

# Global Veterinary Diagnostic Laboratory Equipment Management and Sustainability and Implications for Pandemic Preparedness Priorities<sup>1</sup>

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Substantial investments into laboratories, notably sophisticated equipment, have been made over time to detect emerging diseases close to their source. Diagnostic capacity has expanded as a result, but challenges have emerged. The Equipment Management and Sustainability Survey was sent to the Veterinary Services of 182 countries in mid-2019. We measured the status of forty types of laboratory equipment used in veterinary diagnostic laboratories. Of the 68,455 items reported from 227 laboratories in 136 countries, 22% (14,894/68,455) were improperly maintained, and 46% (29,957/65,490) were improperly calibrated. Notable differences were observed across World Bank income levels and regions, raising concerns about equipment reliability and the results they produce. Our results will advise partners and donors on how best to support low-resource veterinary laboratories to improve sustainability and fulfill their mandate toward pandemic prevention and preparedness, as well as encourage equipment manufacturers to spur innovation and develop more sustainable products that meet end-users' needs.

The COVID-19 pandemic has highlighted the need for laboratory diagnostics in identifying and characterizing new and emerging pathogens to avoid further spread (1). In addition to their role in disease surveillance, laboratories store hazardous pathogens, creating biosafety and biosecurity risks (2). Naturally occurring disease outbreaks, laboratory accidents

(3–6), and deliberate releases of pathogens (7,8) can have severe health (9) and economic impacts (10) and can greatly disrupt progress toward United Nations Sustainable Development Goals (11).

Before the COVID-19 pandemic, there was evidence that many laboratories across sectors faced challenges to their operations and ultimately their sustainability (12), such as lack of access to equipment service providers, continuing education for staff, unreliable utilities, and overengineered and poorly adapted infrastructure, to name a few; those shortcomings represent a major challenge for health services worldwide (13). The World Organisation for Animal Health (WOAH) Ad Hoc Group on Sustainable Laboratories defines a sustainable laboratory network as one that can continuously deliver specialized services in a manner which is efficient, timely, accurate, consistent, secure, and safe; is in line with international standards and best practices; is provided at an acceptable cost; responds to clients' needs across sectors (public or private); and benefits One Health goals and the overall One Health system (14).

The inability to maintain or improve laboratory performance to leverage investments made by national governments and donors undermines the safety, quality, and security of laboratory activities (15). Through its laboratory capacity building and advocacy efforts, WOAHA aims to understand and address its member countries' challenges to sustainability to reduce the risk for biologic escape from veterinary diagnostic laboratories.

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We present the results of the WOAHA Equipment Management and Sustainability Survey (EMSS) to assess the status of laboratory equipment maintenance, calibration, and repair in veterinary diagnostic laboratories globally. The EMSS sought to quantify the proportion of veterinary diagnostic laboratory equipment that was not properly maintained or calibrated, out of service, and obsolete, as well as access to in-house and local maintenance services and donation of laboratory equipment. Results will enable stakeholders to better understand equipment-related challenges and to inform capacity-building practices, especially in the context of the Pandemic Treaty negotiations and Pandemic Fund investments.

## Methods

The EMSS was distributed to National Focal Points for Veterinary Laboratories and Delegates of all 182 WOAHA Member Countries on a rolling basis during May–August 2019. Nearly 500 questions were asked, and data were collected by using online (SurveyMonkey.com) and offline (Microsoft Excel, <https://www.microsoft.com>) forms in English, Russian, French, and Spanish. The EMSS targeted central veterinary laboratories, defined as the most advanced veterinary laboratory in a country, the national reference laboratory of  $\geq 1$  diseases, often in the administrative capital. Participation was enabled for several national reference veterinary laboratories and other interested veterinary diagnostic laboratories in any country, and the laboratory network level was measured.

We used common reference data and strata (Table 1): World Bank country classifications by income level (which measure gross national income into high, upper middle, lower middle, and low income) (16) and WOAHA Regional Commission Membership (Africa, Americas, Asia Pacific, Europe, and Middle East) (17).

