Chapter

Contribution to the Management of Toxicological Risks in Burkina Faso: Design Process and Implementation Strategies for a Clinical Toxicology Laboratory

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Abstract

In Burkina Faso, toxicological risks have increased for more than a decade, with the irrational use of chemicals in agri-food and mining activities, as well as the consumption of psychoactive substances (PAS); and are now a public health problem. This situation has led to the establishment of a clinical toxicology laboratory, which now contributes to the diagnosis of poisoning and the prevention of risks to the health of populations through toxicological biomonitoring. The development of this initiative required a proactive approach adapted from the “interconnected chain” innovation process. The creation of a unit called the “Toxicological Analysis and Expertise Service” or “SAET” at the National Public Health Laboratory of Burkina Faso or “LNSP” is the main result of this innovative initiative in Burkina Faso’s health system. If this laboratory now has a certain technical capacity or expertise, it must be strengthened through the acquisition of the additional equipment necessary to increase the supply of expertise. To do this, the strengthening of technical and financial collaborations is essential for the improvement of health security in Burkina Faso in particular and in the world in general.

Keywords: toxicology laboratory, laboratory project, innovation, SAET, LNSP

1. Introduction

For more than 50 years, the world has known about an extension of chemical products (pesticides, industrial products, drugs, dangerous products for domestic use, psychoactive substances, etc.) and their use in several fields of activity. According to the United Nations Environment Program (UNEP), international sales of chemicals would increase by around 3% per year until 2050 and there would have been an average increase of 40% in chemical production between 2012 and 2020 for Africa and the Middle East [1]. This is why the International Program on Chemical Safety (IPCS) has been in place since 1980 to assess the risks to human health and the environment that will be increasingly exposed to chemicals [2].

Indeed, man and the environment are exposed to these chemical substances, in various circumstances and to varying degrees, which can cause them acute or chronic damage. These toxic effects, which are more prevalent in the field of public health, must be subject to special monitoring [2, 3].

In addition, the chemicals to which the population may be exposed differ from one country to another, from one region to another, from one profession to another, etc. Thus in Burkina Faso, the chemical risks to which the population is exposed are mainly linked to the use of pesticides and mercury and/or cyanide, respectively, in agriculture and mining [4–10]. To these risks is added the increased consumption of psychoactive substances (PAS), specifically illicit drugs, and adulterated alcohols [6, 11–13]. As a result, the Ministry of Health of Burkina Faso is increasingly challenged by the population to deal with these ever-growing toxicological risks [14].

In order to contribute to the management of toxicological risks, our initiative had the main goal of designing and developing a project (strategic plan) to set up a Clinical Toxicology Laboratory (CTL) in Burkina Faso, in order to strengthen the system of health on the one hand in the diagnosis of intoxications and on the other hand in the assessment of the toxicological risk by biomonitoring: research, identification and/or dosage of toxins in biological and/or environmental matrices [9, 12, 15–17].

Through this chapter, we want to share our experience on a strategic approach carried out for the development of toxicological analysis in Burkina Faso, especially in the clinical field, in order to contribute to the improvement of health safety. This chapter consists of three parts. The first part deals with the context of toxicological risks and their management in Burkina Faso, the second part will unfold our strategy to develop, that is to say all the elements of a laboratory project and finally the third part will take stock of the results obtained.

2. First part: context

A toxicology laboratory in general, and a CTL in particular, constitutes an essential structure in a health system, as it is capable of providing data on the exposure to toxic substances of a population living in a given environment. This information can contribute not only to the assessment of the extent of exposure of the general population to toxic substances, but above all to the implementation of a public health intervention process aimed at analyzing and reducing toxicological risks in the population (human and environmental biomonitoring).

For several decades, the health situation related to Burkina Faso toxicology has been quite worrying. The initiative for the establishment of a CTL at Burkina Faso was mainly induced by two important public health situations:

- obvious and increasingly high toxicological risks: the existence of chemical risks to which the population is exposed in several areas of activity today constitutes a public health problem in Burkina Faso;

- a fairly limited health system in the management of toxicological risks: the absence of a Poison Control Center (PCC) and the nonperformance of clinical toxicology analyses limit Burkina Faso's health system in the assessment and management of toxicological risks, including toxicological emergencies [18].

2.1 Main toxicological risks in Burkina Faso

The toxicological risks in Burkina Faso are essentially of a chemical nature. The chemicals most often involved are pesticides, mercury, cyanide, illicit drugs, medicines, lead, arsenic and petroleum products (hydrocarbons).

These risks are most often related to:

- the use of pesticides in the food industry,
- the use of mercury and cyanide in mining (modern and/or artisanal),
- the consumption of PAS (an increasingly common practice among the general population, especially among adolescents).

2.1.1 Use of pesticides in agriculture

In Burkina Faso, agriculture occupies a prominent place in the national economy. Producers use chemical substances (fertilizers, pesticides) to increase their production and/or fight against diseases and crop pests. This situation has been promoted through a national policy known as the "Support Program for Agro-Sylvo-Pastoral Sectors." This program was developed following the decrease in agricultural productivity and therefore food deficits linked to precarious climatic conditions and attacks by crop pests.

2.1.1.1 Toxicological risks linked to the use of pesticides

If pesticides are one of the factors of agricultural development, it is good to note that their inappropriate use could be a danger brought about on several levels:

- among users, including professionals in the phytosanitary industry, farmers and their families who are exposed to the toxicity of these products during crop [19] formulation or processing activities,
- among consumers of agricultural products: the exposure is linked to the presence of toxic residues in crop products
- in the environment through the spread of pesticides in the fields. Soils, air and some surrounding water points are contaminated with these products [3–5, 9, 16, 20].

2.1.1.2 Contribution of a toxicology laboratory

With these toxicological situations/risks on these targets (users, consumers and environment), what could a toxicology laboratory bring to Burkina Faso? Indeed, the search for pesticide residues in edible products (cereals, fruits, drinking water, etc.) is already carried out in Burkina Faso, in particular at the National Public Health Laboratory (NPHL [21, 22]). This expertise could be reinforced by highlighting markers of exposure and effects through analyses of biological matrices (blood, urine) in professionals exposed to these substances and possibly in consumers.

2.1.2 Use of mercury and cyanide in mining

In addition to the increasing use of pesticides in Burkina Faso, the mining "boom" experienced by the country (in Burkina Faso in 2009, gold became the first source of foreign currency, ahead of cotton) through mining modern and artisanal is one of the major sources of exposure to highly toxic chemical substances, in particular mercury (Hg) and cyanide, both for workers, the local population and for the environment [23].

2.1.2.1 Toxicological risks

Large quantities of cyanide and mercury have often been used in a relatively short time and for a small quantity of gold. According to a report submitted by the Ministry in charge of the environment, approximately 200 tons of cyanide was used to extract 600 kg of gold only over a period of one quarter and for a single modern mining site. And during the same period, mercury was used the most (due to 1 g Hg/g of gold for a daily exploitation of approximately 25 g of gold) in artisanal mining [23].

Besides other chemical substances, such as acids (sulfuric acid, nitric acid), hydrocarbons (for blasting) and detergents are also used.

The use of these products constitutes a major toxicological risk for these workers, particularly in small-scale mining sites where health and safety measures are not often observed [5–8, 10, 23]. Also, in view of the relatively large quantities and their poor exploitation, the use of these substances is a major source of environmental pollution (contamination of water, soil, vegetation, air, etc.) and a toxic risk for the surrounding population. Indeed, these substances after exploitation in the treatment of ores or any other purpose are dumped in nature and can be conveyed by dust and rainwater (contaminant of large surfaces, water of rivers, dams, etc.). Other toxins are often generated following chemical reactions produced or released through the grinding or crushing of minerals (cadmium, lead, etc.) [6].

Although it brings a plus to the national economy, mining is a source of several diseases and risks; and therefore, constitutes a public health problem in Burkina Faso today.

2.1.2.2 Contribution of a toxicology laboratory

Faced with the health risks associated with this activity, monitoring of exposed professionals, monitoring of populations living near mining sites and monitoring of environmental pollution levels (water, soil and air) by toxicological analyses are necessary. A national toxicological biomonitoring strategy should be put in place.

2.1.3 Consumption of psychoactive substances

The consumption of PAS has now become a real public health problem in Burkina Faso, with a strong negative socioeconomic impact [11, 13]. This phenomenon is reinforced by:

- a growing precariousness within the population, especially of its young fringe (unemployment, disorientation and despair), leads to delinquency and prostitution which rub shoulders with drugs and alcohol;

- doping in the workplace to increase performance: there is a high consumption of PAS in gold panning sites (where amphetamine is the most used, alone or in combination with other substances such as cannabis and alcohols) [6].

