulation will be employed to estimate the true burden of non-typhoidal Salmonellosis based on identified risk factors. The proposed study is expected to raise awareness on the risk, causes and prevention of Salmonellosis among the general public. Additionally, a database for *Salmonella* serovars in Ghana will be established for future work. The study will also inform Public Health Officials, the Food and Drug Authority and Policy makers on better resource allocation and intervention efforts.

Keywords: Samonellosis, Food borne disease, Bayesian inference

Development of a surveillance model for monitoring, predicting risk factors and evaluating prevention methods of non-communicable diseases among urban street-cooked food consumers in Tanzania: A non-randomized trial.

Gibson Benard Kagaruki*[1]

Michael Jonson Mahande[2], Sayoki Mfinanga[1], Esther Ngadaya[1], Daniel Haydon[3], Bonfoh Bassirou[4]

[1]National Institute for Medical Research, Dar es Salaam, Tanzania
[2]Kilimanjaro Christian Medical College of Tumaini University, Moshi, Tanzania
[3]University of Glasgow,-Institute of Biodiversity, Animal Health and Comparative Medicine, Glasgow, United Kingdom

*Corresponding author: gkagaruki@gmail.com

Type 2 Diabetes (DM) and hypertension (HTN) are a growing global problem with unhealthy eating habits identified as a major cause of these diseases.In urban areas large parts of the population from low and middle income classes eat food, especially lunch, which is supplied by street-food vendors and have limited control over nutritional values. In Tanzania 97% of people consume below the recommended level of fruit and vegetable servings per day. Furthermore, the majority of food vendors lack knowledge on nutritional values of food. At the same time food quality control practices available focus on monitoring risk factors linked to infectious diseases only. We aim to implement and evaluate anintervention package to reduce risk factors for DM and HTN and develop a model for monitoring, predicting and preventing risks among urban street cooked food consumers in Tanzania. We will implement a non-randomized trial in two urban districts, one as interventional site and the other as control site. A sample size of 556 consumers and 50 vendors of urban street cooked foods will be recruited. Education on DM and HTN plus a food plate model will be applied to urban street consumers and vendors in interventional site. The package will be evaluated to assess its effectiveness in reducing DM and HTN risk factors among consumers. Determinants established during the intervention will be used in developing a model for monitoring and predicting DM and HTN risk factors among consumers. The study findings will be used to improve food systems in urban areas, inform food related policy and improve the guidelines for food regulatory authorities in Tanzania and elsewhere.

Keywords: Diabetes, Hypertension, nutritional disease risk factors, urban street-cooked food, nutrition education, food plate model

Assessing the role of pastoral nutritional systems in early childhood and risk factors of emergence of NCDs in adults among Maasai in Tanzania

Wedson Aifello Sichalwe*[1] et al.

[1]Kilimanjaro Christian Medical College of Tumaini University, Moshi, Tanzania

*Corresponding author: chifurumakb@yahoo.co.uk

Socioeconomic analysis of Non-Communicable Diseases (NCDs) linked to dibiteries meat consumption

Malik Orou Seko*[1]

Bassirou Bonfoh[2], Dao Daouda[2], Khalifa Sylla[1], Sayoki Mfinanga[3], Gilbert Fokou[2], Walter Ossebi[1], Aurelie Cailleau[1], Emmanuel Nonga[4], Fabrizio Tediosi[5]

[1]Ecole Inter-Etats des Sciences et Médecine Vétérinaires, Dakar, Sénégal
[2]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire
[3]National Institute for Medical Research, Dar es Salaam, Tanzania
[4]Sokoine University of Agriculture, Morogoro, Tanzania
[5]Swiss Tropical and Public Health Institute, Basel, Switzerland

*Corresponding author: orousekom@gmail.com

The consumption of braised meat at a 'Dibiterie restaurant' is very prized and socially anchored in the eating habits in Senegal. However, studies conducted in informal food enterprises have shown a lack of hygiene mainly due to insufficient mastery of good hygiene practices by the personnel. This deficiency in hygiene is often the origin of product deterioration and microbial meat contamination causing shortfalls for the dibiterie-owner and foodborne infections for consumers. Several case-control type sanitary interventions on a small-scale have been carried out with the aim of reducing the risk factors for microbial contamination within these dibiteries. However, the results have not been sustainably satisfactory. Indeed, the interventions did not significantly reduce the microbial contamination of braised meat and, one year after the interventions, the dibiteries have resumed their former practices of meat preparation that do not guarantee good quality of the finished product. This study aims to evaluate the interconnections between economic gain and managerial behaviour regarding food safety and customer satisfaction of dibiteries.

The methodological approach is transdisciplinary and based on the One Health concept. It involves several disciplines and modelling of a cost-effective intervention on a large-scale.

This study will allow the set-up of tools for decision-making and control of the risk factors for microbial contamination of braised meat, through a cost-effective intervention.

The mastery and control of risk factors for meat contamination through cost-effective sanitary interventions at the level of dibiteries could contribute to a reduction in the incidence of foodborne illness.