For the survey, maintenance was defined as actions carried out on a specified schedule, involving functional checks and servicing, and replacement of consumables. Calibration was defined as precise adjustments made to laboratory equipment to ensure accurate measurement for a particular function and to establish the metrological traceability of the reported results.

Results are based solely on self-reporting. Although equipment inventories were not directly accessed, a list of 40 common types of veterinary laboratory equipment was used, focusing on critical items for basic and essential veterinary laboratory analysis. Infrastructure and premises status were not included in the survey. We provide the original survey (Appendix, <https://wwwnc.cdc.gov/EID/article/29/4/22-0778-App1>.

pdf); full dashboards and detailed figures for all data reported are available on the WOAHA website (<https://www.woaha.org/en/what-we-offer/emergency-and-resilience/sustainable-laboratories/laboratory-equipment-management-and-sustainability>).

## Results

### Responses

Of 182 WOAHA member countries, 136 (75%) countries were represented, and detailed data were received from 223 veterinary laboratories from all 5 WOAHA regions. The largest proportions of represented countries (30%, 41/136) and participating laboratories (45%, 101/223) were in Europe. Most responses were from central veterinary laboratories (58%, 129/223). The proportion of nonresponse was relatively consistent across regions (range 23%–36%) and World Bank income levels (range 24%–42%).

### Overall Equipment Reported

Laboratories reported 68,455 items. Of those items, monochannel and multichannel pipettes (44.5%, 30,528/68,455) were the most frequent, followed by incubators (7.5%, 5,155/68,455), refrigerators (7%, 4,823/68,455), agitators (6.8%, 4,671/68,455), freezers (5.8%, 3,994/68,455), centrifuges (4.5%, 3,076/68,455), and biosafety cabinets (4.3%, 2,965/68,455). Most (74.6%, 51,047/68,455) items were in high-income countries. Europe reported 65.4% (44,747/68,455) of total equipment reported. Most equipment reported (76.5%, 52,355/68,455) was at the central level. Equipment inventory reviews were performed at least annually by 88.8% (190/214) of laboratories. Given that some equipment does not require calibration, those items were removed from the denominator for all calibration measurements.

### Equipment Maintenance and Calibration

Overall, 21.8% (14,894/68,455) of equipment was not properly maintained, and 45.7% (29,957/65,490) was not properly calibrated. Regional differences were observed in improperly maintained equipment (Figure 1). High-income countries reported the largest amount of equipment and the lowest proportion of improperly maintained (15.8%, 8,044/51,047) and calibrated (38.4%, 19,607/51,047) equipment (Figure 2). However, an inverse trend was observed in the lowest-income countries. Laboratories in low-income countries had the smallest amount of equipment (1,512) but had the highest proportions reported as improperly maintained (74.1%, 1,120/1,512) and calibrated (80.5%, 1,157/1,438).

Noncompliance with maintenance protocols based on self-report for different types of equipment ranged from 14.1% (pipettes, 4,296/30,528) to 42.9% (roller systems, 27/63) (Table 2). Given that pipettes represented 44.6% (30,528/68,455) of equipment reported and could bias overall results, when they were excluded from the analysis, the proportion of equipment that was improperly maintained (21.8% [14,894/68,455]) increased to 27.9% (10,598/37,927). Similarly, the proportion of equipment that was improperly calibrated (45.7% [29,957/65,490]) increased to 48.1% (16,825/34,962).

Calibration was reported as a larger problem than improper maintenance. Although the lowest levels of improper calibration were in Europe, there was a range of noncompliance with calibration protocols within that region, from 25.2% (real-time PCR, 152/603) to 54% (centrifuges, 1,660/3,076) (Table 3) across different types of equipment.

