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# Two and a half decades of impact: contributions of the Noguchi Memorial Institute for Medical Research Laboratory Animal Facility to biomedical research in Ghana and the West African sub-region

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**Abstract**

***Background:*** Laboratory animal facilities are essential enablers of biomedical research, supporting disease modelling, drug evaluation, and safety studies. The Laboratory Animal Facility (LAF) at the Noguchi Memorial Institute for Medical Research (NMIMR), established in 2000 with Japanese support, has become a cornerstone of biomedical research in Ghana and West Africa.

***Objective:*** This study documents the LAF's operations and contributions over 25 years, highlighting its role in disease research, medicinal plant studies, training, and ethical compliance.

***Methods:*** A retrospective review of LAF records, training logs, publications, and collaborations (2000 – 2025) was conducted. Data were summarised using descriptive statistics, with research models and training outputs organised thematically.

***Results:*** The LAF produced over 20,000 Specific Pathogen Free (SPF) rodents, supporting >75 ethically approved projects in communicable and non-communicable disease research. It trained >170 researchers in animal science and contributed to >500 peer-reviewed publications. Key disease models developed included Buruli ulcer, malaria, diabetes, epilepsy, benign prostate hyperplasia (BPH), and wound healing. The facility's output is regionally significant, with 60% of supported projects involving international collaborations. Continuous upgrades have enhanced biosafety and welfare standards, as well as ISO/IEC 17025:2017-aligned operations.

***Conclusion:*** The LAF has strengthened regional research capacity through good-quality animal models, training, and ethical oversight. Sustained investment in infrastructure, molecular characterisation of strains, and partnerships will expand its role in translational research and innovation.

**Keywords:** Laboratory animal facility, Noguchi Memorial Institute for Medical Research, research impact

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## INTRODUCTION

Laboratory animals remain indispensable in contemporary biomedical research. From elucidating disease mechanisms to assessing the safety and efficacy of candidate therapies, animal models provide essential translational platforms that bridge basic science with clinical application [1,2]. Their use enables controlled experimentation under standardised conditions, ensuring reproducibility that is critical for advancing scientific knowledge and informing public health interventions. To meet these needs, well-structured Laboratory Animal

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Facilities (LAFs) are vital—not only for safeguarding ethical animal use but also for upholding scientific rigour and data quality in animal-based studies [3,4]. Although alternative methods such as in vitro systems, in silico or computational modelling, and organ-on-chip technologies are increasingly applied, these approaches cannot yet fully recapitulate the systemic complexity of whole organisms. In vivo models, therefore, remain central to understanding physiological interactions, long-term outcomes, and translational relevance [5]. In sub-Saharan Africa, the expansion of biomedical research has created rising demand for quality-assured animal facilities that adhere to internationally accepted welfare and husbandry standards [6]. Such compliance not only ensures ethical practice but also strengthens the credibility, safety, and global competitiveness of research outputs [7,8]. Recognising this need, the Noguchi Memorial Institute for Medical Research (NMIMR) established its LAF in 2000 as a centralised unit to support ethical, high-quality animal research while fostering local capacity in experimental science, training, and regulatory compliance.

Over the past 25 years, LAF has become a cornerstone of biomedical research in Ghana and the West African sub-region. It supports infectious and non-infectious disease modelling, toxicological evaluations, vaccine and drug development, and molecular pathophysiology studies. The facility has also emerged as a hub for hands-on training in laboratory animal science for both local and international researchers. Despite these contributions, comprehensive documentation of its scope and impact has been limited. This review provides a critical account of LAF's operations since its inception in March 2000, focusing on research support, training initiatives, biosafety practices, and ethical oversight. It highlights the facility's contributions to Ghana's biomedical research ecosystem and outlines priorities for future investment and regional leadership in laboratory animal science.

## MATERIALS AND METHODS

### Study design

This retrospective review evaluated the operations, contributions, and impact of the LAF at the NMIMR over a 25-year period (2000–2025). The assessment was based on a comprehensive review of institutional records, operational logs, ethical approval databases, training program documentation, and publication outputs associated with the facility. The scope of the review encompassed both internal activities and external engagements, including the provision of laboratory animals to national and international research institutions.

### Parameters evaluated

The following thematic areas were examined: history; infrastructural features and operational standards of the facility; facility utilization (number and type of animal species used, volume of research projects supported, and collaboration with internal and external researchers; compliance and oversight (ethical review and approval trends, adherence to international animal welfare standards, and biosafety practices; training and capacity building (frequency, content, and scope of laboratory animal science training workshops, participant demographics, and institutional partnerships); research output (the research outputs reviewed in this study were derived from peer-reviewed journal publications (Google Scholar, Web of Science, Scopus and PubMed), arising from studies that utilised animals supplied by LAF or studies conducted in the LAF; progression of facility upgrades and financial implications.

### Data sources and literature search

A comprehensive search was performed across four databases: PubMed, Scopus, Web of Science, and Google Scholar. Boolean operators were used to combine keywords related to the LAF, geographic location, animal models, and biomedical research. The base search string applied was: ("Laboratory Animal Facility" OR "Animal House" OR "Animal Facility" OR LAF) AND ("Noguchi Memorial Institute" OR NMIMR OR "University of Ghana" OR "West Africa") AND ("SPF rodents" OR "specific-pathogen-free" OR mice OR rats OR "animal models" OR "disease models") AND ("biomedical research" OR "drug discovery" OR "natural products" OR "in vivo" OR toxicity). Additional terms such as thesis, dissertation, technical report, and research report were used to identify non-journal outputs. Searches were limited to materials published between 2000 and 2025. The retrieved publications were exported to EndNote for screening and duplicate removal.

### Inclusion criteria

Documents were included if they reported studies that clearly involved animals obtained from or maintained within the NMIMR Laboratory Animal Facility; were peer-reviewed articles, theses, dissertations, or research/institutional reports; addressed in vivo biomedical research or toxicity studies (covering both communicable and non-communicable diseases); and were published between 2000 and 2025.