Keywords: Dibiterie, Socio-cultural determinants, Cost of disease, Modelling, cost-effective intervention, Senegal

Urban street food market and associated health risks: determinants of food hygiene among "garba" sellers/ consumers and effective behaviour change plan in Abidjan (Côte d'Ivoire)

Judicaelle Lydie Aya Koffi*[1,2]

Gilbert Fokou[2], Roch Yao Gnabeli[1], Bassirou Bonfoh[2,3,4]

[1]Université Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire
[2]Centre Suisse de Recherches Scientiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[3]Swiss Tropical and Public Health Institute, Basel, Switzerland
[4]University of Basel, Basel, Switzerland

*Corresponding author: judicaelle.koffi@csrs.ci

Lack of food hygiene is of global concern, particularly in developing countries where the fast-food trade is dominated by street food in informal settings. In Abidjan, sanitary and nutritive quality of "Garba" remains a big issue despite the control of sellers by the municipality. Garba is steamed couscous of cassava served with fried tuna, oil and raw vegetable and prepared and served in "garbadromes". This traditional food is highly appreciated by the population. However, its safety to consumers is of major concern as it can be the cause of foodborne diseases. This study aims to define the determinants of food hygiene practices followed by garba sellers and consumers and to develop an effective behaviour change plan. Using an One Health approach, questionnaires will be administered to 768 consumers in Abidjan to define their perceptions of food hygiene, risks related to garba consumption and their practices in garbadromes. Semi-structured interviews and focus group discussions with consumers will be used to define risk management strategies related to garba consumption. Additionally, semi-structured interviews with sellers will determine their perception of food hygiene and their practices. A survey with municipalities agents will identify control and monitoring actions regarding hygiene in garbadromes. Structuralism-constructivism by Bourdieu will be applied as a theoretical framework. Sanitary education will be given to sellers and subsequent evaluation will show the effect of the intervention on sellers' hygiene practices. A tool which can reduce disease transmission of communicable and non-communicable diseases, related to the consumption of garba will be developed.

Keywords: Garba, food hygiene, One Health, Abidjan, Côte d'Ivoire

Value chain of bushmeat consumption and its role in nutrition and disease transmission in Côte d'Ivoire and in Tanzania

Arlette Olaby Dindé[*1,2]
Georgette Amoin Konan[2,3], Gilbert Fokou[2], Esther Schelling[4,5], Julius Dotto Keyyu[6], Sayoki Mfinanga[7], Marina Koussémon[1], Bassirou Bonfoh[2,4,5]

[1]Université Nangui Abrogoua, Abidjan, Côte d'Ivoire
[2]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[3]Université Félix Houphoüet, Abidjan, Côte d'Ivoire
[4]Swiss Tropical and Public Health Institute, Basel, Switzerland
[5]University of Basel, Basel, Switzerland
[6]Tanzania Wildlife Research Institute, Arusha, Tanzania
[7]National Institut of Medical Research, Dar es Salaam, Tanzania

*Corresponding author: arlette.dinde@csrs.ci

Bushmeat or game meat originates from wild fauna and is still widely consumed in sub-Saharan Africa. Unfortunately, this natural resource is overexploited. Studies suggested alternatives to poaching and bushmeat consumption but these substitutes are rarely accepted by populations and their introduction poorly implemented. Bushmeat consumption is often associated with diseases, such as the Ebola Virus epidemic in West Africa in 2014. However, there is little information on mechanisms of disease transmission through the bushmeat chain. In this study, we investigate the relevance of bushmeat use for the actors and identify sustainable alternatives. In addition, we develop a model of disease transmission within the bushmeat chain from contact networks. Using a transdisciplinary approach, a questionnaire-based survey, semi-structured interviews and focus group discussions are conducted with hunters, traders, sellers in the markets and bushmeat consumers in households to estimate the importance of bushmeat and related issues for the actors. The nutritional status of people is determined using anthropometric measurements and nutritional biomarkers. The modelling of contact networks is done to capture dynamics of salmonellosis transmission. The study will identify sustainable bushmeat alternatives and gives data on the prevalence of nutritional deficiencies for the local populations. It will also describe diseases transmission within the bushmeat chain and suggest ways to mitigate any spread. Thus, policy makers are provided with more information for health interventions and a better fauna management system.

Keywords: Bushmeat, nutrition, contact network, modelling, salmonellosis

Food restrictions and well-being: Food practices, identity construction and health among Agni's community of Bongouanou in Centre-East of Côte d'Ivoire

Valentin Bognan Kone[*1,2,3]
Gilbert Fokou[2], Bouaki Baya Kouadio[1], Brigit Obrist[3], Roch Yao Gnabeli[1], Bassirou Bonfoh[1,2]

[1]Université Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire
[2]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[3]University of Basel, Basel, Switzerland

*Corresponding author: bognan.kone@csrs.ci

Food restriction is one of the important means for social and cultural control in many communities in the world. Food practices have several social, religious, and even political dimensions. Some cases of allergies due to the consumption of certain foods suggest that the prohibition may also have a health dimension (Protection or risk). Among the Agni community of Bongouanou in Centre-East of Côte d'Ivoire, there are social norms that prevent population from consuming foods which can be found in their immediate environment such as silurus from Siluridae Family. This study questions the rationale of restrictions of one animal source protein in communities in a context insecure access to food and basic livelihoods. A survey using qualitative and quantitative approaches (semi-structured interviews, focus group discussions and household questionnaires) was conducted in four villages selected on the basis of their foods restrictions. This study aims to analyze the social construction of food restrictions in relation to health. Examining the link between food habits and health, it is argued that food restrictions contribute to the social equilibrium of these communities. The close association between food restrictions and diseases responds to indigenous needs for identity and health preservation. The problematization of populations' attitudes and practices in response to food restrictions will contribute to the development of a socio-cultural approach in preventing food allergies among some people in Côte d'Ivoire.