### Equipment Service Providers

Results from the EMSS indicated that the main reported barriers to maintenance were expensive services, insufficient budget allocation, and no local (i.e., within one's country) service providers available. Globally, competencies to maintain and calibrate existed in-house for 18% of each type of equipment and locally

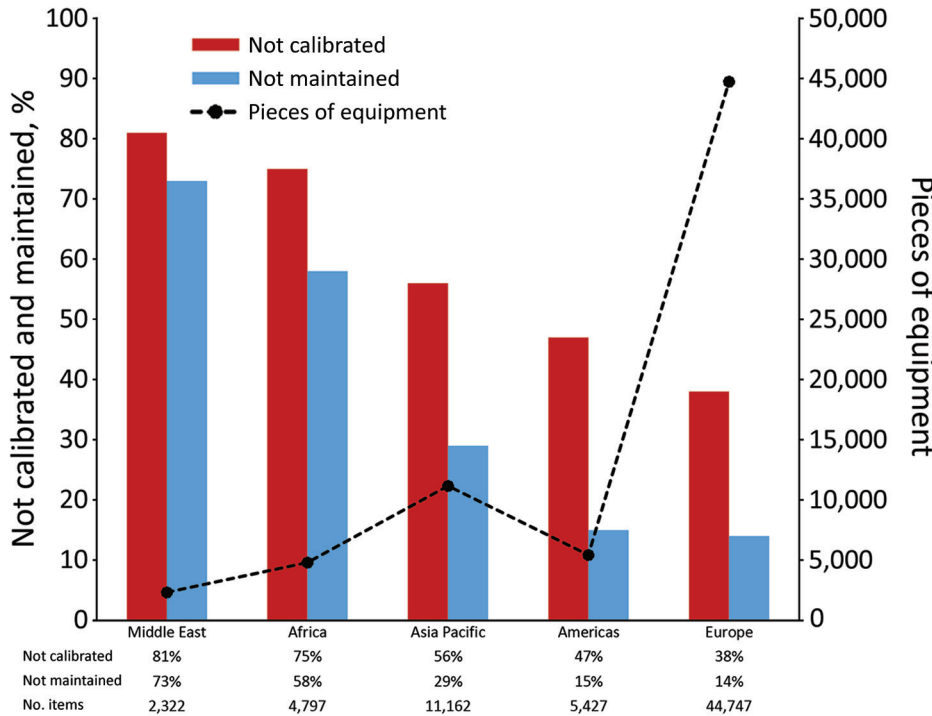
for 74%. In Africa, competencies to maintain and calibrate existed in-house for only 10% of equipment and locally for 47% of equipment (Figures 3, 4). The largest proportion of in-house expertise (27%) and the smallest proportion of local service providers (51%) was in low-income countries and did not translate to higher maintenance and calibration compliance levels. A total of 69% of laboratories were satisfied with local service providers, compared with 58% with external (e.g., outside of a country) service providers.

### Out-of-Service and Malfunctioning Equipment

Globally and for all equipment combined, 10.8% (7,394/68,455) was out of service. Laboratories in low- and lower-middle income countries reported that 25.8% (390/1,512) were out of service, compared with 15.5% (1,536/9,939) of upper-middle income countries and 7.6% (3,905/51,047) of high-income countries. Pipettes represented the largest proportion of out-of-service equipment. However, when they were removed from the dataset, the global out-of-service rate increased to 14.4% (5,479/37,927), suggesting that pipettes are in a slightly better condition than other equipment. Globally, the top 3 reported causes of malfunction were overuse, software, and electricity problems, such as voltage incompatibility (i.e., 120V to 220V), power surges, inconsistent electricity, and

**Table 1.** Definitions of terms used in Equipment Management and Sustainability Survey conducted by World Organisation for Animal Health, 2019