### Exclusion Criteria

Documents were excluded if they did not involve animals bred or supplied by the NMIMR LAF; focused exclusively on in vitro studies; consisted only of abstracts, editorials, or news articles lacking full methodological data; fell outside the specified date range; or did not confirm the source of the laboratory animals used.

### Data extraction

For each eligible document, the following information was extracted: publication year, animal species and strain used, type of research (infectious vs non-infectious disease), collaboration details, and study output (journal type).

### Data analysis

Quantitative data (e.g., the number of animals used per

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year, the number of training participants, and publication counts) were analysed descriptively using Microsoft Excel.

**Ethical considerations**

This study involved a secondary data review. All data were handled in accordance with NMIMR's institutional guidelines on confidentiality and responsible research.

## RESULTS

**Facility history, infrastructural features and operational standards**

Animal housing and use at the NMIMR began in 1981, when animals were produced and maintained as extensions of research laboratories without structured scientific oversight. Nineteen years later, the LAF was formally established through a grant-in-aid from the Government and people of Japan under the Infectious Diseases Phase II Project and was commissioned in March 2000.

The LAF occupies over 1,029 m² within a dedicated two-storey building (Figure 1a) designed with a double-corridor system: clean corridors provide access to housing and procedure rooms, while dirty corridors connect to cage-washing and sterilisation areas. The first floor accommodates a HEPA-filtered, four-room barrier suite for breeding and housing Specific Pathogen-Free (SPF) animals, along with four animal holding rooms equipped with clean-air racks that connect directly to rodent and rabbit procedure rooms for studies involving biosafety level 2 (BSL-2) agents (Figure 1b–1). Isolators are available for caesarean derivation and the maintenance of specialised strains. Access is restricted, and animal rooms are individually controlled with automated lighting; ventilated rodent rooms are equipped with clean racks, standard cages, and contact bedding. Supporting spaces include an autopsy/diagnostic laboratory, post-mortem/waste disposal rooms, a dual-sided (clean/dirty) cage-washing area with equipment sanitation capability, and storage areas for materials and supplies. The ground floor provides conventional housing for ruminants, birds, and non-human primates.

Access to the LAF is strictly regulated, with biosafety reinforced through restricted entry, safety signage, and comprehensive documentation. Animals are housed in sterilised shredded paper and softwood shavings, fed commercial rodent pellets (AGRIFEEDS, Kumasi), and provided water ad libitum. Environmental parameters are carefully maintained (temperature: 23 ± 2 °C; relative humidity: 30 – 70%; 12-hour light/dark cycle). The facility operates seven days a week and is staffed by a multidisciplinary team of animal caretakers, laboratory technicians, laboratory technologists, veterinarians, and faculty members specialising in laboratory animal science, veterinary medicine, and One Health. Daily inspections ensure animal welfare through high standards of breeding, husbandry, handling, and care.

Overall operations adhere to ISO/IEC 17025:2017 principles, with a strong emphasis on quality assurance and risk-based process management.

**Animal production and utilisation**

The LAF produces and maintains a range of laboratory animal species to support diverse biomedical research activities. The facility breeds and supplies mice, rats, guinea pigs, rabbits, and hamsters, with additional access to zebrafish through collaborative research arrangements. Animal production follows controlled breeding programs designed to ensure genetic integrity, optimal health status, and reproducibility of research outcomes. Routine health monitoring, microbial surveillance, and environmental control (temperature, humidity, ventilation, and light cycles) are maintained according to institutional standard operating procedures and international guidelines (FELASA, CIOMS). All breeding and experimental activities are overseen by the Institutional Animal Care and Use Committee (IACUC) to ensure compliance with ethical and welfare standards. The facility maintains several animal strains to meet varying research needs (Table 1).

The LAF recorded varied trends in the production and utilisation of different laboratory animal species in the last four years (Figure 2). Mice constituted the largest proportion of animals produced, with 5,846 weaned during the reporting period. Of these, 2,561 (44%) were utilised internally for research, while 1,006 (17%) were supplied to external investigators. Similarly, rats were produced in high numbers (3,989), with 1,457 (36%) used internally and 723 (18%) distributed externally. In contrast, guinea pigs, hamsters, and rabbits were produced in smaller numbers. Only 25 guinea pigs were weaned; however, internal use (170) exceeded production, suggesting reliance on carryover colonies or supplementary acquisitions, with minimal external distribution (3). Hamster production remained low (90 weaned), with negligible utilisation (6 internally; none externally). For rabbits, 21 were weaned, yet internal utilisation (32) again surpassed production, with six supplied externally.

Overall, mice and rats dominate both production and usage, underscoring their central role in biomedical research conducted within and outside the Institute. Conversely, the relatively low production and use of guinea pigs, hamsters, and rabbits reflect specialised, limited research applications. These patterns highlight the facility's dual role in sustaining in-house research while supporting external collaborations, as well as the need for optimised breeding strategies to align production with utilisation demands.

**Ethical oversight and regulatory compliance**

The use of animals in research, teaching, and testing at the NMIMR-LAF is regulated by the University of Ghana Institutional Animal Care and Use Committee (UG-IACUC). This committee provides independent ethical

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Table 1. Common laboratory animal strains produced and maintained at the LAF in NMIMR