Keywords: Food restrictions, health, Agni community, Identity, Ecology, Bongouanou, Côte d'Ivoire

Potential beneficial health effects of kankankan, a spice powder produced and consumed in Côte d'Ivoire: physico-chemical and microbiological aspects

Armel Elysée Yapo*[1,3]
Rémi Constant Ahoua[1,3], Solange Aka[1,3], Gilbert Fokou[3], Georgette Konan[2,3], Bassirou Bonfoh[3,4,5], Marina Koussémon[1]

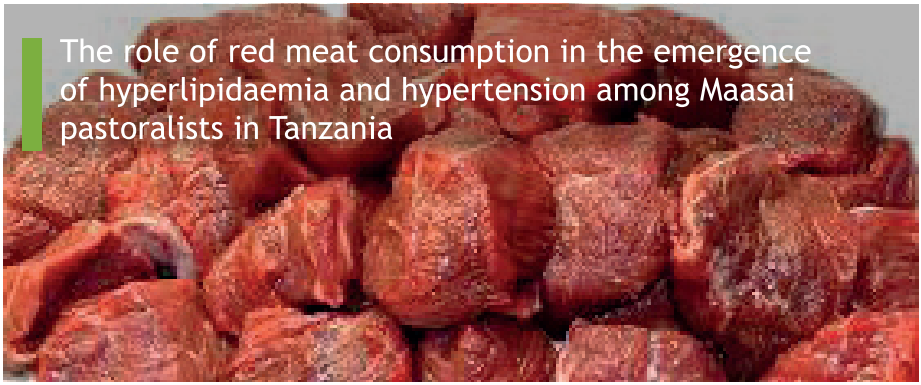
[1]Université Nangui Abrogoua, Abidjan, Côte d'Ivoire
[2]Université Félix Houphouet Boigny, Abidjan, Côte d'Ivoire
[3]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[4]Swiss Tropical and Public Health Institute, Basel, Switzerland
[5]University of Basel, Basel, Switzerland

*Corresponding author: armel.yapo@csrs.ci

Spices are plant based productsused in food preparation. They are recognized as sources of micronutrients and bioactive compounds with a potential protective effect on health. In Côte d'Ivoire, the most popular way of cooking red meat is by roasting. The roasted beef or sheep is commonly called choukouya. Choukouya is consumed with a spice powder called kankankan obtained after grinding a mixture of spices. However, production practices and nutritional knowledge related to this product are not documented. This spice mixture could have a protective role on consumers' health against the harmful effects of red meat consumption. The main objective of this study is to determine the antioxidant and antimicrobial properties of kankankan and the spices used for its composition as well as its physicochemical and microbiological characteristics. During a cross-sectional study, data will be collected from key actors such as producers of kankankan powder (n=7), roasted meats sellers (n=182) and consumers (n=572) through interviews. The study of the antioxidant activity will be carried out by using ferric reducing antioxidant power and free radical-scavenging capacity methods. The antimicrobial activity will be evaluated using the agar diffusion technique and any polyphenolic compounds will be identified by thin layer chromatography and spectrophotometry methods. Finally, physicochemical analysis and identification of any present, potentially pathogenic microorganisms contaminating kankankan will be done. Scientific knowledge of the potential benefits for and risks to health of kankankan will contribute to betterhealth.

Keywords: Bushmeat, nutrition, contact network, modelling, salmonellosis

The role of red meat consumption in the emergence of hyperlipidaemia and hypertension among Maasai pastoralists in Tanzania



Ester Jacob Diarz[*1,2]

Sokoine Kivuyo[1], Thomas Mwinyeheri[3], Sayoki Mfinanga[1], Bassirou Bonfoh[4], Bernard Ngowi[1], Michael Johnson Mahande[2]

[1]National Institute of Medical Research – Muhimbili Medical Research Centre, Tanzania
[2]Kilimanjaro Christian Medical College of Tumaini University, Moshi, Tanzania
[3]Centre for Disease Control and Prevention, Tanzania
[4]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire

*Corresponding author: diarzester@gmail.com

Red meat consumption is a major dietary risk factor for hyperlipidaemia and hypertension. In a 2010 meta-analysis, the relationship between meat consumption and the emergence of these conditions was shown to vary depending on the amount consumed and the extent of processing of the meat product. Maasai pastoralists of Tanzania have unique cultural practices and lifestyle influencing their diet which consists almost entirely of milk, meat, and blood. Few studies have assessed hyperlipidaemia and hypertension among Maasai using standard methods. The proposed study is aiming to measure the burden of hyperlipidaemia and hypertension in rural settlements of Maasai and develop a model predicting the risk of developing hyperlipidaemia and Hypertension among the Maasai communities in Ngorongoro district Arusha region northern Tanzania. The Study will be a cross-sectional analytical study design employing a quantitative method of data collection and analysis. A multistage random sampling technique will be used to enrol study participants from 4 villages within the Enduleni ward in Ngorongoro district. A minimum sample size of 334 participants is required to have a design effect of 3% and a confidence interval of 95%. A descriptive analysis will be done to estimate the burden of hyperlipidaemia and hypertension. Bivariate and multiple logistic regression analysis will be employed to calculate the association of hyperlipidaemia, hypertension and the demographic characteristics with P-value < 0.05. The results of this study will be used to develop focused and targeted policies and programs for prevention, control and management of hyperlipidaemia and hypertension tailored to pastoral communities.