| Term   | Definition  |
|--|---|
| Donated equipment                            | Equipment that was given by a partner for an unlimited amount of time and belongs to the beneficiary laboratory   |
| Equipment                                    | Critical laboratory tools and machines for basic and essential veterinary laboratory diagnosis and analysis   |
| External service provider                    | A service provider outside a country  |
| High-income country                          | >12,535 Gross National Income per capita in United States Dollars 2020, as defined by World Bank Income Level Index   |
| Improperly/not properly calibrated equipment | Equipment to which precise adjustments have not been made to ensure accurate measurement for a particular function and to establish the metrological traceability of the reported results |
| Improperly/not properly maintained equipment | Equipment for which preventive maintenance has not been conducted in accordance with a specified time schedule, involving functional checks and servicing, and replacement of consumables |
| In-house service provision                   | Equipment maintenance and calibration tasks assigned to and conducted by existing laboratory employees  |
| Local service provider                       | A service provider within a country   |
| Low-income country                           | <1,035 Gross National Income per capita in United States Dollars 2020, as defined by World Bank Income Level Index  |
| Lower-middle-income country                  | 1,035–4,045 Gross National Income per capita in United States Dollars 2020, as defined by World Bank Income Level Index   |
| Malfunctioning                               | Equipment that is not working properly, which might require maintenance, repair, or calibration   |
| Out-of-service equipment                     | Equipment that is not being used because it is not working properly   |
| Repair                                       | Corrective maintenance performed after failure or detection of a fault, to restore equipment to working order, including repairing or replacing parts of the equipment                    |
| Upper-middle-income country                  | 4,045–12,535 Gross National Income per capita in United States Dollars 2020, as defined by World Bank Income Level Index  |
| World Organisation for Animal Health regions | Africa, Asia Pacific, Europe, Middle East, Americas, as defined by the World Organisation for Animal Health   |



**Figure 1.** Reported laboratory equipment and proportion not properly calibrated or maintained, by World Health Organization region, for Equipment Management and Sustainability Survey conducted by World Organisation for Animal Health, 2019.

subsequent wear on electrical components. However, in Africa, the leading causes of malfunction reported were delayed maintenance, electricity problems, and overuse. The 3 most frequent ways that obsolete, damaged, or outdated equipment was managed were labeled out-of-service, placed in storage, and isolated in the laboratory without labeling.

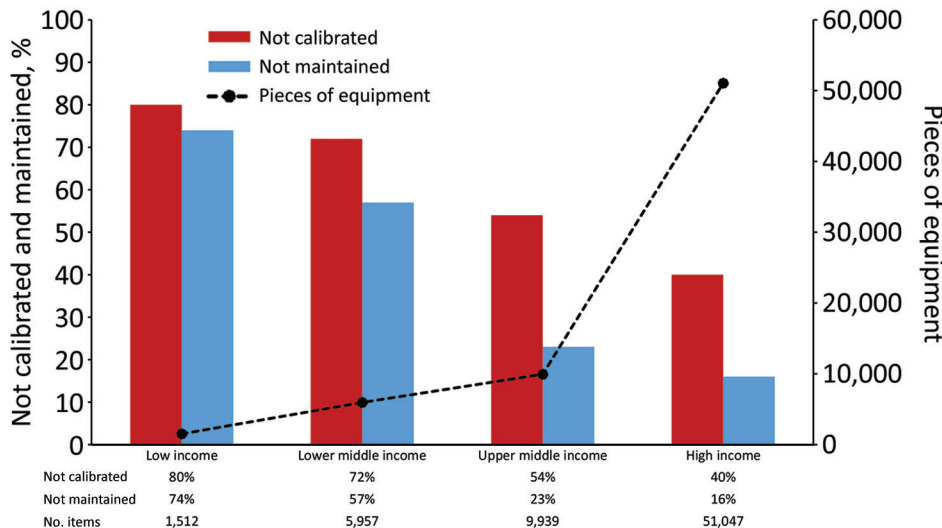
countries estimated on average that 57% were donated, followed by lower-middle (38%), upper-middle (22%), and high (1%) income countries (Figure 5). The percentage of reported estimated donated equipment varied by region, with Africa the highest (45%), followed by the Americas (42%), Middle East (28%), Asia (20%), and Europe (14%) (Figure 6).

**Donated Equipment**

Globally, 48.8% (105/215) of laboratories reported donated equipment in their laboratory and estimated on average that 30% was donated. Low-income

**Discussion**

The EMSS results describe the status of equipment in veterinary diagnostic laboratories globally and highlight the difficulties relating to the sustainability of



**Figure 2.** Reported laboratory equipment and proportion not properly calibrated or maintained, by World Bank income level, for Equipment Management and Sustainability Survey conducted by World Organisation for Animal Health, 2019.