Thus, Burkina Faso, formerly a transit country for drug trafficking, has become over the years a consumer country, causing a resurgence of insecurity in the country (acts of crime, rape, terrorism, etc.) [24].

2.1.3.1 Risks and targets

The increase in the phenomenon of drug and alcohol consumption is nowadays the cause of several cases of acute intoxication, drug addiction and other diseases such as liver and heart damage, cancers among consumers, in particular youth.

These situations challenge not only the National Committee for the Fight against Drugs (CNLD), but also all the actors who can intervene in the fight against this scourge.

2.1.3.2 Contribution of a toxicology laboratory

To contribute actively fighting against this plague, a laboratory of toxicology may provide expertise in the identification or profiling of seized products and screening for PAS through biological analyses.

2.1.4 Other chemical risk situations in Burkina Faso

Some professionals are also exposed in their work environment to potentially toxic chemical substances. We can note:

- dispensers at gas stations (called commonly gas station attendants), mechanicians and painters are exposed to hydrocarbons (gasoline fuel):

If most pump attendants do not have appropriate personal protective equipment (PPE) during work and therefore are exposed to hydrocarbon vapors (fuel); mechanicians frequently use gasoline or kerosene to clean their hands at the end of the working day.

- People working in physicochemical analysis laboratories:

These workers, especially analysts, are exposed to chemical solvents and reagents in their work environment. Indeed, most of the premises are not only not suitable (lack of ventilation, confinement of the rooms), but above all are not well equipped (absence of extractor hoods or more often nonfunctional and do not have a vacuum cleaner).

There are very few studies related to the exposure of these professionals to chemical substances and insufficient application of the regulations on the prevention of risks among these professionals [25].

Biomonitoring of workers exposed to chemical substances in their workplace: worker follow-up.

2.2 Health management of toxicological risks in Burkina Faso

2.2.1 Situation of clinical toxicology analyses in Burkina Faso

With regard to the toxicological risks described above, cases of poisoning are recorded in health facilities; however, there is no Poison control center (PCC) and the clinical toxicology analyses are not sufficient to contribute to the effective management of these cases. This constitutes one of the difficulties encountered by medical practitioners relating to the prevention and treatment of poisonings. So only symptomatic treatments are most often applied for the care of poisoning victims.

Some studies report that cases of poisoning recorded in health facilities were due to drugs, pesticides and mercury; but these studies had not been confirmed by the demonstration of the suspected toxins [4, 26–28]. However, toxicological analysis (qualitative and/or quantitative) could provide diagnostic, prognostic and even therapeutic interest in the management of emergency poisoning in hospitals.

The absence of a CTL does not make it easy to carry out biomonitoring analyses in the country. For example, biological data on a population of Burkina Faso, which we have noted in the literature, come from the laboratory of the "Institut Universitaire Romand de Santé au Travail (IST)" in Lausanne, Switzerland, relating to the dosage of urinary mercury in artisanal gold miners, carried out since 2006 [29]. Also, the dosage of lead, most often requested by mining companies, as part of the medical follow-up of workers, is subcontracted with laboratories in France. This practice is not compatible for emergency toxicology analyses (clinical and hospital), nor accessible for a large number of the population, because the delay in obtaining the results and the additional cost are not in favor of such an alternative.

There is therefore the need to set up a CTL in Burkina Faso, for a major contribution to occupational health and safety, through the assessment and monitoring of certain professionals exposed to toxic substances in their workplace through worker biomonitoring.

2.2.2 Clinical toxicology analyses carried out in Burkina Faso

These analyses are rare in Burkina Faso's health system, both at the level of public and private structures. Before 2015, only certain private clinics carried out urine screening tests for psychoactive substances (PAS) (illicit drugs) using rapid diagnostic tests (RDTs). These clinics also carried out subcontracts for certain analysis requests (blood assay for lead) with international laboratories.

Since 2011, we have seen that several requests for toxicological expertise (hospital, forensic, legal and others) are increasingly addressed to the LNSP. However, the response to these requests is most often limited to this Ministry of Health reference structure for toxicological analyses, which was created in 1999. Some examples of requests for toxicological expertise, addressed to the "Direction de la toxicologie, du contrôle de l'environnement et de l'hygiène publique (DTCE/HP)" or Direction of Toxicology, environmental control and public health summarized in **Table 1**, reveal the limits of the LNSP relating to the toxicological expert opinions requested.

For the purposes of ensuring, on the one hand, the preservation of the health of workers and consumers, the diagnosis and management of poisonings and, on the other hand, the carrying out of forensic toxicology expertise, the setting up of a clinical toxicology unit proved necessary in Burkina Faso, hence the development of a

Domain	Expertise requested	Expertise offered	Observation
Hospital	Mercury blood test	None	Not done
	Blood lead test	None	Unrealized
	Drug and medication testing	None	Service offered limit
	Therapeutic follow-up: dosage of drugs in the blood	None	Not done
	Identification of unknown substances	Pesticide research	Service offered limit
Forensic	Detection of toxic substances in autopsy specimens: alcohol, drugs, carbon monoxide or carbon dioxide	None	Not done
Judicial	Identification of a product Determination of the chemical profile of suspicious substances	Pesticide research	Service offered limit
	Determination of the toxicity of a product	None	Not done
Others	Identification of unknown substances	Pesticide research	Service offered limit
	Verification of the composition of certain building materials	Analysis based on documentary research	Service offered limit

Table 1.
Cases of toxicological analysis requests sent to the National Public Health Laboratory of Burkina Faso (LNSP) between 2011 and 2013.

project entitled "Contribution to the improvement of the health system in Burkina Faso: establishment of a clinical toxicology laboratory" [30].

2.3 Some literature review data on toxicological analysis in Burkina Faso

Through a literature review, we were able to note that most of the studies carried out in Burkina Faso on toxicology dealt with exposure factors, risks to the population or the environment linked to the use of chemicals in agri-food and mining activities, and the scourge of psychoactive substance consumption.

During the design phase of our project, we were unable to find an article dealing with clinical toxicology aspects, in terms of diagnosis or screening for intoxication, therapeutic follow-up of patients or toxicological biomonitoring of any population, through biological analyses carried out by a national laboratory. However, these studies alerted us to the existence, frequency and seriousness of these risks, with proposals for corrective and preventive measures.

Some documents dealing with toxicological risks for the population or the environment, occupational risks or risks linked to drug consumption in Burkina Faso are listed in Appendix A (**Tables A1–A3**).

However, other toxicological analyses, apart from clinical toxicology, have long been carried out in certain health facilities and university and/or research training courses. These include the LNSP, a reference health facility of the Ministry of Health, one of whose technical departments is responsible for carrying out toxicological analyses; the Institut de Recherche en Sciences de la Santé (IRSS) and Université Joseph KI ZERBO, where fundamental research in toxicology is carried out; and private health facilities that subcontract certain analysis requests to international laboratories (lead blood assay).

Significance and contribution of a clinical toxicology laboratory

A. Why a clinical toxicology laboratory in Burkina Faso

- High chemical risks in several areas of activity
- Limited health system: absence of a poison control center (PCC) and insufficient clinical toxicology analyses.

    1. Main chemical risk situations in Burkina Faso

        - Poor practice and use of pesticides in the cultivation and preservation of foodstuffs
        - Intensification of artisanal mining with the use of cyanide and mercury
        - Consumption of alcohol and drugs by young people
        - Exposure of workers to chemicals: solvents and laboratory reagents, hydrocarbons, etc.

    2. Health management of toxicological risks in Burkina Faso

        - Absence of a poison control center
        - Limited analytical capacity in clinical toxicology
        - Insufficient treatment for poisoning
        - Increase in urgent requests for toxicological analysis

B. Potential contribution of the clinical toxicology laboratory

- Improved diagnosis and management of poisoning
- Improvement in the therapeutic follow-up of patients
- Implementation of biomonitoring systems for exposed populations
- Improvement in forensic toxicology expertise: search for causes of death.

3. Second part: our project

In our project to develop a clinical toxicology laboratory, we have set goals to achieve.