Keywords: Bushmeat, nutrition, contact network, modelling, salmonellosis

Association of consuming red meat and emergence of hypertension in the Ivoirian population: a hospital-based case-control study

Therese Debia Kossia Gboko*[1]

Esther Ngadaya[3], Georgette Konan[1,2], Sayoki Mfinanga[3], Bassirou Bonfoh[1]

[1]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[2]Université Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire
[3]National Institute of Medical Research, Dar es Salaam, Tanzania

*Corresponding author: kossia.gboko@csrs.ci

Emergence of hypertension in many developing countries is closely linked to major changes in populations' lifestyles and diet, including a shift toward a "western" type of diet rich in animal source food and processed red meat. Evidence from western surveys suggests that high intakes of processed and unprocessed red meat are consistently associated with the increased risk of hypertension. However, this relationship has not yet been investigated in an Ivorian setting. We will examine the role of red meat intake in relation to the occurrence of hypertension through a case-control study. Hypertension cases and negative controls will be recruited from tertiary hospitals in Abidjan. A structured questionnaire, including a food frequency questionnaire focused on red meat, will be used to collect data on socio-demographic, economic and lifestyle factors and for dietary assessment. Anthropometrics and blood glucose measurements will be performed. Logistic regression models will be used to calculate odds ratios with adjustment for hypertension risk factors. This study aims to determine the relation of red meat consumption with hypertension risk in an Ivorian context and identify factors that may influence the effect of these foods on blood pressure. This study is the first to provide local knowledge on dietary risk factors for hypertension creating a base for subsequent in-depth investigations. Outcomes can be converted into nutritional recommendations and integrated into the national program for hypertension prevention and control through alternative interventions.

Keywords: Hypertension, red meat, dietary risk factor, Côte d'Ivoire

Significance of Livestock to Pastoralists, Psychosocial Implications of Trauma Superimposed by Asset Losses: A Study of the Northern and Southern Belts of Ghana

Francis Sena Kwaku Nuvey*[1]

Bassirou Bonfoh[2], Dixon Chibanda[3], Gilbert Fokou[4], Bismark Sarfo[5], Samuel Atindanbila[6]

[1]School of Public Health University of Ghana, Legon-Accra, Ghana
[2]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[3]Department of Psychiatry University of Zimbabwe, Harare, Zimbabwe
[4]Centre Suisse de Recherche Scientifique en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[5]School of Public Health University of Ghana, Legon-Accra, Ghana
[6]Department of Psychology University of Ghana, Legon-Accra, Ghana

*Corresponding author: fsnuvey@gmail.com

Globally, there is a growing sense of food insecurity especially in sub-Saharan Africa, where increasing human population is not accompanied by a corresponding increase in agricultural production. With an estimated 836 million people living in extreme poverty, agriculture for most remains the only option for self-sustainability. Pastoralism being the main livestock rearing system in Sahel and West-Africa is often harnessed to attain this goal. However, pastoralists are frequently neglected by governments and society. An increased incidence of adverse events (droughts, floods, zoonoses and conflicts) in pastoral communities is leading to loss of assets. Despite the resulting increase in food insecurity and added psychological toll of asset loss on pastoralists, there is little research on the impact on their mental health, resilience and quality of life. Additionally the strong emotional link between pastoralists and livestock, which explains pastoralists' reaction to suspected danger to their animals, is understudied. This study aims to fill this knowledge gap.

We will conduct a cross-sectional survey employing a mixed-method design. Data will be obtained using questionnaires and semi-structured interviews. The study will span 12 months.

Any increased occurrence of adverse events, the strong emotional bond between pastoralists and livestock and the prevalence of depression and anxiety as well as decreased resilience and quality of life in pastoralists will be ascertained.

Findings would provide better understanding of pastoralists' bond with livestock and psychosocial implications of asset loss in pastoralism, paving the way for implementation of health care (social-support systems) in pastoral communities to mitigate food insecurity through increased productivity.

Keywords: Pastoralists, quality of life, assets, livestock, resilience, food insecurity emotional links, adverse events

Interspecies transmission of antibiotic resistance of Salmonella spp and E. coli from poultry to human in farms of Burkina Faso: assessment and factors

Abdul Gafar Victoir Coulidiaty*[1,2]

Adama Sanou[1], Olufunsho Awodele[2], Bassirou Bonfoh[3]

[1]Centre Muraz, Bobo-Dioulasso, Burkina Faso
[2]University of Lagos, Lagos, Nigeria
[3]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire

*Corresponding author: gafarvictoir@gmail.com

For several decades antimicrobial resistance (AMR) has been a growing threat to the effective treatment of an ever-increasing range of infections caused by bacteria, parasites, viruses and fungi. AMR has been accentuated by usage of antibiotics in animal husbandry. The purpose of this study is to isolate and identify E. coli spp. and Salmonella spp. in poultry; to determine the antibiotic susceptibility pattern of the isolates; to analyze the antibiotic used in poultry production and to propose a strategy of mitigation of such transmission.

A descriptive cross-sectional study will be performed from January 2018 to second semester of 2019. A survey will be done to determine the range of antibiotics that are used in the breeding of poultry. We will sample feces from 377 poultry and 377 farmers to identify E. coli and Salmonella spp strains, and then evaluate their antibiotic resistance patterns in rural and urban settings of Bobo-Dioulasso. These resistances will be correlated to the antibiotics used in poultry to deduct the pharmacological type of such resistance to the antibiotics used in humans.

We expect that the outcomes of this study will contribute to the improvement of policies regarding the use antibiotics in poultry breeding. It will also help by its One Health approach in a suitable monitoring of antibiotic resistance.