**Table 2.** Reported equipment not properly maintained by equipment category for Equipment Management and Sustainability Survey conducted by World Organisation for Animal Health, 2019\*

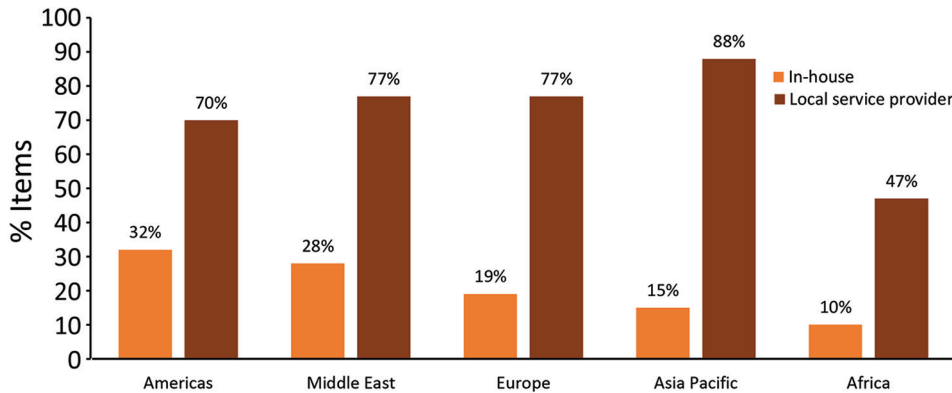
| Laboratory equipment                  | Africa | Americas | Asia Pacific | Europe | Middle East | Global |
|---------------------------------------|--------|----------|--------------|--------|-------------|--------|
| Roller system                         | 85%    | 50%      | 20%          | 34%    | 0%          | 43%    |
| Distillator                           | 66%    | 23%      | 36%          | 29%    | 66%         | 41%    |
| BSC class II A1                       | 74%    | 31%      | 40%          | 26%    | 83%         | 40%    |
| Magnetic agitator                     | 66%    | 9%       | 29%          | 47%    | 61%         | 39%    |
| Water bath                            | 62%    | 23%      | 29%          | 36%    | 87%         | 39%    |
| Microtome                             | 71%    | 19%      | 36%          | 23%    | 89%         | 38%    |
| Trichinoscope                         | 67%    | 100%     | 21%          | 37%    | 50%         | 35%    |
| Vortex                                | 58%    | 11%      | 32%          | 33%    | 88%         | 35%    |
| Autoclave                             | 63%    | 16%      | 36%          | 24%    | 61%         | 34%    |
| Gas incubator                         | 54%    | 74%      | 25%          | 14%    | 54%         | 34%    |
| Microplate reader                     | 60%    | 14%      | 37%          | 26%    | 70%         | 34%    |
| Dark-field microscope                 | 73%    | 8%       | 38%          | 24%    | 50%         | 33%    |
| Mixer jar                             | 69%    | 38%      | 22%          | 28%    | 67%         | 31%    |
| Oven                                  | 53%    | 17%      | 37%          | 14%    | 83%         | 31%    |
| Colony counter                        | 52%    | 29%      | 34%          | 19%    | 100%        | 30%    |
| Ovoscope                              | 100%   | 38%      | 37%          | 13%    | 100%        | 30%    |
| Freezer                               | 66%    | 4%       | 23%          | 25%    | 75%         | 29%    |
| pH meter                              | 83%    | 20%      | 26%          | 16%    | 58%         | 29%    |
| Gel documentation                     | 52%    | 21%      | 29%          | 24%    | 57%         | 28%    |
| Refrigerator                          | 59%    | 13%      | 31%          | 21%    | 64%         | 28%    |
| Shaker                                | 65%    | 14%      | 21%          | 26%    | 57%         | 28%    |
| Spectrophotometer                     | 51%    | 24%      | 19%          | 26%    | 58%         | 28%    |
| Vacuum pump                           | 70%    | 13%      | 32%          | 20%    | 58%         | 28%    |
| Fluorescent microscope                | 47%    | 21%      | 26%          | 19%    | 67%         | 26%    |
| Fume hood                             | 44%    | 29%      | 43%          | 16%    | 92%         | 25%    |
| Microplate washer                     | 70%    | 13%      | 22%          | 17%    | 72%         | 25%    |
| Water filtration                      | 71%    | 24%      | 33%          | 11%    | 55%         | 25%    |
| Centrifuge                            | 54%    | 14%      | 35%          | 12%    | 66%         | 24%    |
| Plate shaker                          | 52%    | 11%      | 31%          | 12%    | 78%         | 24%    |
| Real-time PCR                         | 33%    | 19%      | 29%          | 16%    | 75%         | 24%    |
| Inverted light microscope             | 61%    | 9%       | 33%          | 16%    | 71%         | 23%    |
| Microscope                            | 53%    | 17%      | 22%          | 13%    | 76%         | 23%    |
| Incubator                             | 45%    | 15%      | 31%          | 16%    | 61%         | 22%    |
| Conductometer                         | 67%    | 13%      | 25%          | 10%    | 56%         | 21%    |
| Transilluminator                      | 65%    | 9%       | 29%          | 13%    | 56%         | 21%    |
| Thermal cycler                        | 64%    | 12%      | 20%          | 12%    | 55%         | 19%    |
| Biological safety cabinet class II A2 | 41%    | 40%      | 25%          | 8%     | 88%         | 18%    |
| Biological safety cabinet class I     | 57%    | 31%      | 57%          | 6%     | 67%         | 17%    |
| Electrophoresis                       | 49%    | 6%       | 28%          | 8%     | 36%         | 15%    |
| Pipette                               | 57%    | 8%       | 26%          | 8%     | 77%         | 14%    |