The aim was to "contribute to strengthening Burkina Faso's health system by setting up a clinical toxicology laboratory". The achievement of this objective aims to make up for the shortcomings of Burkina Faso's health system in the management of toxic risks. Indeed, there is a great insufficiency in national analytical data, especially clinical data to provide evidence-based decision-making. So chronologically, three specific objectives have been set for the realization of the project:

- develop the necessary strategies for setting up a toxicology laboratory in Burkina Faso,
- strengthen the technical capacities necessary for the activities of the toxicology laboratory, and
- ensure the efficient functioning of the laboratory by carrying out clinical toxicology analyses

3.1 Design process

Our methodological approach or design process followed a proactive design process through the adaptation of acquired knowledge and the development of collaboration with several actors.

Data collection was carried out in parallel with the strategic actions developed over 4 years (2012–2015). This very often required readjustments and/or additions, reframing according to the evolution of the situation and the strategic actions carried out.

The development of the project took place in two phases:

- initially in Burkina Faso, a documentary review, exchanges with potential collaborators (industrial partners, reagent suppliers, medical practitioners, etc.) and observations on inappropriate practices or the misuse of chemicals made it possible to describe the country's health situation in toxicology,
- second in Québec (Canada), thanks to training in toxicological expertise at the Quebec Toxicology Center (CTQ) of the National Institute of Public Health of Quebec (INSPQ) (this is one of the major strategic actions of the development of our initiative), as well as interviews with partners (industrialists, suppliers, potential customers, researchers, and the like), we were able to identify and estimate the needs adapted to the context of Burkina Faso for setting up the laboratory.

By comparing our approach to those of many innovation process models described in the literature, our action strategy for setting up the clinical toxicology laboratory seems best suited to the "interconnected chain" innovation model by S. Kline and N. Rosenberg [31–33].

This is an "open" type approach to the innovation process, because technical and financial collaborations were established not only during the development of the project, but also for the implementation of the other planned actions [34–36]. With regard to collaboration, the following supports can be noted:

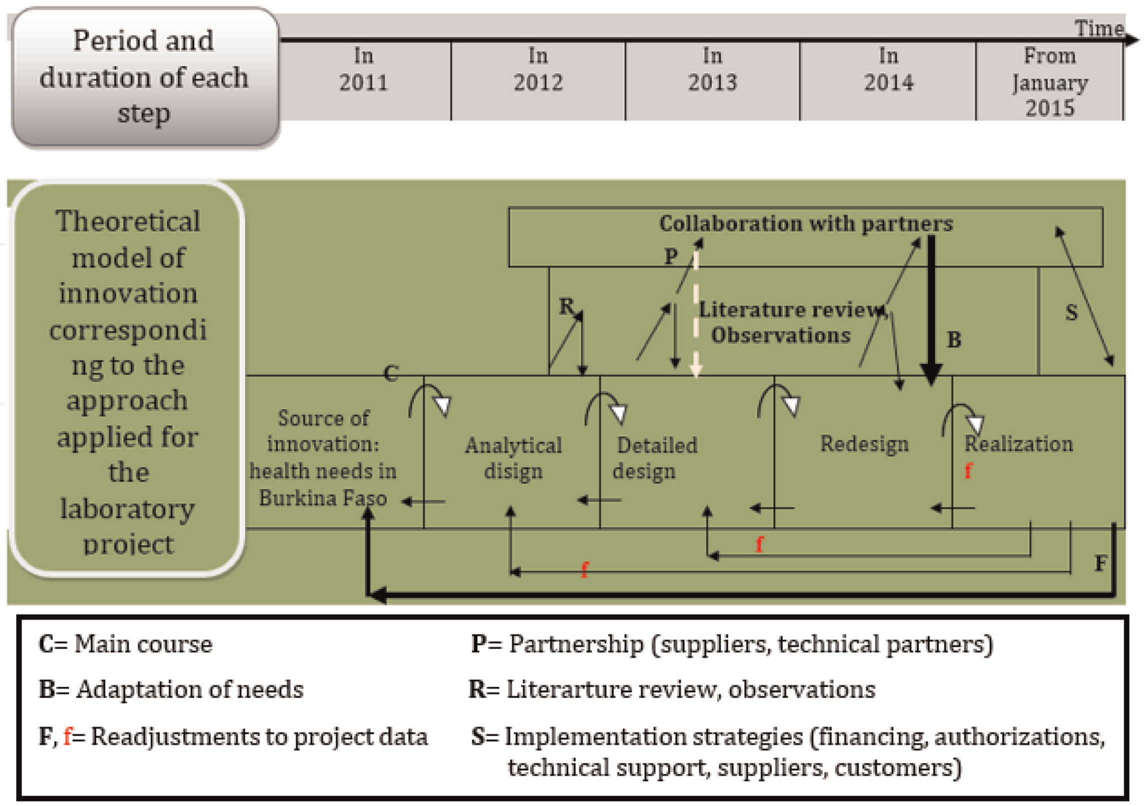

Figure 1.
Diagram adapted from the interconnected chain (S. Kline and N. Rosenberg) for the development of a clinical toxicology laboratory (CTL).

- support from the "Programme Canadien des Bourses de la Francophonie" (PCBF) or Canadian Francophonie Scholarship Program for training and project design,
- the technical support of the CTQ (INSPQ) during the design and implementation of the project,
- technical support of ChemTox in Strasbourg in France during the design, in particular on the identification and estimation of the appropriate technical needs, and
- collection of information from industrial partners specializing in the production and distribution of equipment suitable for a toxicology laboratory during design: this information is mainly related to the availability and costs of equipment.

Figures 1 and **2** summarize through this diagram our design approach and the strategic actions carried out: "Strategic approach adapted to the interconnected chain innovation model (S. Kline and N. Rosenberg, 86) for the initiative to set up a Clinical Toxicology Laboratory in Burkina Faso".

3.2 Strategies' implementation

3.2.1 Duration, orientations and planned actions

3.2.1.1 Duration

The development of the initiative is split into two phases:

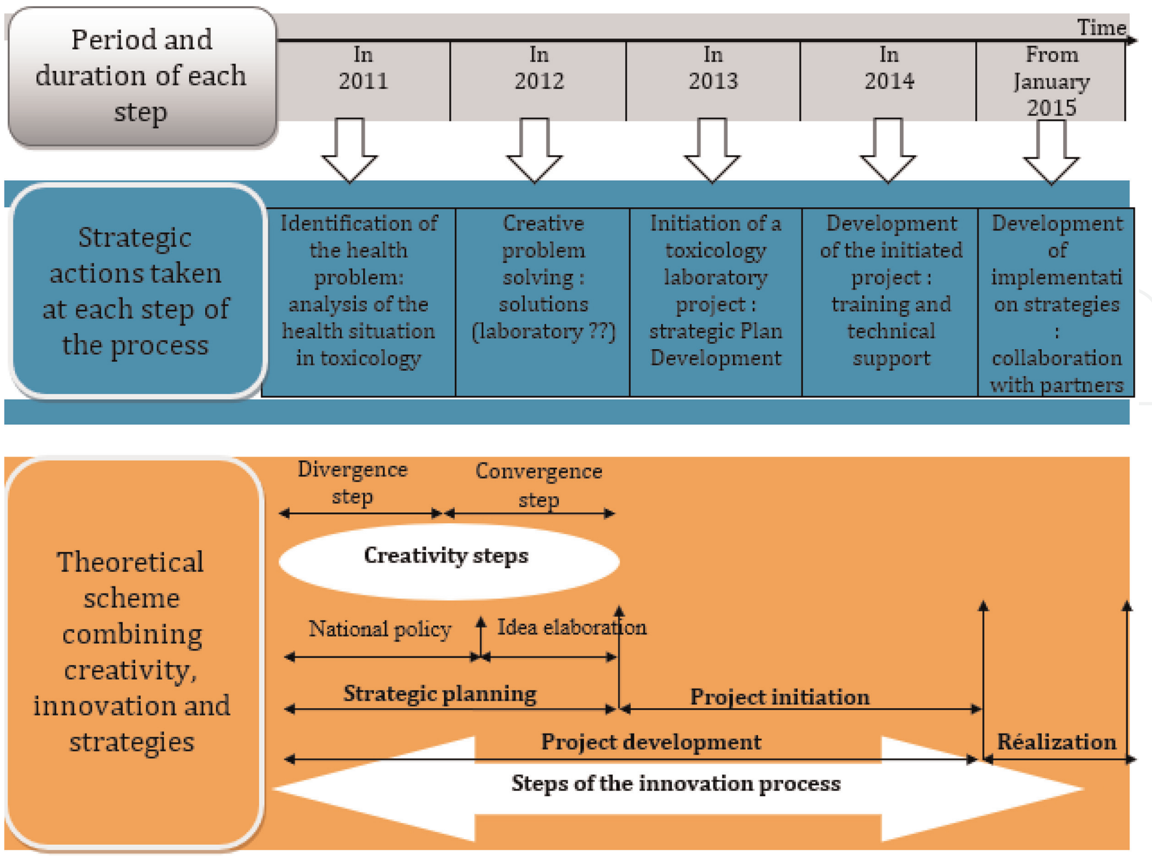

Figure 2.
Creativity and innovation combination scheme and strategic actions taken.