| Species | Strain / Type | Key Characteristics | Major Research Applications |
|---|---|---|---|
| Mouse (*Mus musculus*) | ICR (Outbred) | Robust, fertile, genetically diverse, adaptable to multiple research settings | General pharmacology, toxicology, infectious disease, and nutritional studies; preclinical drug screening and training models |
| | BALB/c (Inbred) | Albino, docile, Th2-biased immune response, highly immunologically characterized | Immunology, infectious diseases (Leishmaniasis, malaria, TB), vaccine testing, monoclonal antibody production, tumour biology |
| | C57BL/6 (Inbred) | Black coat, Th1-biased, genetically defined, reference genome strain, widely used for transgenics | Genetics, immunology, oncology, metabolic and obesity studies, neuroscience, behavioural and autoimmune disease models |
| | SKH1 (Hairless, Outbred) | Immunocompetent, hairless phenotype allows direct skin observation, sensitive to UV | Dermatology, wound healing, topical toxicity, photobiology, and transdermal drug delivery studies |
| Rat (*Rattus norvegicus*) | Sprague-Dawley (SD) | Albino, rapid growth, high fertility, easy handling | Behavioural, pharmacokinetic, and reproductive studies; toxicology and safety testing |
| Guinea Pig (*Cavia porcellus*) | Dunkin-Hartley (Albino) | Sensitive to respiratory pathogens, immune response similar to humans | Vaccine potency testing, infectious disease (TB, Lassa), immunology, allergy models |
| Rabbit (*Oryctolagus cuniculus*) | New Zealand White | Large body size, gentle temperament, high blood yield | Antibody production, pyrogen testing, reproductive biology, ocular and dermal toxicology |
| Hamster (*Mesocricetus auratus*) | Golden Syrian | Compact body, unique metabolic physiology | Metabolic and infectious disease models, respiratory virus studies |
| Other Species (Collaborative use) | Grasscutter (*Thryonomys swinderianus)*<br>Zebrafish (*Danio rerio*)<br>Non-Human Primates (limited) | Grasscutter: Buruli ulcer pathology<br>Zebrafish: Transparent embryos, rapid development;<br><br>NHPs: High translational relevance | Comparitive anatomy, Infectious disease and zoonosis research, Developmental biology, neurobehavioral studies, translational and vaccine research |

Notes:
- All animals are bred and maintained under controlled environmental, hygienic, and biosecurity conditions in the LAF
- Research involving animals is conducted in compliance with CIOMS, FELASA, and UG Institutional Animal Care and Use Committee (UG-IACUC) ethical standards.
- Strain selection is guided by study objectives, ethical justification, and model validity.
- Routine health monitoring, genetic quality assurance, and continuous staff training are key hallmarks of the LAF, ensuring both experimental reproducibility and high standards of animal welfare.

oversight by reviewing and approving all protocols before implementation, monitoring compliance during studies, and advising investigators on applying the principles of the 3Rs—Replacement, Reduction, and Refinement—to optimise animal welfare without compromising scientific integrity [9]. Animals produced by the facility and utilised by the research community are documented through protocols reviewed, as presented in Table 2 and illustrated in Figure 3. In alignment with international standards, the NMIMR-LAF operates under the Guide for the Care and Use of Laboratory Animals [10] and complies with relevant legal and ethical frameworks, including the Ghana Criminal Code [11], the U.S. Animal Welfare Act and amendments (P.L. 89-544 and successors) [12], the Council for International Organizations of Medical Sciences (CIOMS) guidelines [13], and the Five Freedoms framework [14], which emphasise freedom from hunger and thirst, discomfort, pain, injury or disease, fear or distress, and the ability to express normal behaviours.

All personnel engaged in animal care and use are trained in laboratory animal science, handling, and biosecurity, ensuring both ethical responsibility and scientific reliability. Through structured ethical review, periodic facility inspections, and continuing professional education, the NMIMR-LAF promotes a sustained culture of care that safeguards animal welfare while enabling rigorous, high-quality biomedical research.

**Training and capacity building**

Since its establishment, the facility has trained more than 120 individuals from 15 institutions across Ghana, Côte d'Ivoire, Burkina Faso, and Nigeria (Table 3). Trainees have included undergraduate and graduate students, veterinary interns, and biomedical researchers (Figure 1f). A landmark achievement was the 2017 FELASA-certified Workshop in Laboratory Animal Science, funded by Laboratory Animals Limited, which recorded participant

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satisfaction levels above 90%. This milestone validated local training against international standards, reinforced ethical research practices, and enhanced the region's visibility in global collaborations and funding. Consequently, the facility instituted the Laboratory Animal Care and Ethical Use in Biomedical Research (LACEBR) course, now delivered annually as a certificate programme. In addition, LAF staff have played a leading role in organising training for ethics committees and researchers at other universities, contributing to national capacity development and the strengthening of IACUCs. Collectively, these efforts have fostered a skilled regional workforce capable of supporting world-class biomedical research (Figure 4).

Table 2. Laboratory animal usage by the research community

| Institution/Group | Number of Research Projects |
|---|---|
| NMIMR | 20 |
| UG (non-NMIMR) | 36 |
| KNUST | 2 |
| UCC | 1 |
| UDS | 3 |
| Other Ghanaian Institutions | 10 |
| West African Institutions | 2 |
| Other African Institutions | 1 |
| Total | 75 |

**Research support and impact**

Between 2000 and 2025, the LAF provided critical support for more than 75 ethically approved projects (Table 2), spanning bacteriology, immunology, parasitology, pharmacology, toxicology and virology. Collectively, this research output has generated over 500 peer-reviewed publications, 95% of which are indexed in Google Scholar, PubMed, Scopus, or Web of Science, highlighting the LAF's visibility and scholarly impact. Over the years, the facility has played a central role in establishing disease models across a spectrum of communicable and non-communicable conditions, as well as in other applied research areas (Table 4). The distribution of animal species used in research at the LAF between 2000 and 2025 is illustrated in Figure 5. The data reveal a marked