Keywords: antimicrobial resistance, E. coli spp., Salmonella spp., poultry, One Health

Socioeconomic cost of hypertension treatment in the health district of Taabo

Litie Baliet Adams[*1,4]
Clémence Essé[2,3], Daouda Dao[2,3], Nicole Probst[4], Bassirou Bonfoh[3,4], El Hadj Gueye[5]

[1]Centre Hospitalier Universitaire de Yopougon, Abidjan, Côte d'Ivoire
[2]Université Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire
[3]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[4]Swiss Tropical and Public Health Institute, Basel, Switzerland
[5]Centre Africain d'Etudes Supérieures en Gestion, Dakar, Senegal

*Corresponding author: balietlitie@cesag.edu.sn

Sub-Saharan Africa is facing an epidemiologic transition with a dual burden of communicable and noncommunicable diseases (NCD). The NCD with the highest prevalence is high blood pressure (hypertension). In Côte d'Ivoire, the prevalence of high blood pressure has risen sharply from 22% in 2005 to 31% in 2015. High blood pressure has now a substantial effect on quality of life and the economy, leading to disruption of the patient's life, his/her family and social network.

The project CODUBU has laid the foundation and. The current study aims to assess the cost of hypertension treatment in rural areas where there is poverty and access to the healthcare services is difficult.

We plan a transversal socioeconomic cost analysis of hypertension in the health district of Taabo with the Health and Demographic Surveillance System (HDSS). The study will use a combination of quantitative and qualitative data from the HDSS to assess the monthly average cost of hypertension treatment.

The study looks at direct costs of medical and nonmedical expenditure and indirect costs of time and money for health service utilization. We will also determine the socio-demographic and economic factors which affect the access to healthcare for the patients. We hypothesize that the cost of hypertension treatment for patients who live in rural areas are higher than the part of their income related to heath and that it is difficult for those patients to access healthcare because of inadequate health systems.

Keywords: Cost, Hypertension, Access to healthcare, socioeconomic, rural area

Notes

Zoonoses Syndromic Surveillance and Response Systems

Lead

Richard Ngandolo
IRED, Chad

Co-lead

Joram Buza
NM-AIST, Tanzania

Collaboration

IRED, Chad
NM-AIST, Tanzania
IHI, Tanzania
CSRS, Côte d'Ivoire
MAKUN, Uganda
Swiss-TPH, Switzerland

The Thematic Training Programme (TTP) on zoonoses syndromic surveillance and response systems has the huge responsibility to offer a suitable training platform to new generation of African Scientists who are interested to develop new tools and ideas that will contribute to the elimination of zoonotic diseases. Building on demographic surveillance systems in humans, joint human-animal surveillance and disease response systems will be developed to achieve near real-time surveillance-responses for early detection and response to zoonotic diseases applying locally adapted communication technology.

As main objective, the TTP will integrate animal disease surveillance questionnaires within the existing human Health and Demographic Surveillance Systems (HDSS) and use of new technologies (mobile phone) devises to define and establish a feasible surveillance system for zoonosis.

Three research questions are addressed:

- What tools are necessary for joint human and animal diseases surveillance?
- How can community involvement improve zoonotic diseases surveillance?
- Cost benefits analysis of joint human-animal diseases surveillance?

Integrated “One Health” syndromic surveillance of and response to zoonotic diseases using digital health information solutions in Africa

Mahamat Fayiz Abakar[*1,2]
Salome Düerr[2], Richard Ngandolo[1], Djimet Seli[3], Bassirou Bonfoh[4], Jakob Zinsstag[5,6]

[1]Institut de Recherche en Élevage pour le Développement, N’Djamena, Chad
[2]Veterinary and Public Health Institute, University of Bern, Switzerland
[3]Centre de Recherches en Anthropologie et Sciences Humaines, N’Djamena, Chad
[4]Centre Suisse de Recherche Scientifique en Côte d’Ivoire, Abidjan, Côte d’Ivoire
[5]Swiss Tropical and Public Health Institute, Basel, Switzerland
[6]University of Basel, Basel, Switzerland

*Corresponding author: fayizalhilou@gmail.com
fayiz.abakar@swisstph.ch

A substantial part of the population in sub-Saharan Africa live in rural areas characterized by insufficiently equipped health centers and shortages of qualified health workers. These people usually depend on agriculture and livestock but have limited access to social services including health. In Chad, over 78% of the total population lives in rural areas and 3.5% are mobile pastoralists. Previous research has shown that agro-pastoralists suffer from a broad range of diseases of mostly unconfirmed biomedical etiology. We propose a synergistic approach of integrated “One Health” surveillance-response combining epidemiology, anthropology and advanced biomedical diagnostic with essential complementary elements to anticipate outbreaks of endemic and emerging diseases from perceived illnesses (syndromes). Community-based syndromic surveillance, coupled with mobile technology adapted to the rural agro-pastoralists context, could offer an alternative to existing surveillance systems for humans and animals. Linking such a system with the etiologic confirmation of suspected cases from freshly collected samples would increase the potential of anticipating diseases outbreaks and leads to evidence-based and locally adapted interventions. Such participatory approach to surveillance and intervention could be further used for public and veterinary health service improvement along with zoonosis integration into existing digital and open source health information system application (DHIS2)

Keywords: Syndromic surveillance, zoonotic diseases, One Health, agro-pastoralists, Chad

New tools for integration of animal disease surveillance into existing HDSS in Sub-Saharan Africa

Zacharia Mtema*[1] et al

[1]Ifakara Health Institute, Ifakara, Tanzania

*Corresponding author: zmtema@ihi.or.tz

Epidemiology and surveillance of livestock abortigenic pathogens in northern Tanzania

George Semango*[1]
Joram Buza[1], Sarah Cleaveland[2], Bassirou Bonfoh[3]

[1]Nelson Mandela African Institution of Science and Technology, Arusha, Tanzania
[2]University of Glasgow, Glasgow, United Kingdom
[3]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire

*Corresponding author: george.semango@nm-aist.ac.tz

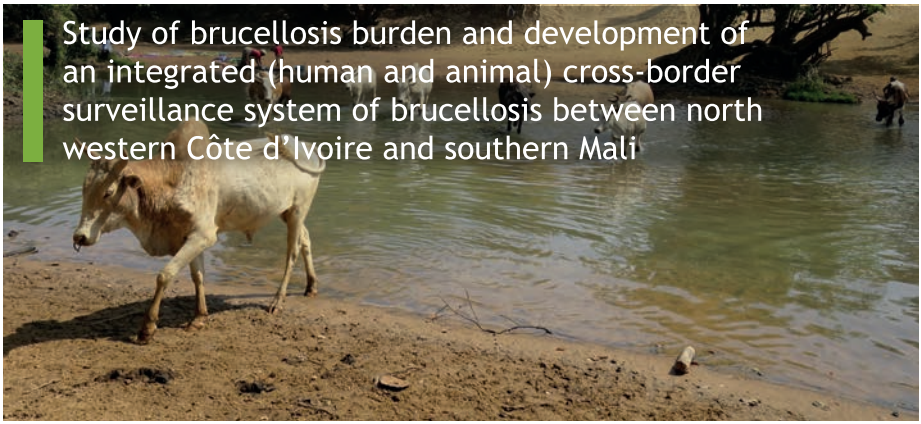
Abortions in livestock are a major cause of economic loss in Sub-Saharan Africa including Tanzania. The burden is greatly underestimated due to poor reporting systems. An enhanced surveillance system using mobile phones involving the community could gather comprehensive data. In Tanzania, mobile phones have great potential in surveillance systems because of their wide availability and good service coverage. They can be used for community based surveillance systems. Livestock abortion events cause morbidity and mortality as well as heavy financial losses to the communities affected. This project focuses on the barriers preventing farmers from reporting abortion while also determining the seroprevalence of cases in livestock. Additionally common infectious agents causing abortion in cattle, sheep and goats will be genotyped. Furthermore, we aim to stimulate community participation on reporting by enhancing existing reporting channels using mobile phones.

A questionnaire-based survey for farmers, Livestock Field Officers and District Veterinary officers will investigate the barriers of abortion reporting, in depth interviews and review of archived data will help to characterize the abortion reporting systems. Serological analysis and real-time quantitative PCR will determine the seroprevalence of common abortigenic agents followed by genotyping the DNA isolated from the collected tissue samples.

For the first time reporting barriers impacting surveillance systems will be determined and the existing abortion surveillance systems characterized. This is combined with information on seroprevalence and genotypic identification of the most common abortigenic agents in livestock in northern Tanzania. Together the information will provide the much needed basis to put a working, community based surveillance system in place.

Keywords: Livestock abortion, Mobile based surveillance, abortigenic agents, Northern Tanzania

Study of brucellosis burden and development of an integrated (human and animal) cross-border surveillance system of brucellosis between north western Côte d'Ivoire and southern Mali



Wilfried Délé Oyetola*[1]

Rianatou Bada Alembedji[1], Richard Ngandolo[2], Bassirou Bonfoh[3], Joram Buza[4]

[1]Ecole Inter-Etats des Sciences et Médecine Vétérinaires, Dakar, Sénégal
[2]Institut de Recherche en Elevage pour le Développement, N'Djamena, Chad
[3]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[4]Nelson Mandela African Institution of Sciences and Technology, Arusha, Tanzania

*Corresponding author: oyetolaw@yahoo.fr

Brucellosis is a highly contagious notifiable zoonosis, caused by Brucella bacteria widely abundant in sub-Saharan Africa, yet it is neglected. Transhumance is an important risk factor for this disease, the prevalence of which is estimated to be close to 5% in Côte d'Ivoire and more than 20% in Mali. Strong pastoral activity links the two border countries furthering cross-border transmission. There is a lack of a common, integrated (human/animal) information system for surveillance and intervention between the countries. We propose to determine the brucellosis burden, the perception and practices related to brucellosis by breeders and to establish an integrated surveillance system to aid the control of brucellosis in pastoral populations by considering transboundary nomadic activity between Côte d'Ivoire and Mali. For this purpose, we will carry out a prospective investigation in pastoral populations (including transboundary nomads) and their livestock in north-west Côte d'Ivoire, coupled with a serological diagnosis (ELISA and Rose Bengale Test). Interviews and meetings with the actors of the human and animal surveillance systems and the local populations will be used to discuss and validate a monitoring protocol. The integrated system proposed at the end should make it possible to capitalize surveillance and intervention of human and animal health services on brucellosis and could be applied to others zoonoses and cross-border systems.

Keywords: Integrated surveillance system, brucellosis, pastoralists, transhumance, Côte d'Ivoire, Mali

Integrated surveillance of bovine TB in nomadic pastoralist people in Chad

Lamireou Didi*[1]

Richard Ngandolo[1], Bassirou Bonfoh[2,3,4], Jakob Zinsstag[3,4]

[1]Institut de Recherche en Elevage pour le Développement, N'Djamena, Chad
[2]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[3]Swiss Tropical and Public Health Institute, Basel, Switzerland
[4]University of Basel, Basel, Switzerland

*Corresponding author: lamdidi2000@gmail.com

In sub-Saharan countries, some populations are hard to reach by public health services and therefore suffer often particularly badly from major diseases like tuberculosis (TB). These diseases have a negative impact on human and animal health but receive less attention by the government. The populations most at risk are nomadic pastoralists; they are in permanent close contact with livestock and with high risk of exposure to zoonotic diseases and hard to reach by health services because of their travelling life-style. We propose to implement a new system linking animal cases and intervention for human infection for this zoonosis. Linking information of animal and human cases would greatly increase the capability for successful interventions.