- Phase 1: Design phase (needs assessment) and project development (search for funding and technical partnerships);
- phase 2: Installation and operation of the laboratory.

The duration of phase 2 is planned for 5 years; however, its start depends on the end of phase 1 with the creation and obtaining of the necessary financing.

3.2.1.2 Strategic directions

For an effective implementation of the CTL, three main axes have been identified from which strategic actions have been defined:

- **Axis 1: Creation of the laboratory**

It focuses first on obtaining legal and administrative authorizations (administrative formalities, technical agreements) and second on strengthening technical capacities (financial resources (financing agreements), material (construction and fitting out of premises, acquisition of equipment, materials, reagents, etc.) and human (assignment and/or recruitment of personnel, training of assigned personnel, and so on).

- **Axis 2: Carrying out toxicology analyses**

This axis relates to the actions of research and collection of samples for analysis from customers and the performance of clinical toxicology analyses such as screening and biomonitoring.

- **Axis 3: Search for performance and recognition of the laboratory**

This last axis concerns the establishment of an effective quality assurance system with participation in interlaboratory test programs and which will be supplemented by the search for accreditation, the ultimate goal of any reference laboratory.

The main strategic actions already implemented during the design of the project and those planned for the future are summarized in **Table 2**.

3.2.2 Missions and organization planned for the toxicology laboratory

3.2.2.1 Potential assignments

The potential assignments set for the toxicology laboratory are as follows:

- ensure analyses related to clinical and hospital toxicology;
- provide analyses related to occupational and environmental toxicology: biomonitoring;
- provide forensic analyses and expertise related to forensic toxicology; and
- carry out any other activity related to toxicological expertise: research, biomonitoring and epidemiological studies.

3.2.2.2 Technical organization and potential activities of the laboratory

According to the missions mentioned above, potential customers and development prospects (future vision) on the one hand and according to the health context in Burkina Faso on the other hand, the toxicology laboratory can be organized into several technical sections [37].

Five sections have been planned in the project. These are:

- a section "reception and collection" of samples;
- a "clinical and hospital analytics" section;
- a section "analytical environment / Occupational Health and Safety (OHS)";
- a "Research and innovation" section; and
- "Quality Assurance" section.

Table 3 describes the attributions of the different technical units that have been defined, according to certain fields of application of analytical toxicology.

Execution phase	Strategic axis	Shares
Phase 1: Development of the laboratory project	AXIS 1: Creation of the toxicology laboratory	• **Project design:** ◦ Realization of a pilot study: prioritization of toxicological analysis needs ◦ Assessment of appropriate and adapted needs ◦ Research and collaboration with technical and financial partners (TFPs)
		• **Setting up the laboratory/creation**: ◦ Search for the necessary authorizations and financing ◦ Capacity building in infrastructure and material resources ◦ Capacity building in human resources
Phase 2: Implementation or realization of the project	AXIS 2: Carrying out toxicological analyses	• **Research and collection of analytical samples** ◦ Information of potential customers: health structures, industries, mines, Ministry of the environment, agriculture, World Organization Health (WHO), etc. ◦ Initiation and development of biomonitoring projects with clients
		• **Realization of qualitative and quantitative analyses** ◦ Screening for drugs, medicines in biological or nonbiological environment ◦ Dosage of metals in biological matrices or not (mercury, lead, arsenic, etc.) ◦ Research and dosage of pollutants in biological media (cyanide, pesticides)
	AXIS 3: Increase in performance and search for recognition	• **Implementation of an appropriate quality assurance program:** ◦ Adapted quality assurance system (ISO 9001 and ISO 17025) ◦ Participation in interlaboratory controls
		• **Accreditation search for the main analytical parameters:** ◦ Organization of audits in collaboration with reference technical partners ◦ Submission of application for accreditation to qualified structures
REMARK: Actions can take place concurrently.		

Table 2.
The main strategic actions for the implementation of a clinical toxicology laboratory (CTL).

3.2.3 Service offers and potential beneficiaries

Different service offers had been targeted (**Table 3**). They could be:

- diagnosis in intoxication, screening in the context of the consumption of psychoactive substances, as well as the therapeutic follow-up of patients will be used for the benefit of health structures, the sports environment (doping control), customs services, mining companies national and/or subregional … ,

Unit/section of activity	Orientation/activities
Reception and collection	Collecting, receiving, registering, sorting and distributing samples
Clinic and hospital	• Toxicological emergencies: diagnosis: detection/dosage of toxic substances in a biological environment or not • Therapeutic follow-up: dosing of drugs, in a biological environment • Judicial or nonjudicial requests: analysis of autopsy samples
Environment/ OHS	• Biomonitoring of workers: analysis of metals, pesticides, cyanide and solvents in biological matrices • Population biomonitoring: health surveys, projects
Research and innovation	• Judicial requisitions: • detection/dosage of toxins in biological or nonbiological matrices and • evaluation of the toxicity of a sample. • Epidemiological studies: health surveys (with other units) • Development of analytical methods • Training of staff and trainees
Quality assurance	• Implementation and development of a quality policy

Table 3.
Organization and potential fields of activity of the toxicology laboratory.

- toxicological biomonitoring and health surveys planned as part of public health studies and/or health programs for the benefit of the authorities, national and international organizations for the promotion of health and the protection of the environment (World Organization Health (WHO), United Nations Environment Program (UNEP), International Labor Organization (ILO), etc.)

- forensic medical expertise for the benefit of forensic doctors and judicial police officers (JPOs).

NB: Diagnosis, screening and follow-up therapeutic will be the category of the most frequent service offer with regard to the absence of PCC and requests for analyses from health practitioners in the context of the management of poisoning. Health structures and societies mining should be the greatest beneficiaries of the activities of the toxicology laboratory.

The analytical parameters targeted for these different offers have been identified according to the toxicological risks identified. The potential target parameters that may be set depending on the type of service are summarized in **Table 4**.

3.2.4 Needs identified for the establishment and operation of the laboratory

The needs identified within the framework of the clinical toxicology laboratory project relate essentially to technical needs, in particular human and material resources.

3.2.4.1 Needs in qualified human resources

Several categories of technical personnel are needed to effectively carry out the activities of a toxicology laboratory, the analysts being the most important. The technical profiles to be mobilized are technologists, chemists and toxicologists. Technologists (50% of the total laboratory workforce) and chemists or biochemist (25% of

Service offer	Settings of interest targeted	Devices
Screening and follow-up therapeutic	Illegal drugs	Organic and nonorganic
	Medications	Organic and nonorganic
	Alcohols	Organic and nonorganic
Biomonitoring	Arsenic	Organic and nonorganic
	Mercury	Organic and nonorganic
	Lead	Organic and nonorganic
	Pesticides	Organic
Health research and surveys	Any parameter possible in the laboratory	Organic and nonorganic
Forensic expertise	Any parameter possible in the laboratory	Organic and nonorganic

Table 4.
Service offerings and priority analysis parameters.

the total laboratory workforce) should be the most represented profiles. The toxicologists and the support staff (maintenance technician, equipment upkeep and cleaning staff) in reduced numbers (20% of the total laboratory staff) will have to supplement the number of technical staffs. The mobilization of this technical staff should be progressive, due to at least 50% of each profile the first 2 years and the rest the following years according to the planned duration of the project (i.e., 5 years).

3.2.4.2 Material resources requirements

Infrastructure and material needs (equipment, consumables, laboratory reagents) must be adapted to the planned toxicological analysis activities.

For infrastructure, it will be necessary that the constructions and fittings of the premises meet certain quality and safety standards. However, this should depend on the chosen implantation site.

The main needs of a laboratory are analytical instruments. These devices should be able to cover all the analytical parameters of interest. Chromatographs and atomic absorption devices are the most targeted (**Table 5**).

3.2.5 Budget estimate

The overall budget for all needs (human and material resources) and for operation for 5 years is estimated at United States Dollars (US$1,907,590 (**Tables B1–B5**)).

This budget covers five investment headings, each with a defined proportion in relation to the overall budget. The acquisition of analytical devices occupies the largest share of the overall budget with 57% (**Figure 3**).