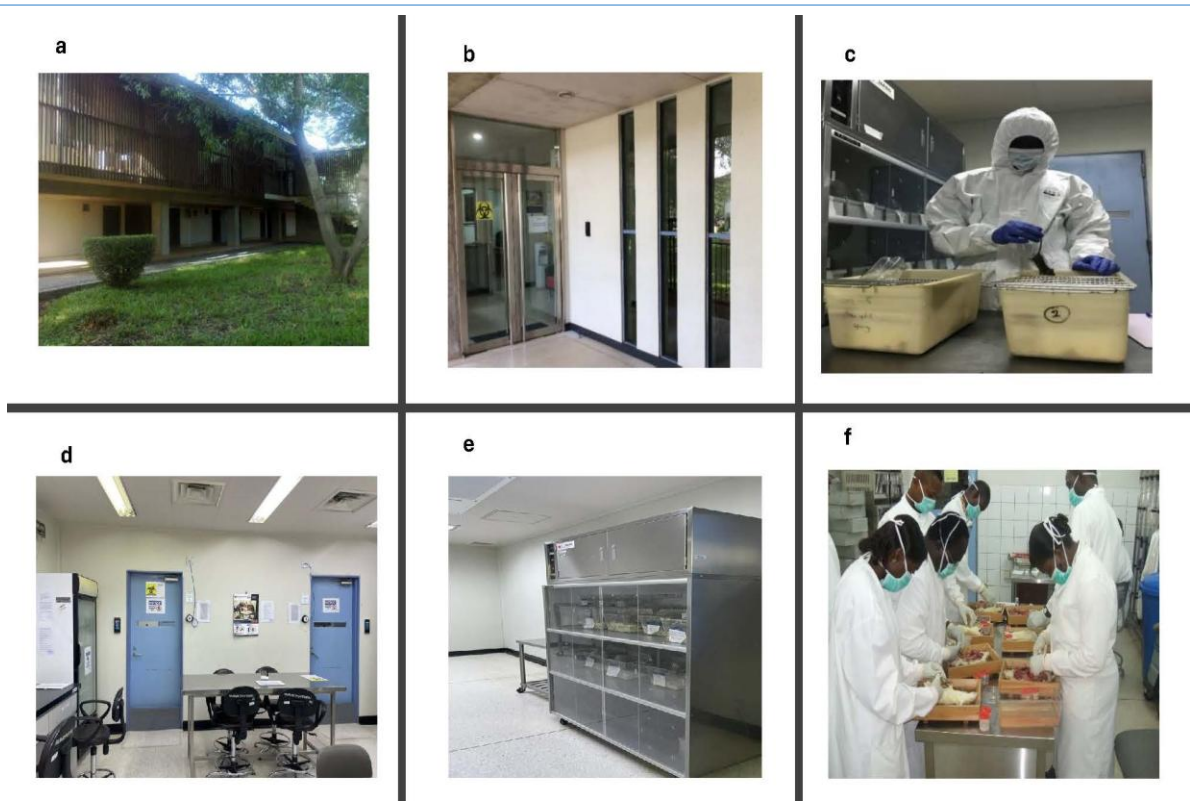


Figure 1. Infrastructure and activities within the NMIMR Laboratory Animal Facility (LAF). (a) Side view of the Laboratory Animal Facility; (b) Main entrance to the facility; (c) One of the specific pathogen-free (SPF) animal breeding rooms; (d) Laboratory designated for infectious disease animal experimentation; (e) Additional breeding room for rodent colonies;; f Gross pathological examination of an experimental animal post-study.

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predominance of mice and rats across all research domains, reflecting their suitability and cost-effectiveness as experimental models for a wide range of biomedical investigations. Rats were most frequently employed in pharmacological and toxicological studies, accounting for the largest share of experimental animals during the period. This pattern aligns with the extensive use of rat models for toxicological screening, drug metabolism, and physiological investigations. Mice were the second-most-utilised species overall and served as the dominant model in parasitology and neuroscience-related studies, consistent with their genetic tractability and well-established disease models. Use of guinea pigs and rabbits was relatively limited, featuring mainly in infectious disease, reproductive

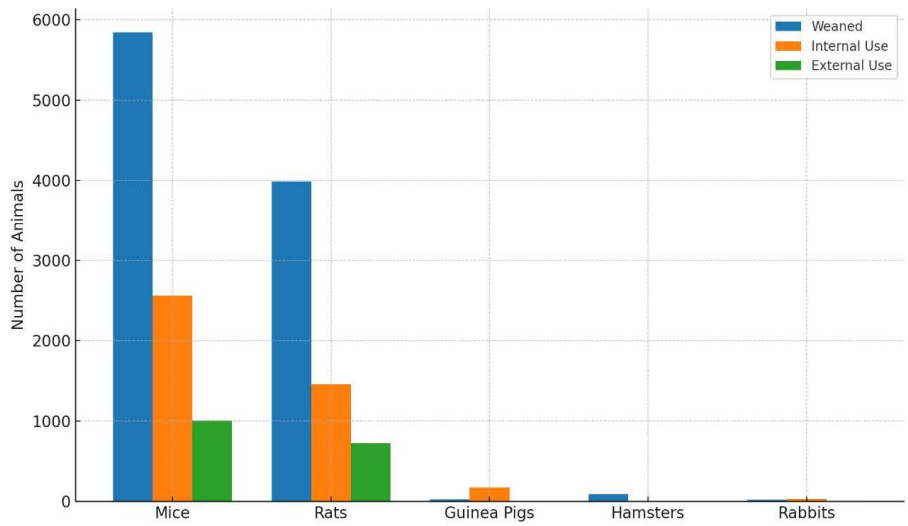


Figure 2. Comparative analysis of animal production, in-house utilization, and external distribution

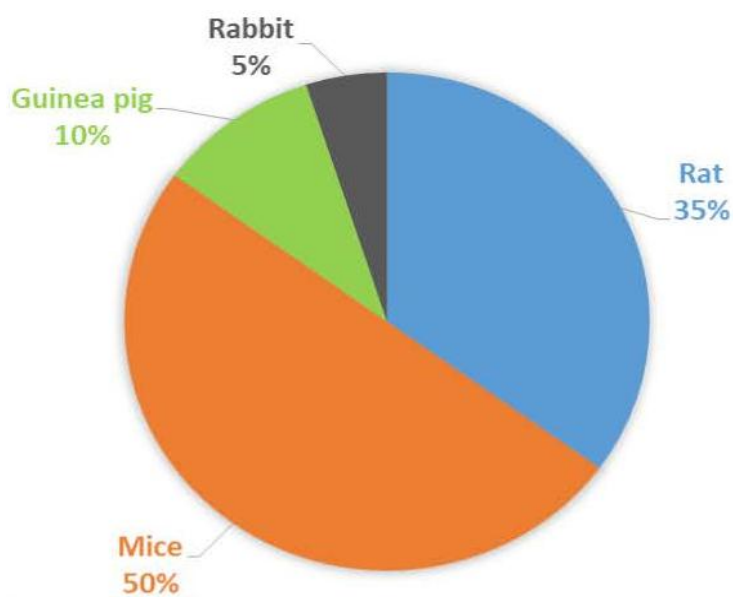


Figure 3. Distribution of laboratory animal species used between 2000 and 2025

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biology, and veterinary/comparative medicine research. A few studies involved other species (e.g., grasscutters or poultry), reflecting specialised investigations or collaborative projects targeting zoonotic and translational health challenges. Overall, the pattern of animal use mirrors international trends in biomedical research, with rodents, particularly mice and rats, remaining the cornerstone of in vivo experimentation due to their accessibility, well-characterised physiology, and relevance to human disease modelling. In the domain of communicable diseases, the LAF has been instrumental in advancing knowledge of Buruli ulcer, malaria, leishmaniasis, schistosomiasis and trypanosomiasis.