This study aims to put in place an integrated surveillance system detecting TB disease in animals and humans based on information collected from the affected community itself. Iformation will be reported to the medical staff using mobile phones. This pilot study will be carried out in nomadic livestock populations in Chari-Baguirmi and Hadjer lamis in Chad with the main objective to implement joint, active surveillance based on community knowledge. Nomadic pastoralists will detect cases and inform the team at Institut de Recherche en Elevage pour le Développement (IRED), who will come to the community and test the suspected infected human or animal for confirmation. After that sputum samples and lesions will be collected from suspected patients and cattle respectively, and then sent at IRED for diagnosis. Bovine and avian tuberculin will be injected to the cattle and some of the positive animals will be sold and slaughter at the slaughterhouse. Infected patients with TB will be reported and treated by the health services.

This approach of joint animal and human community based surveillance and intervention could be further used by health and veterinarian systems in countries were nomadic pastoralists are present.

Keywords: Surveillance, tuberculosis, One Health, nomadic pastoralists, Chad

Modelling an integrated surveillance system for its suitability for detecting and recording brucellosis prevalence in Cameroon using mobile phone technology

Patiene Chouop Kawe*[1]

Joram Buza[1], Bassirou Bonfoh[2], Jakob Zinsstag[3]

[1]Nelson Mandela African Institution of Science and Technology, Arusha, Tanzania
[2]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[3]Swiss Tropical and Public Health Institute, Basel, Switzerland

*Corresponding author: patiene@aims-cameroon.org

Brucellosis is caused by a bacterium of the genus Brucella spp, with B. abortus primarily affecting cattle. It is ignored by many Cameroonians and is neglected although considered a major zoonosis. The impact of this disease on human and animal health and the socio-economic burden is considerable. Previous research carried out in the northern part of Cameroon showed a seroprevalence ranging from 7.5 to 31%. The lack of good health infrastructure and the low diagnostic capacity of the laboratories contribute to the spread of brucellosis in Cameroon and the prevalence of brucellosis in the country is likely to be underestimated. The aim of this study is the modeling of an integrated surveillance system for its suitability for detecting and recording brucellosis prevalence in Jakiri, a municipality located in the North western region of Cameroon with a higher concentration of livestock, using mobile phone technology. The model will be done using ordinary differential equations. The implementation of a suitable integrated surveillance systems consolidating information from infections in ruminants and humans could accelerate the detection and reporting of brucellosis infections and help improve surveillance, timely feedback and facilitate effective response to brucellosis threats. The model could be adapted to other endemic settings to evaluate the suitability of surveillance systems. The information generated can influence policy decisions to adjust future surveillance activities to increase the effectiveness and efficiency of the brucellosis control program. For effective control, a holistic approach that takes into account the relationships between humans, animals and the environment is essential.

Keywords: Brucellosis, Cameroon, prevalence, cattle, brucella, mobile phone technology, differential equations

Antimicrobial resistance and molecular diversity of foodborne pathogens in Ghana

Helena Dela[*1,2]
Langbong Bimi[2], Kennedy Addo[1], Bassirou Bonfoh[3], Richard Ngandolo[4], Joram Buza[5], Beverly Egyir[1]

[1]Noguchi Memorial Institute for Medical Research, Bacteriology Department, Accra, Ghana
[2]University of Ghana, Legon, Accra, Ghana
[3]Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, Abidjan, Côte d'Ivoire
[4]Institut de Recherche en Elevage pour le Développement, Ndjamena, Chad
[5]Nelson Mandela African Institution of Science and Technology, Arusha, Tanzania