these laboratory networks (Table 4). We expect the results represent the tip of the iceberg in the veterinary laboratory sector. Although we are aware of no equivalent study in human health or clinical laboratory settings, equipment-related challenges, such as limited local capacity and capability and sustainable resourcing, are common to both sectors (12,19–23).

Estimates suggest that ≈40% of medical equipment in the hospital setting in developing countries remains out of service, predominantly because of a lack of infrastructure, training, and maintenance (24–27). Given the smaller number of veterinary laboratories compared with human health laboratories, we expect that the equipment management and sustainability

**Table 3.** Reported equipment not properly calibrated by equipment category for Equipment Management and Sustainability Survey conducted by World Organisation for Animal Health, 2019

| Laboratory equipment | Africa | Americas | Asia Pacific | Europe | Middle East | Global |
|----------------------|--------|----------|--------------|--------|-------------|--------|
| Centrifuge           | 73%    | 66%      | 79%          | 37%    | 79%         | 54%    |
| Fume hood            | 76%    | 59%      | 63%          | 39%    | 92%         | 49%    |
| Spectrophotometer    | 70%    | 59%      | 81%          | 29%    | 75%         | 48%    |
| Pipette              | 69%    | 13%      | 39%          | 44%    | 80%         | 43%    |
| pH meter             | 82%    | 78%      | 59%          | 14%    | 50%         | 42%    |
| Microplate reader    | 76%    | 40%      | 51%          | 22%    | 80%         | 41%    |
| Autoclave            | 77%    | 36%      | 62%          | 14%    | 77%         | 40%    |
| Conductometer        | 67%    | 50%      | 33%          | 12%    | 67%         | 28%    |
| Thermal cycler       | 77%    | 39%      | 35%          | 12%    | 70%         | 28%    |
| Real-time PCR        | 52%    | 44%      | 33%          | 12%    | 64%         | 25%    |



**Figure 3.** Reported availability of in-house and local service providers for laboratory equipment, by World Organisation for Animal Health region, for Equipment Management and Sustainability Survey conducted by World Organisation for Animal Health, 2019.