Buruli ulcer models in mice, using footpad and tail inoculation, helped demonstrate lymphatic dissemination of *Mycobacterium ulcerans* rather than hematogenous spread [15]. The grasscutter (Thryonomys swinderianus) was later developed as a novel model, offering valuable insights into host–pathogen interactions within an ecological context [16]. Further studies revealed that the free-living amoeba *Acanthamoeba polyphaga* can harbour *M. ulcerans* and exacerbate pathology in murine models, suggesting a potential environmental reservoir [17]. Current investigations using the SKH1 hairless mouse aim to unravel the role of polymicrobial colonisation in Buruli ulcer wound healing. Similarly, malaria research has been

Table 3. Capacity-building metrics of NMIMR LAF trainings

| Year | Number of persons Trained | Institutions Involved | Training Format |
|---|---|---|---|
| 2001 - 2009 | 9 | 4 | |
| 2010 | 3 | 2 | |
| 2011 | 2 | 1 | |
| 2012 | 1 | 1 | |
| 2013 | 0 | 0 | |
| 2014 | 1 | 1 | |
| 2015 | 4 | 2 | |
| 2016 | 3 | 1 | |
| 2017* | 27 | 10 | In person + hands-on practical |
| 2018 | 7 | 3 | |
| 2019 | 3 | 2 | |
| 2020 | 3 | 2 | |
| 2021 | 8 | 3 | |
| 2022 | 28 | 2 | |
| 2023 | 29 | 6 | |
| 2024 | 20 | 4 | |
| 2025 | 22 | 5 | |

*Inclusion of FELASA Certified International training course in Laboratory Animal Science.

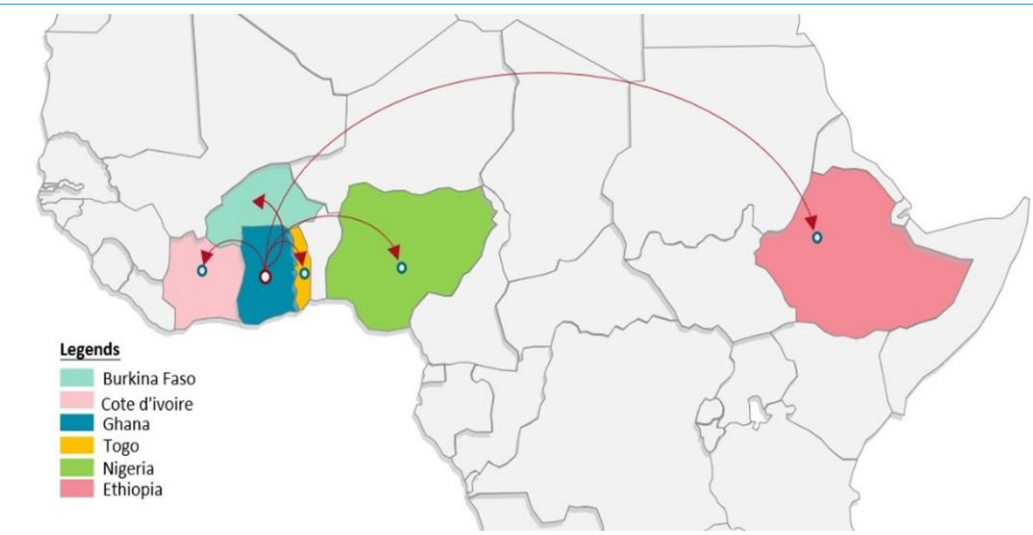


Figure 4. Geographic distribution of institutions represented by training participants and animals supplied.

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strengthened through the routine use of *Plasmodium berghei* in mice, which replicates key features of human disease and has been pivotal for preclinical testing of plant extracts such as *Alchornea cordifolia*, *Carapa procera*, *Moringa oleifera*, and *Phyllanthus niruri* [18–20]. In addition, under a collaborative research agreement, a zebrafish facility is being established within the LAF to support advanced neuroscience research. Furthermore, an avian malaria model utilising *Plasmodium gallinaceum* infection in chickens is being optimised as an ethical and cost-effective surrogate for human malaria studies. These infectious disease models have provided vital platforms for drug discovery, immunological investigations, and the study of host–parasite dynamics.

The facility has also made substantial contributions to non-communicable disease research. Diabetes models have been developed using streptozotocin (STZ) to induce Type 1 diabetes and a high-fat diet combined with low-dose STZ to mimic Type 2 diabetes. These systems have been widely applied to evaluate the therapeutic potential of Ghanaian medicinal plants on glucose homeostasis, insulin sensitivity, and lipid metabolism [21–26]. Hypertension models, including L-NAME-induced hypertension, have facilitated investigations into vascular function and oxidative stress, providing mechanistic evidence for ethnomedicinal remedies [27]. In neuroscience, chemically and electrically induced seizure models have demonstrated anticonvulsant effects of *Synedrella nodiflora* and *Antiaris toxicaria*, implicating GABAergic and antioxidant pathways [28,29]. Research on benign prostatic hyperplasia (BPH) has employed testosterone propionate-induced models, validating the traditional use of Croton membranous root extracts through significant reductions in prostate size and epithelial thickness [30–33]. Gastric ulcer research, using ethanol- and aspirin-induced lesions, has revealed the gastroprotective and antioxidant effects of several local medicinal plants [34,35]. Models of inflammatory bowel disease, particularly dextran sulfate sodium (DSS)-induced colitis, have enabled preclinical