*Corresponding author: helena.ogum@gmail.com

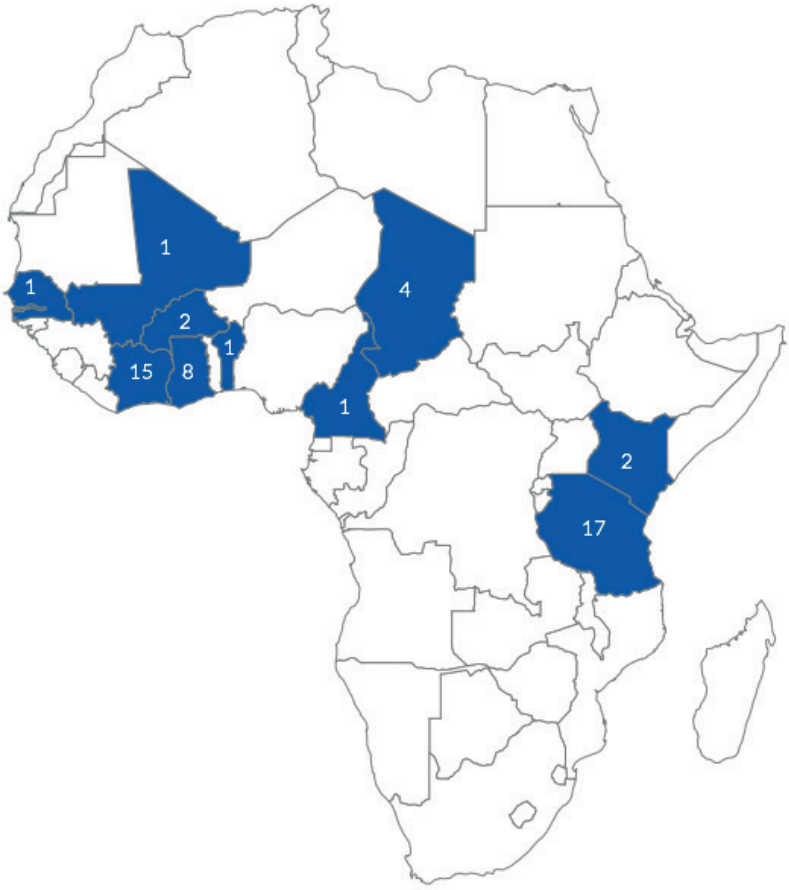
Foodborne diseases are one of the most important public health concerns worldwide but few studies have investigated the various causes and applied the required surveillance and laboratory tools for interventions in Ghana. In 2015, 5,100 children under the age of five were recorded to die each year due to foodborne diseases. This study will provide essential information on the antimicrobial resistance and molecular diversity of some selected foodborne pathogens in Ghana. This will be a cross sectional study where samples will be obtained from selected abattoirs and animal farms in Ghana. Stool samples of animal handlers and their livestock will be collected. Livestock products (meat, eggs), vegetables and water sources in the selected sites will also be sampled and processed according to specific Standard Operating Procedures. Some selected foodborne pathogens to be investigated include *Campylobacter spp*, *Salmonella spp, Shigella spp*, *Staphylococcus spp*, *Listeria spp*, *E. coli 0157* (and other *diarrheagenic E. coli*), *Yersinia spp*, *Vibrio spp*, *Toxoplasma gondii*, *Giardia lamblia* and *Cryptosporidium spp*. Antimicrobial susceptibility testing will be carried out to determine the antimicrobial resistance profile of the bacterial pathogens that will be isolated. Several molecular tests will also be carried out using phenotyping and molecular analysis tools to investigate the molecular diversity of the different strains of the selected foodborne pathogens. The risk factors involved in contracting foodborne pathogenic diseases among the animal handers will be determined.

Keywords: Cross sectional surveillance, antimicrobial resistance, foodborne pathogens, Ghana

Notes

Notes

Fellows' country of origin



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CSRS
Centre Suisse de Recherches Scientifiques en Côte d'Ivoire

Centre Suisse de Recherches Scientifiques en Côte d'Ivoire (CSRS)
01 P.O Box 1303 Abidjan 01

Fax: (+225) 23 45 12 11
Tel: (+225) 23 47 27 90 / 92
afriqueone.aspire@csrs.ci

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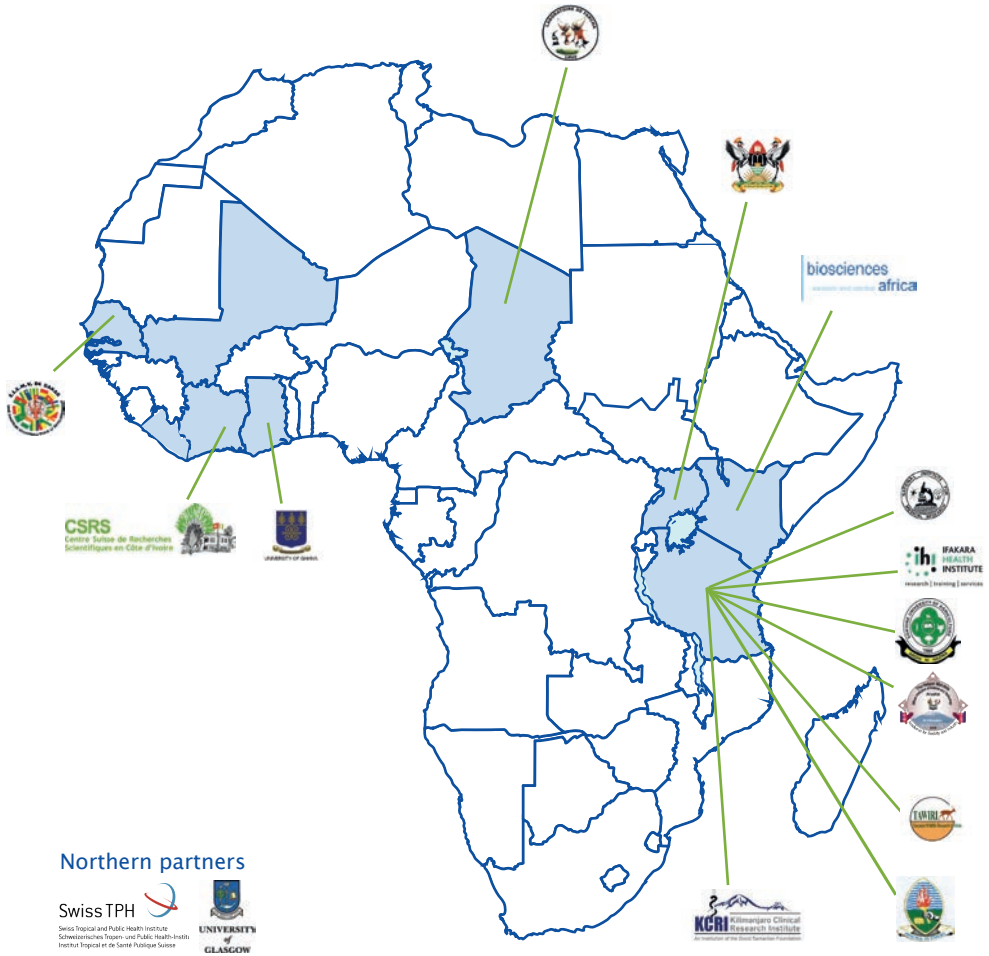

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