The average annual investment is estimated at US$317,911.79 or about 17% of the total estimated budget. The fourth year of the laboratory establishment process should see the largest proportion of investment with approximately 93% of the overall budget (**Figure 4**).

Depending on the source of funding, the technical and financial partners (TFPs) could support the project up to about 30–40% of the overall budget.

Analytical technique	Device identified	Possible analytes	Estimated quantity	Expected vesting period
Immunochemistry	RSS II (+RDT drugs)	Drugs, medicines	1	Year 1
	Immunochemical automaton	Drugs, medicines	1	Year 1
Atomic absorption	CV-AAS: FIMS 100	Mercury	1	Year 2
	GF-AAS AAnalyst 600	Metals	1	Year 2
Chromatography	GC-MS	Drugs, medicines, pesticides, cyanide ...	1	Year 3
	HPLC-MS	Drugs, medicines, pesticides, cyanide ...	1	Year 4

CV-AAS, cold vapor atomic absorption spectrometry; FIMS, flow injection mercury system; GF-AAS, graphite furnace atomic absorption spectrometry; GC, gas chromatography; HPLC, high-performance liquid chromatography; MS, mass spectrometry; RSS, rapid slide scanner.

Table 5.
The main analytical devices identified and their acquisition scheme.

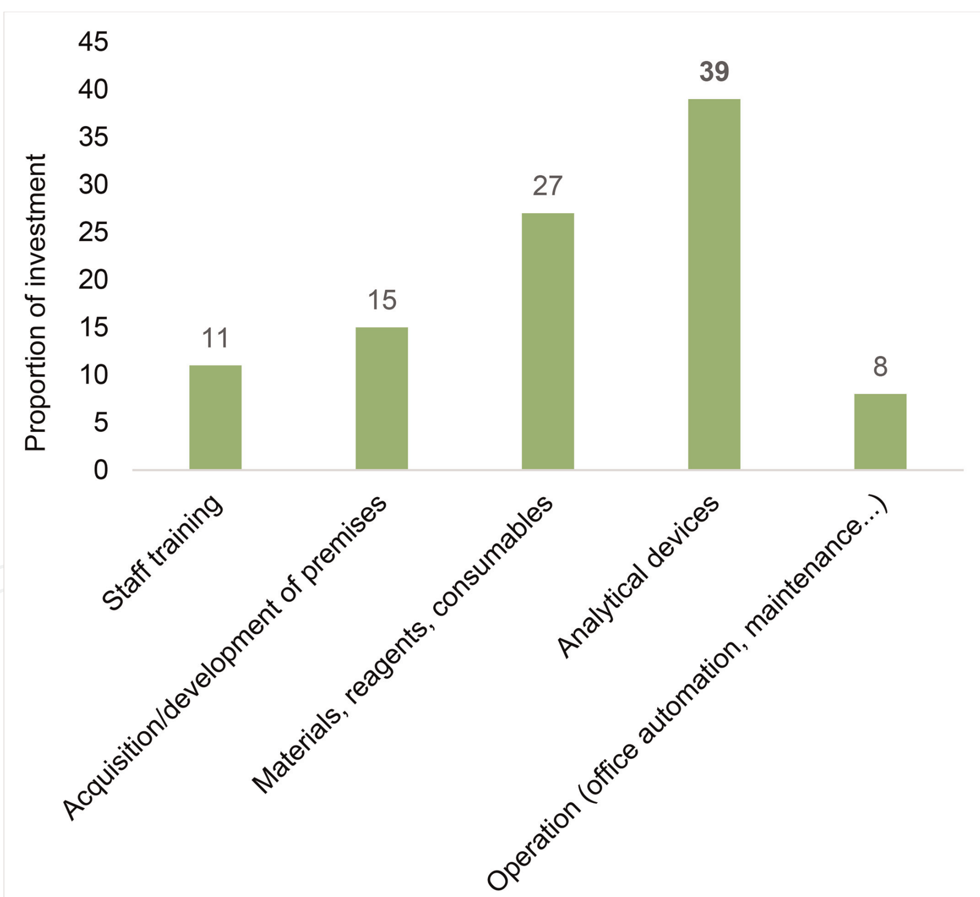

Figure 3.
Breakdown of the budget according to investment headings.

3.2.6 Determination of the location of the laboratory

There were several possibilities for setting up a clinical toxicology laboratory in Burkina Faso. Several hospitals and others can house this type of laboratory. However,

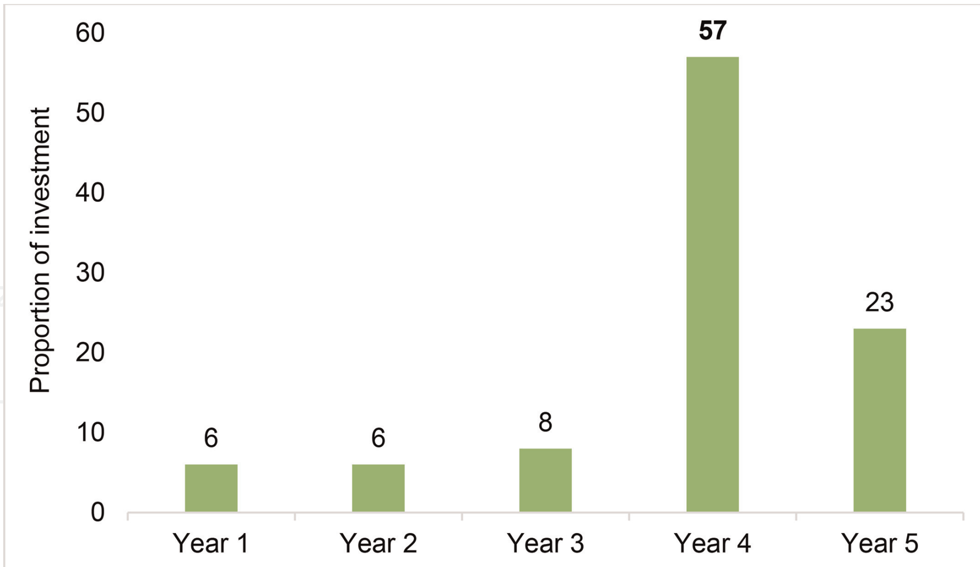

Figure 4.
Breakdown of the budget by year.

according to the existing analytical potential, the LNSP was the most favorable site of choice in terms of minimizing costs and reducing implementation times. During the development of the initiative, the LNSP already had the following assets:

- a relatively advanced technical platform (materials and devices available): Chromatographs (GC-MS, HPLC), biochemical analysis automaton,
- infrastructure and premises,
- a space available for possible construction of new premises,
- the missions of the clinical toxicology laboratory meet certain attributions or missions of the DTCE/HP of the LNSP,
- the clinical toxicology laboratory project is part of the LNSP's 2014–2018 strategic plan,
- the LNSP is the supervisory structure of the initiator of the project, having benefited from training at the CTQ for the establishment of the laboratory, and
- the project was already introduced to the authorities of the Ministry of Health for the creation.

3.2.7 Implementation constraints or risks for the project

The risks associated with the development of this project were the refusal or noncommitment of the health authority, the insufficiency or absence of the necessary funding. The lack of cooperation from potential customers (other health structures, mines, etc.) was also noted as an element that could slow down the progress of the implementation of the project.

To deal with these risks; mitigation measures had been planned, such as:

- the involvement of health authorities in the implementation, and of resource persons,
- the development of a financing and advocacy plan with financial partners according to their potential and orientations.
- developing a communication, information and awareness-raising plan for medical clinicians, mining companies and others, to incorporate toxicological analyses into their practices.

Project summary

A. Project objectives

- develop strategies for setting up a toxicology laboratory in Burkina Faso,
- strengthen the technical capacities necessary for the activities of the toxicology laboratory, and
- ensure the efficient functioning of the laboratory by carrying out clinical toxicology analyses

B. Methodological approach to main chemical risk situations in Burkina Faso

- Proactive approach, inspired by the "interconnected chain" innovation model of Kline and Rosenberg, 1986
- Design was carried out in two phases (in Burkina Faso and in Québec) based on documentary review, observations, training and interviews, from 2011 to 2015.

C. Implementation plan

- Two stages:
    - phase 1: design and development of the project and
    - phase 2: installation and operation of the laboratory.
- Three axes of strategic orientation
    - axis 1: creation of the laboratory,
    - axis 2: performing toxicology analyses and
    - axis 3: search for accreditation for the laboratory.