Table 4. Summary of key disease models supported by NMIMR-LAF (2000–2025)

| Disease Area | Model | Application | Representative Outcome / Reference |
|---|---|---|---|
| Communicable Diseases | Murine footpad & tail inoculation (Buruli ulcer) | Pathogenesis, environmental reservoirs, wound microbiome | Lymphatic dissemination; *Acanthamoeba* as reservoir [15–17] |
| | Grasscutter (*Thryonomys swinderianus*) | Alternative ecological host for BU | Susceptibility and ecological relevance [16] |
| | SKH1 hairless mouse | Polymicrobial wound colonization in BU | Insights into wound microbiome interactions (ongoing) |
| | *Plasmodium berghei* in mice | Antimalarial screening; host immunity studies | Evaluation of *A. cordifolia*, *C. procera*, *M. oleifera*, *P. niruri* [18–20] |
| | *P. gallinaceum* – *Gallus gallus domesticus* | Avian malaria research; ethical alternative | Development of avian malaria system (ongoing) |
| | Rodent infection models (schistosomiasis, trypanosomiasis, leishmaniasis) | Host–parasite interactions; therapy evaluation | Facilitated parasitology studies [62-64] |
| Non-Communicable Diseases (NCDs) | Streptozotocin (STZ) Type 1 diabetes; HFD + STZ Type 2 diabetes | Glycaemic control, insulin sensitivity, lipid metabolism | Evaluation of Ghanaian medicinal plants [21–26] |
| | L-NAME-induced hypertension | Vascular function, oxidative stress, ethnomedicine validation | Cardio-metabolic health studies [27] |
| | PTZ and MES seizure models | Anticonvulsant evaluation of medicinal plants | *S. nodiflora* and *A. toxicaria* validated [28,29] |
| | Testosterone propionate-induced BPH | Preclinical validation of phytotherapy | *C. membranaceus* reduced prostate size [30–33] |
| | Ethanol- and aspirin-induced gastric ulcers | Gastroprotection, antioxidant and anti-secretory effects | Validated plant extracts [34,35] |
| | DSS-induced colitis | IBD therapeutic testing | Bergapten alleviated colitis [36] |
| | LPS- and hemolysis-induced AKI | Mechanisms of renal injury, therapy development | *Neuregulin-1* protective effect [47] |
| | Triple-transgenic Alzheimer's mouse (3xTg-AD) | Neurodegeneration research, therapeutic interventions | Amyloid, tau, cognitive decline modeled [48] |
| | Eker rat | Uterine fibroid pathogenesis and therapy | mTOR signaling, phytotherapeutics [49–54] |
| Other Models & Applications | Excisional & incisional wound models in rodents | Wound contraction, epithelialization, angiogenesis | Plant extracts and Kombucha enhanced healing [55–61] |
| | Toxicology studies (OECD-guided) | Preclinical safety evaluation of medicinal plants | Hematology, histopathology, biochemistry [65–69] |
| | Preclinical validation of traditional medicine | Integration with in silico docking and pharmacology | Expanded mechanistic insights (ongoing) |

testing of synthetic and natural compounds, with bergapten demonstrating strong anti-inflammatory and antioxidant activity [36]. Additionally, the facility has supported acute kidney injury (AKI) studies using LPS and hemolysis-induced models relevant to sickle cell disease, where Neuregulin-1 has shown renoprotective effects [37]. In neurodegenerative disease research, the triple-transgenic Alzheimer's disease (3xTg-AD) mouse model has allowed exploration of amyloid deposition, tau pathology, and cognitive decline, facilitating collaborations such as those with CSIR-WRI to identify potential therapeutic interventions [38]. Reproductive health research has benefited from the use of the Eker rat, which carries a spontaneous Tsc2 mutation and develops uterine fibroids that closely resemble human disease. Studies employing this model have elucidated molecular mechanisms such as mTOR dysregulation and angiogenesis, while also evaluating phytochemicals as candidate anti-fibroid therapies [39–44].

Beyond communicable and non-communicable diseases, the LAF has advanced research in wound healing, toxicology, and medicinal plant validation. Excisional and incisional wound models have been used to assess plant extracts and novel agents, such as Kombucha, which have accelerated wound contraction, collagen synthesis, angiogenesis, and epithelialisation [45–51]. Toxicological evaluations, conducted under OECD guidelines, have integrated haematological, biochemical, and histopathological assessments, ensuring that candidate therapies meet safety benchmarks. These preclinical safety studies are often complemented by in silico analyses, such as molecular docking and dynamics simulations, to identify active constituents and clarify mechanisms of action [52–59]. In doing so, the LAF has become a national and regional hub for the rigorous preclinical evaluation of traditional medicinal products, bridging indigenous knowledge with global biomedical standards. Overall, the NMIMR-LAF has established itself as a cornerstone of biomedical research in Ghana and West Africa (Figure 4). Its portfolio of infectious, non-communicable, and applied research models demonstrates in-depth expertise, translating into high-impact scientific outputs and tangible public health insights. By providing infrastructure, expertise, and ethical oversight, the facility continues to foster collaborations, enhance scientific credibility, and drive innovations that address pressing health priorities in the sub-region and beyond.