D. Organization and missions and projects for the laboratory

- Reception and sample collection section
- Clinical and hospital analytical section for analyses relating to clinical and hospital toxicology

- Environment/OHS analytical section for analyses relating to occupational and environmental toxicology: biomonitoring
- Research and innovation section for any other activity related to toxicological expertise: research, toxicovigilance and forensic expertise
- Quality assurance section for setting up quality systems.

E. Service offers and potential beneficiaries of the clinical toxicology laboratory

- Screening and therapeutic monitoring for health structures mainly
- Biomonitoring for health authorities and organizations, mines and industries
- Health studies and surveys for research institutes, authorities and health organizations
- Forensic medical expertise for judicial authorities and others.

F. Resources required

- Technical human resources required: technologist, chemist and toxicologist
- Necessary analytical equipment: chromatographs ++

G. Estimated budget

- Overall budget for 5 years: US$1 907 589,65
    - average annual investment US$317 911,79
    - thirty-nine percent of the overall budget to be invested in year 4
    - fifty-seven percent for analytical devices
- Potential sources of financing: TFPs identified (WHO, UNEP, ILO, etc.)
    - forty percent of the overall budget
    - proactive approach, inspired by the "interconnected chain" innovation model of Kline and Rosenberg, 1986
- Design carried out in two phases (in Burkina Faso and in Québec) based on documentary review, observations, training and interviews, from 2011 to 2015.

H. Choice of the laboratory site

- National Public Health Laboratory of Burkina Faso for its many potentialities:
    - high-level technical platform: chromatographs and others available,
    - infrastructure and premises available, and
    - space available for possible construction of new premises

I. Implementation risks and mitigation measures

- Main risks:
    - noncommitment of the health authority and
    - insufficient or no necessary funding
- Main mitigation measures:
    - involvement of health authorities in the implementation,
    - development of a financing plan, and
    - advocacy with financial partners for funding

4. Part three: project implementation status

The initiative to set up a CTL arose from our professional ambition to contribute to strengthening toxicological expertise in Burkina Faso. While the subject was being considered, this need was expressed by the Ministry of Health in an administrative note addressed to the LNSP, with the subject “assessment of the operational capacity of the National Public Health Laboratory in the field of environmental and clinical toxicology” [38]. While the LNSP was a benchmark for its technical capacity in environmental toxicology, in terms of water and soil monitoring and health aspects, this was not the case for clinical toxicology, for which we had just proposed setting up this expertise. This memorandum reinforced our initiative, which led to it being included as one of the key points in the National Public Health Laboratory’s (LNSP) 2014–2018 strategic plan [39]. In addition to this, in response to this note from the Ministry of Health, the first draft of the initiative entitled “Projet de renforcement des capacités du Laboratoire national de sante publique en analyses toxicologiques: mise en place d’une Unité de toxicologie (UNITOX-LNSP)"or Project to strengthen the capacities of the National Public Health Laboratory in toxicological analysis: setting up a toxicology unit was submitted to it [40]. These were the first administrative actions that led to the creation of the STM, which later became SAET.

This part will deal with the inventory and the results obtained in the implementation of the clinical toxicology laboratory project. First of all, we will present the results of the implementation over the period of 5 years, that is to say from 2015 to 2019, then we will come to the difficulties encountered and finally the situation at the current state (2023) and prospects.

4.1 Implementation review

Toxicological Analysis and Expertise Service has become a national reference in toxicology, and above all in Burkina Faso's health system. Today, SAET is involved in a number of toxicological assessments. After 5 years of operation, we carried out an evaluation of SAET's performance, especially in the context of increasing demand. This evaluation, carried out in 2020, was intended to take stock of the current situation, assess the level of efficiency and define prospects for improvement.

Some of the data from this evaluation, which show the considerable contribution made by SAET at national level, are summarized in the following points.

4.1.1 Number of toxicological expertise requests received

The LNSP, through SAET, received and processed more than 238 requests for toxicological expertise between 2015 and 2019, of which 62% (n = 147) were of a judicial nature. These data were considered as a statistical basis of toxicological expertise needs in Burkina Faso, even if some data could not be recorded or dismissed for technical insufficiencies. We also noted that the number of requests each year gradually increased from 2015 (n = 39) to 2019 (n = 58). This situation could essentially be justified either by a wide dissemination of information on the availability of this toxicological expertise offer at LNSP or by a reinforcement and improvement in the quality of this service offer at LNSP.

4.1.2 Applicants for toxicological expertise

In 81.93% (n = 195) of cases, the main clients for toxicological assessments were public institutions. Among these, JPOs were strongly represented (over 70%). This situation may reflect the use of analytical solutions to JPO requests in the processing of legal cases. In addition, the number of recourses by private structures has gradually increased over the years, to exceed the frequency of recourse by public institutions in 2019 (62% private structures vs. 38% public structures). This considerable proportion of referrals from private facilities could be explained by the improvement in LNSP's technical offering through SAET's activities.

In addition, the Ministry of Health has progressively called on the SAET's expertise in the investigation of poisoning cases, particularly those of a collective nature that have occurred in recent years in the country.

4.1.3 Data on samples analyzed

Over 1650 samples were processed between 2015 and 2019, an average of 332 per year. These samples mainly included food, chemical, biological and pharmaceutical products, as well as substances of unknown nature.

Food products were the most represented (70%) of the samples analyzed. This was justified by the fact that food products were the most incriminated in cases of suspected poisoning or chemical submission, and in cases of involuntary intoxication. SAET's various analytical reports on these samples led to the reinforcement of the monitoring system for food products, particularly those produced locally at national level [21, 41].

Biological samples, mainly urine and blood, are most often taken in response to requests for diagnosis in clinical toxicology, forensic toxicology (autopsy sampling) and occupational health and safety (mining company workers). In the latter field, SAET contributes to the screening and monitoring of PAS consumption by mining site professionals on an ongoing basis.

Pesticides, drugs and chemical screening were the main analyses carried out. Pesticides were identified as the main etiology of emergency intoxications with fatalities. In addition, for the same assessment period, a review of 194 samples submitted for drug testing revealed a positivity rate of 33.69% (n = 65), of which 80% concerned biological samples. Amphetamines and cannabinoids were the most frequently detected PAS.

4.1.4 SAET efficiency level

Through this study, we were able to note that 40% of the requests processed had provided a satisfactory analytical solution to the request submitted; i.e., precise guidance had been given to the requestor. These are situations in which, a causal relationship between exposure and the toxic effects observed in the intoxications had been established. In other cases, where the response was incomplete, the insufficiency was most often linked not only to the absence of certain materials (equipment, standards and reagents), but also to the low sensitivity and the low sensitivity and specificity of certain techniques and methods. Over the years, however, SAET has strengthened its technical capabilities through the introduction of new analytical methods, increasing the frequency of complete responses to over 52% in 2019. The assessment made in 2022 indicates that the level of efficiency is over 60% [24, 42–44].

To further boost efficiency, SAET should work on developing suitable methods with even lower detection limits, to detect as many toxic substances as possible in a sample. This could be achieved by implementing and exploiting certain chromatographic techniques (gas chromatography coupled-mass spectrometry (GC/MS)), liquid chromatography coupled-high-resolution mass spectrometry (LC/MS-MS) and inductively coupled plasma mass spectrometry (ICP-MS)).

4.2 Difficulties encountered and prospects

The constraints and limits in the implementation of the laboratory project are of several orders.

4.2.1 On the administrative level

As the LNSP is a public administration institution, financial procedures are one of the major constraints in the process of acquiring the necessary material resources. Also, a relatively small budget has been allocated for the acquisition of the necessary equipment.

In addition, the instability and small size of the SAET's technical staff make it impossible to plan the development of the laboratory's activities.

4.2.2 On the technical side

Several aspects can be identified, which handicap the activities of the toxicology laboratory:

- Insufficient maintenance of equipment (chromatographs) most often causing recurring breakdowns,
- absence or insufficiency of some materials and reagents, and
- insufficient capacity building of technical staff.

4.3 Outlook

Currently, several types of clinical toxicology analyses can be carried out at SAET, but they must be improved and reinforced (**Tables C1** and **C2**). To do this, we plan to:

- continue the development of analytical toxicology through the implementation of new methods and parameters analytically,
- continue and strengthen technical collaboration with the CTQ, United Nations Office on Drugs and Crimes (UNODC), and
- advocate with TFPs for technical capacity building support.

The establishment of a PCC and the development of a national toxicological biomonitoring strategy will greatly contribute to strengthening the activities of the CTL [45].

5. Conclusion

The increasing and uncontrolled use of chemicals (pesticides, mercury, cyanide, illicit drugs, adulterated alcohols, etc.) in Burkina Faso, in various sectors of activity, has always been a major health concern, with many risks of exposure to dangerous substances. Unfortunately, the health system of Burkina Faso presented a rare availability, if not difficult accessibility, to clinical toxicological analyses for monitoring the exposure of the population or for a better management in case of intoxications.

But, since 2015, with the creation of the SAET, which has a clinical toxicology laboratory, the health system has been strengthened by performing certain clinical toxicology analyses locally. The performance of these analyses has enabled the Ministry of Health to deal with certain toxicological health situations.

Today, the CTL contributes to the diagnosis, screening and therapeutic monitoring of patients in health facilities. It is therefore a valuable solution for doctors in the management of intoxications. It is also involved in the monitoring of populations exposed in their working or living environments [46]. Today, the SAET is involved in all health incidents with toxicological suspicions and provides its expertise in investigations.

Beyond the health field, the SAET makes an enormous contribution to the forensic, regulatory and judicial fields by analyzing suspect samples in cases (attempted poisoning, autopsies, product counterfeiting, fraud, etc.) [47–51].

The SAET initiative now has an impact on health security at several levels:

- At the socioeconomic level, the SAET's expert assessments make it possible to better identify risk areas and take appropriate preventive measures (awareness and training) for the benefit of the population. As a result, the number of cases of acute poisoning is reduced, as well as the number of victims. Healthy people are much more productive and the Ministry of Health (State) saves money by reducing the number of emergency interventions, which are extremely costly.

- From an environmental point of view, the knowledge of the circumstances in which poisoning occurs and of the products involved has made it possible to take measures to protect and preserve the environment and the quality of life.

- In terms of health safety and public health, the SAET data provide an overview of toxicological risk management in Burkina Faso, reliable real-time data on poisonings and a greater capacity for anticipation on the part of health services in the face of toxicological emergencies. We also note the strengthening of controls on consumer products, the prohibition or withdrawal of adulterated products, etc.

- On the scientific front, the sharing or dissemination of SAET data through scientific productions (congresses, articles and others) contributes to the improvement of health safety in Burkina Faso and worldwide.

However, this unit encounters difficulties most often of a technical nature, such as the lack of adequate equipment. This is why an advocacy program for obtaining the necessary support has been drawn up with the aim of submitting it to the various potential partners. The capacity building of this laboratory will further strengthen Burkina Faso's health system in particular, and thus contribute to improving health security in the world in general [2, 15].

Acknowledgements

I express my gratitude to the authorities of Burkina Faso, in particular to those of the Ministry of Health and the National Public Health Laboratory for the authorization to set up clinical toxicology analyses and for all the efforts made for the development of toxicological expertise in Burkina Faso.

I take the opportunity through this document to express my gratitude to the Canadian Government, particularly to the Department of Foreign Affairs, Trade and Development (DFATD), which fully funded my training in toxicological expertise at the CTQ, through the Canadian Francophonie Scholarship Program (CFSP) or PCBF. It was during this training that much of the project was designed.

Also, my greetings go to the managers of the PCBF at this time, specifically to Jeanne Ghallager, senior manager of the PCBF in Canada and to Mrs. NEBIE at the Canadian Embassy in Burkina Faso, who could be considered as coauthors of the design of the laboratory project.

I salute the authorities of the "Institut national de santé publique du Québec" and thank the entire team of the Center de Toxicologie Québec for the acceptance in their institution, the welcome and the sympathy.

I particularly thank all the staff of the toxicology laboratory for their professional cooperation and all the scientific lessons they gave me during this training.

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I particularly thank all the technical collaborators at SAET who have contributed and are still working to strengthen the technical offer related to clinical toxicology

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Conflict of interest

"The authors declare no conflict of interest."

Notes/thanks/other declarations

The following abbreviations, LNSP, SAET, DTCE/HP and STM, are kept as such in the document because they are established designations within the establishment and also adopted by technical and financial collaborators (reagent suppliers and other service providers). So, any translation would result in a distortion of their denomination.

It is essential to note that the "LNSP" has more recently become "ANSSEAT" (i.e., National Agency for Environmental, Food, Occupational and Health Product Safety). We have kept "LNSP" because it is under this name that the project was developed.

Annex

A. Documentary related to the toxicological situations in Burkina Faso

See **Tables A1–A3**.

Documentary references	Toxicological situations/risks and targets
Adama TOE (rapport): Approche méthodologique et conceptuelle d'évaluation de l'impact environnemental et social pour la construction de cinq magasins de stockage des pesticides dans la région du Sahel – Burkina Faso, 2013 (Revue Africaine de Santé et de Productions Animales, © 2013 E. I.S.M.V. de Dakar)	• Cases of poisoning among producers after application of the product in the cotton field • Risks of exposure to pesticides for: • producers (lack of compliance with safety and hygiene measures: nonuse of protective equipment, noncompliance with hygiene rules), • the rural population, • professionals in the phytosanitary industry, • the consumer of crop products, and • the environment.
Adama TOE. (rapport): Étude pilote des intoxications dues aux pesticides agricoles au Burkina Faso, 2010	
Adama TOE et coll: (rapport): Etude d'impact environnemental et social pour la construction d'un magasin de stockage de pesticides à Gorom-Gorom (province de l'Oudalan), 2010	
Alain P.K. Gomgnimbou (article): Usage des intrants chimiques dans un agrosystème tropical: diagnostic du risque de pollution environnementale dans la région cotonnière de l'est. du Burkina Faso, 2009 (Base volume 13 (2009) numéro 4)	
Baba OUATTARA (article): Effet des pesticides sur l'activité microbienne d'un sol ferrugineux tropical du Burkina Faso, 2010 (Cameroon Journal of Experimental Biology 2010 Vol. 06 N° 01, 11–20.)	
Moustapha OUÉDRAOGO: (article) Étude des facteurs de risques d'intoxications chez les utilisateurs de pesticides dans la région cotonnière de Fada N'Gourma au Burkina Faso; 2009	
Moustapha OUÉDRAOGO: Pesticides in Burkina Faso: Overview of the Situation in a Sahelian African Country, 2011(Pesticides in the Modern World-Pesticides Use and Management, Dr. Margarita Stoytcheva (Ed.), ISBN: 978-953-307-459-7, InTech	
NGANOAH Victoire Sylvie (mémoire): Étude des risques environnementaux et sanitaires liés à l'utilization des pesticides chimiques de synthèse dans la culture du coton à l'Ouest du Burkina Faso, 2009	
Richard OUEDRAOGO et al. 2014: Risk of workers exposure to pesticides during mixing/loading and supervision of the application in sugarcane cultivation in Burkina Faso, 2014 (*International Journal of Environmental Science and Toxicology* (ISSN: 2315-9927) Vol. 2(7) pp. 143-151, July, 2014)	

Table A1.
Documentary references related to the use of pesticides in agriculture.

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Documentary reference	Risks and targets
Aboubakar H. OUEDRAOGO (article): L'impact de l'exploitation artisanale de l'or (orpaillage) sur la santé et l'environnement, 2006	• Workers and residents of modern and artisanal mining sites are exposed to multiple health risks: ∘ exposure to mercury, cyanide, ∘ exposure to lead, cadmium, chromium, ... , and ∘ exposure to hydrocarbons • Environmental pollution
Dr Gountiéni Damien LANKOANDE 1 et Dr. David Maradan (rapport). Coût de l'inaction de la gestion des produits chimiques dans le secteur minier et agricole. Rapport final Ministère de l'Environnement et du Développement Durable (MEDD) Initiative Pauvreté Environnement (IPE). Juin 2013; page 48	
Edith SAWADOGO: L'impact de l'exploitation artisanale de l'or: cas du site de Fofora dans la province du Poni.2011	
Issaka DIALGA: Du boom minier au Burkina Faso: opportunité pour un développement durable ou risque de péril pour les générations futures? 2013	
MBALLO Boubacar (mémoire) impacts possibles des activités minières sur les ressources en eau en Afrique de l'ouest: cas des mines aurifères du Burkina Faso, 2012	
MINISTÈRE DE L'ENVIRONNEMENT ET DU CADRE DE VIE (rapport): contribution du Burkina Faso a l'étude sur le plomb et le cadmium, 2005	
MINISTERE DE L'ENVIRONNEMENT ET DU CADRE DE VIE: rapport de synthèse de l'atelier national de sensibilisation, d'information et d'éducation du public sur le mercure (hg) au Burkina Faso, Ouagadougou du 09 au 11 Novembre 2009	

Table A2.
Literature references relating to toxicological risks in mining.