**Progression of facility upgrades and financial implications**

Since its inception in 2000, the NMIMR-LAF has undergone phased upgrades designed to align with international standards and to support the Institute's expanding research portfolio. The initial setup provided basic rodent housing and breeding capacity, enabling foundational work in infectious disease research. As scientific demand increased and international regulatory requirements became more stringent, the facility pursued progressive enhancements in animal welfare, biosecurity,

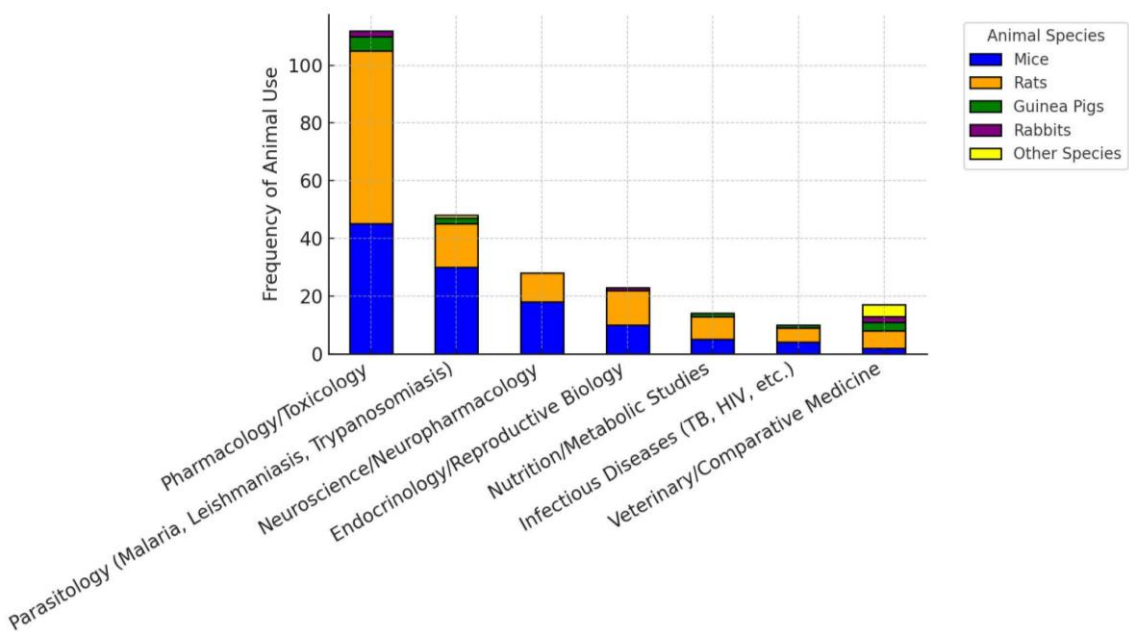


Figure 5. Distribution of animal species used across different research areas at the NMIMR Laboratory Animal Facility (2000–2025). The figure illustrates the frequency of animal use by research domain, with distinct colour codes representing each species (blue = mice, orange = rats, green = guinea pigs, purple = rabbits, yellow = other species).

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and technical infrastructure. The first major upgrade, launched in 2010 with combined institutional and donor support, focused on refurbishing equipment, installing controlled ventilation systems, and strengthening biosecurity protocols. These improvements elevated animal welfare standards and ensured closer compliance with international guidelines. The most recent modernisation phase (2020–2024) has prioritised quality assurance and operational efficiency through the integration of ISO/IEC 17025:2017 principles, risk-based process management, and digital monitoring systems. These changes have expanded the facility's capacity for preclinical and translational research while reinforcing its global credibility.

The financial implications of these upgrades have been considerable. The most significant investments have consistently involved ventilated cage systems, automated environmental controls, and recurring expenditures for feed, bedding, veterinary care, utilities, and personnel. To offset these costs, the LAF operates on a cost-recovery model in which services provided to both internal and external investigators contribute to recurrent expenses. Looking ahead, sustainability will depend on a hybrid financing strategy that combines institutional budget allocations, competitive research grants, cost-recovery mechanisms, and strategic partnerships. Such an approach will safeguard long-term operations while ensuring that the LAF remains responsive to emerging biomedical research priorities in Ghana and the wider sub-region.

## DISCUSSION

This 25-year review underscores the LAF as a cornerstone of biomedical research and ethical animal use in Ghana. Since its establishment, the facility has provided a reliable source of SPF animals and standardised experimental services, enabling reproducible science and minimising background infections. Its scope spans communicable and non-communicable diseases, phytomedicine screening, preclinical drug safety evaluation, training, and regulatory oversight, thereby positioning it as a national and regional asset. The predominance of mice and rats as experimental models at the LAF (Figures 2 and 3) reflects both scientific merit and operational practicality. These rodent species are widely recognised for their cost-effectiveness, small body size, and ease of handling and housing, making them ideal for routine biomedical investigations. Their short lifespan and rapid reproductive cycles enable multi-generational and longitudinal studies to be completed within relatively short time frames.

Furthermore, their well-characterised genomes, the availability of numerous defined strains and disease models, and a wealth of background data enhance experimental reproducibility and translational relevance. Collectively, these features underpin the preferential use of mice and rats for the majority of experimental studies conducted within the facility. Their biological relevance, genetic uniformity, and adaptability make them indispensable for preclinical experimentation.

The observed distribution of animal species at the LAF (Figure 5) shows mice and rats across nearly all research domains, mirroring international trends in laboratory animal science, where these species account for over 80% of all research animals used globally. Within specific research areas, rat models remain particularly prominent in pharmacological and toxicological investigations, reflecting their continued utility in drug safety evaluation, metabolic profiling, and dose–response analyses. Conversely, mice are more extensively employed in parasitology and neuroscience research, owing to advances in murine genetic manipulation and transgenic model development that facilitate mechanistic exploration of host–pathogen interactions and neurobehavioral disorders. The comparatively limited use of guinea pigs and rabbits reflects both ethical and practical constraints, including higher maintenance costs and fewer standardised experimental protocols. Nonetheless, their selective use in reproductive biology, vaccine development, and immunological research demonstrates the facility's flexibility and capacity to support a range of model organisms when justified by scientific objectives. The inclusion of other species, notably grasscutters, highlights NMIMR's responsiveness to national and regional research priorities, particularly in zoonotic and comparative medicine.