Documentary references	Risks and targets
Aboubakar H. OUEDRAOGO (article): L'impact de l'exploitation artisanale de l'or (orpaillage) sur la santé et l'environnement, 2006	• Risk of acute poisoning, drug addiction and other diseases (hepatic, heart damage, cancer, etc.) for consumers within the population (rural population, in particular youth, gold washers)
Dr Gountiéni Damien LANKOANDE1 et Dr. David Maradan (rapport). Coût de l'inaction de la gestion des produits chimiques dans le secteur minier et agricole. Rapport final Ministère de l'Environnement et du Développement Durable (MEDD) Initiative Pauvreté Environnement (IPE). Juin 2013; page 48	
Edith SAWADOGO: L'impact de l'exploitation artisanale de l'or: cas du site de Fofora dans la province du Poni.2011	
Issaka DIALGA: Du boom minier au Burkina Faso: opportunité pour un développement durable ou risque de péril pour les générations futures? 2013	
MBALLO Boubacar (mémoire) impacts possibles des activités minières sur les ressources en eau en Afrique de l'ouest: cas des mines aurifères du Burkina Faso, 2012	
MINISTÈRE DE L'ENVIRONNEMENT ET DU CADRE DE VIE (rapport): contribution du Burkina Faso a l'étude sur le plomb et le cadmium, 2005	

Documentary references	Risks and targets
MINISTERE DE L'ENVIRONNEMENT ET DU CADRE DE VIE: rapport de synthèse de l'atelier national de sensibilisation, d'information et d'éducation du public sur le mercure (hg) au Burkina Faso, Ouagadougou du 09 au 11 Novembre 2009	

Table A3.
Documentary references relating to the consumption of psychoactive substances

B. Project budgeting

See **Table B1**.
NB:

- PTF: Canada, France, European Union (EU), WHO and UNEP
- Equity: Personal investments of the project initiator

Overall budget of the project: 1152776780 West African CFA francs (XOF francs)
See **Table B2**.
A. Project financing plan: Project budget by axis and by year
See **Table B3**.
B. Budget plan according to the two phases of the project
a. Budget for the first phase of the project
The budget for this phase covers the following points:

- Training course in toxicological analysis at the CTQ

Budget Section	Estimated amount (×1000)	Completion period	Potential sources of funding
Study trip/training course	24,698.6	Stage 1	PCBF (already funded)
Acquisition and fitting out of premises	65,256	Stage 1 + Stage 2	TFP
Laboratory equipment, materials and consumables	77,471.7	Stage 1	TFP
Equipment (FIMS, FAAS, GC/MS and LC/MS)	655,078.5	Stage 2	TFP
Reagents and reference standards	15,666.98	Stage 2	TFP
Pilot study: priority parameters	6195	Stage 1	TFP
Training (advanced courses)	51,200	Stage 1 + Stage 2	PCBFs and others
Functioning	252,610	Stage 2	TFP
Research and collaboration with TFPs	4600	Stage 1 + Stage 2	Equity
Total	**1,152,776.78**		

Table B1.
Budget summary: Summary of the overall budget for the implementation of the clinical technology laboratory (CTL).

Objective	Stock	Cost (XOF Francs x1000)
Create a toxicology unit	Design	—
	Internship in a toxicology laboratory	24,698,6
	Research and collaboration with TFPs	4600
	Pilot study: Determination and prioritization of toxicological analysis needs	6195
	Submission and validation of the project and with the authorities	—
	Organization/reorganization or modification of the organization chart.	—
Strengthen the capacities of the LNSP in toxicological analysis	Acquisition and development of premises	65,256
	Acquisition of equipment and materials, reagents	748,217,18
	Staff recruitment/remuneration/training.	129,900
	Training (advanced course)	51,200
Carry out toxicological analyses	Information from potential customers	62,910
	Identification and dosage of drugs and medicines in biological media	
	Dosage of metals in biological media	
	Identification and dosage of drugs in nonbiological media	
	Identification and dosage of environmental pollutants in biological media	
	Monitoring and evaluation	57,600
	Implementation of a quality assurance system: participation in inter-laboratory testing	2200
Total budget		**1,152,776,78**

Table B2.
Estimated overall budget: Provisional budget for the main actions.

AXIS	Year (in XOF francs, ×1000)					
	2011–2015	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Total per axis**
Axis 1	31,893.6	700	700	700	700	34,693.6
Axis 2	86,7852	132,035.98	239,975	389,777	18,800	867,373.18
Axis 3	16,400	44,477.5	67,277.5	55,277.5	67,277.5	250,710
Total per year	**135,078.8**	**177,213.48**	**307,952.5**	**445,754.5**	**86,777.5**	**1,152,776.78**

Table B3.
Project budget by axis and by year.

- Establishment of the laboratory (development of premises, part of the acquisition of equipment and materials, recruitment of staff).

See **Table B4**.

Budget section	Amount/Unit cost (x1000)	Quantity	Estimated amount	Potential sources of funding
Study trip/training course	24,698.6	1	24,698.6	PCBF (already funded)
Pilot study	6195	1	6195	PCBFs, other PTFs
Course development	12,800	1	12,800	
Acquisition and fitting out of premises	35,256	1	35,256	TFP
Acquisition of equipment	99085.2	1	99085.2	TFP
Functioning	18,300	1	18,300	
Research and collaboration with TFPs	1800	1	1800	Equity
Total			198,134 .8	

Table B4.
Budget for the first phase of the project.

b. Budget for the second phase of the project
The budget for phase 2 concerns the following points:

- Functioning
- Training (advanced course)
- Part of the acquisition of equipment
- Project monitoring and evaluation
- Implementation and monitoring of the quality system

See **Table B5**.

Budget Section	Amount/Unit cost (×1000)	Quantity	Estimated amount	Potential sources of funding
Advanced courses	12,800	3	38,400	PCBFs, other PTFs
Acquisition and fitting out of premises	30,000	1	30,000	TFP
Acquisition of equipment	633,465	1	633,465	TFP
Reagents and reference standards	15,666.98 _ _	1	15,666.98 _ _	TFP
Functioning	234,310	1	234,310	PTF and Laboratory
Collaboration with TFPs	700	4	2800	Equity
Total			954,641, 98	
TOTAL BUDGET (phase 1 + 2)			1,152,776.78 _ _	

Table B5.
Budget for the second phase of the project.

C. Assessment according to the strategic orientations

See **Tables C1** and **C2**.

Strategic axis	Shares	Status of implementation
AXIS 1: Creation of the toxicology laboratory	Project design	• Project designed ∘ Existence of the final project document with all the details ∘ Existence of technical collaboration with the CTQ
	Setting up the laboratory/ creation	• Official creation of the Medical Toxicology Service at the LNSP ∘ Existence of a creation order (Ref.: Order No. 2015/344/MS/CAB creating a medical toxicology department at the LNSP) ∘ Staff and premises assigned to the service
AXIS 2: Carrying out toxicological analyses	Research and collection of analytical samples	• Samples received from several structures ∘ Hospital structures ∘ Judicial police officers ∘ Others
	Realization of qualitative and quantitative analyses	• Analyses carried out • Search for PAS in blood, urine and others • Screening for pesticides in blood, urine and others • Dosage of metals in blood and urine not yet effective
AXIS 3: Increase in performance and search for recognition	Implementation of an appropriate quality assurance program	• Quality system in place • Standard adopted: ISO 9001:2105 and ISO 17025:2017 • Participation in UNODC interlaboratory tests
	Accreditation search for the main analytical parameters: drugs, metals, pesticides.	• Unrealized

Table C1.
Assessment of the implementation of strategic actions.

Analytical technique	Device identified	Analytes identified	Analytical situation
Immunochemistry	RSS II (+RDT drugs)	Drugs, medicines	Feasible
	Immunochemical automaton	Drugs, medicines	Feasible
Atomic absorption	CV-AAS: **FIMS 100**	Mercury	**Not yet feasible**
	GF-AAS AAnalyst 600	Metals	Not yet feasible
Chromatography	GC-MS	Drugs, medicines, and pesticides	Feasible
	GC-FID	Alcohol	Feasible
	HPLC-DAD	Drugs, medicines, and pesticides	Feasible

Table C2.
Technical offers relating to clinical toxicology currently available at the Toxicological Analysis and Expertise Service (SAET).

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