Overall, the pattern of animal use at the LAF is well aligned with international standards, reflecting a balanced integration of scientific validity, animal welfare, and institutional capacity. Sustained efforts to strengthen ethical oversight, refine model selection, and promote the use of validated alternatives to animal testing will further enhance the facility's contribution to responsible, high-quality, and impactful biomedical research in Ghana and beyond. The LAF's research support has advanced knowledge in both communicable and non-communicable diseases. In communicable disease research, murine and grasscutter (Thryonomys swinderianus) models have been pivotal in Buruli ulcer studies, demonstrating lymphatic spread of Mycobacterium ulcerans [15,59]. Malaria investigations have highlighted the antiplasmodial activity of Moringa oleifera [19], Phyllanthus niruri [20], and the novel honeycomb-derived formulation BEEMAR [60]. The facility has also contributed to studies on avian haemosporidians [61], leishmaniasis [62], schistosomiasis [63] and trypanosomiasis [64].

For non-communicable diseases, LAF models have supported preclinical investigations into hypertension, diabetes, epilepsy, and neurological pain. Croton membranaceus extracts demonstrated efficacy against benign prostatic hyperplasia [57,58] and cardiovascular biomarkers [24]. Amoateng et al. [29] and Mante et al. [28] validated the anticonvulsant activity of traditional medicinal plants, while Amponsah et al. [65] revealed

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pharmacokinetic interactions between prenatal corticosteroids and neonatal antibiotic therapy. Beyond disease modelling, the facility has provided infrastructure for evaluating biologicals and biomedical products. This includes efficacy testing of anti-snake venom formulations [66], rodenticides [67], and plant-derived or synthetic compounds with therapeutic potential, contributing to national product safety, innovation, and the One Health agenda [68,69]. Strategic partnerships with industry and research stakeholders, including Vestergaard Vector Laboratory and Atlantic Life Sciences Limited, have further strengthened its translational impact. Capacity building remains one of LAF's most significant contributions. Scientists, students, and technical staff have received training in biosafety, animal welfare, and handling techniques, establishing the facility as a regional hub for laboratory animal science education and fostering a culture of ethical and competent animal use.

Despite these achievements, challenges persist. Limited funding constrains infrastructure upgrades, accreditation, and personnel recruitment, while monitoring and data-collection automation remains underdeveloped. Addressing these gaps will require strengthened partnerships with regulatory bodies, donor agencies, and academic consortia to sustain and expand the facility's contributions. Beyond financial limitations, the management and expansion of the LAF have been shaped by several operational challenges. A key issue has been the lack of trained laboratory animal technologists and veterinarians with expertise in laboratory animal science, which initially affected technical consistency and welfare monitoring. This has been mitigated through targeted capacity-building initiatives, including FELASA-aligned training workshops and staff mentorship programmes organised by the Department of Animal Experimentation. Another challenge involved maintaining biosecurity and environmental controls within ageing infrastructure, which risked compromising animal health status and research reproducibility. To address this, the facility has progressively upgraded its housing systems, introduced routine microbial monitoring, and implemented stricter access and sanitation protocols. Additionally, inconsistencies in user compliance with animal use guidelines were observed during early collaborative projects. These were resolved through strengthened ethics review procedures and mandatory pre-study orientation for investigators. Collectively, these measures have enhanced operational reliability, improved compliance with international standards, and established a framework to prevent recurrence of earlier challenges. Sharing these experiences may assist other research institutions in strengthening their own laboratory animal management systems.

Overall, the NMIMR-LAF has played a critical role in bridging basic science and public health interventions in Ghana and the sub-region. Its adaptability, research output, and commitment to ethical standards affirm its importance as a strategic biomedical infrastructure with both national and global relevance.

### Conclusion

Over the past 25 years, the NMIMR Laboratory Animal Facility has been a cornerstone of Ghana's biomedical research ecosystem, advancing experimental science through high-quality animal models, rigorous ethical oversight, and capacity building. Its proven track record and strong institutional integration position it to serve as a regional hub for laboratory animal science and translational research addressing Africa's pressing health challenges. Sustained investment, strategic partnerships, and continued innovation will be critical to strengthening its role and expanding its impact in the years ahead.

### Future outlook

The Laboratory Animal Facility (LAF) will continue to strengthen its role in supporting high-quality biomedical research. The ongoing model expansion agenda, including the establishment of a zebrafish facility and the optimisation of the avian malaria model, is expected to expand the range of experimental systems available to investigators. These developments will provide additional opportunities for cost-effective and ethically sound alternatives to traditional mammalian models, particularly in neuroscience and infectious disease research. The LAF also anticipates greater integration of technological innovations to improve animal monitoring, welfare, and data reproducibility. The adoption of refined enrichment protocols, molecular characterisation tools, and digital health tracking systems will enhance both the quality of animal care and the reliability of research outcomes.

Further, the LAF will continue to contribute to capacity building through an established certificate training programme, with plans to broaden the scope of training to include advanced model systems, regulatory compliance, and applications in One Health research. Importantly, the facility is working towards Association for Assessment and Accreditation of Laboratory Animal Care International (AAALAC) accreditation, which will benchmark its operations against internationally recognised standards of animal welfare, quality assurance, and research compliance. Collectively, these initiatives indicate that the LAF is well-positioned to support emerging scientific priorities, foster collaborative research, and make sustainable contributions to biomedical research in Ghana and the wider West African region.

## DECLARATIONS

### Ethical consideration

All data were handled in accordance with the institutional guidelines of the Noguchi Memorial Institute for Medical Research on confidentiality and responsible conduct of research. The NMIMR Laboratory Animal Facility operates under a program of continuous oversight, including routine facility

inspections, protocol review, and veterinary supervision, to ensure ongoing compliance with institutional policies and internationally accepted animal welfare standards.

**Consent to publish**
All authors agreed on the content of the final paper.

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The authors declare no conflict of interest

**Author contribution**
SA conceptualised and designed the study, curated the data, interpreted the facility records, and wrote the original draft of the manuscript and subsequent revisions. BA curated the data and contributed to writing the original draft and reviewing and editing the manuscript. DAB contributed to writing the original draft and reviewing and editing the manuscript. CA-T and SNA-P contributed to reviewing and editing the manuscript. GAA contributed to the conception of the study and critically reviewed the manuscript. All authors read and approved the final version of the manuscript.

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**Availability of data**
Data is available upon request to the corresponding author

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