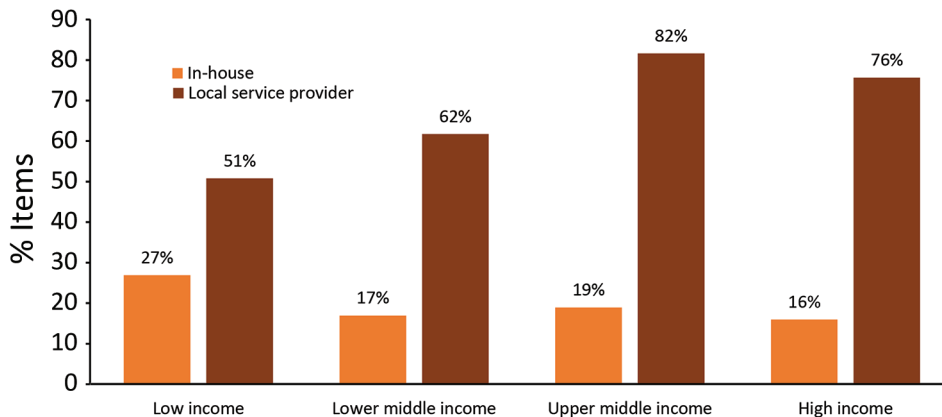
challenges in human health laboratories are likely more pronounced.

The study results provide compelling evidence to formulate strategies toward building and sustaining veterinary laboratory capacity over time. Those strategies include long-term planning; balancing investments from capital to operating expenses; balancing proportions of investments across internal, external, and revenue sources; and setting priorities to maintain strengthened infrastructure and capability, especially in low-resource settings. Given the prevalence of donated equipment, the undesirable proportions of equipment in poor condition, and the uneven access to local service providers in the veterinary laboratory setting, this study has demonstrated that laboratory equipment has become a consumable commodity that can be readily replaced by partners when large (or small) equipment management challenges are encountered, instead of valuable and valued capital investments to be leveraged over time by national authorities and partners.

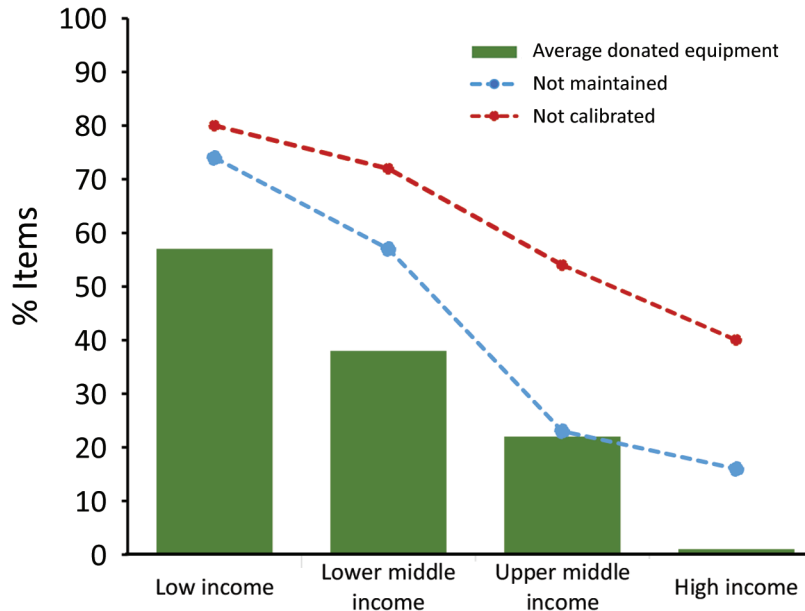
Therefore, creative solutions are required to deal with equipment, consumables, waste, and compliance, which might involve public-private partnerships, cost-sharing arrangements, and other innovative

approaches (28). Proposed actions address equipment management challenges at the laboratory level (Table 5) and key implications for capacity-building policy and practice (Table 6).

The lowest income countries have the least amount of equipment, but they have the most difficulty properly maintaining and calibrating increasingly complex equipment. Improving availability and access to local service providers is an opportunity to address this long-lasting and pervasive problem. Higher satisfaction reported in the EMSS with local service providers suggests an opportunity to develop this market without sacrificing quality. This development could be addressed through public-private partnerships in which local businesses and expertise are supported through subsidies, incentives, or agreements to encourage the development of local service provision and not just in-house expertise, which is affected by staff attrition and brain drain. Demand for those services across the health laboratory sector is large, in animal health, human health, clinical, environmental or food safety laboratories, and should be consolidated to support local service providers. To support that strategy, One Health investment from the national government and private sector will be required.



**Figure 4.** Reported availability of in-house and local service providers for laboratory equipment, by World Bank income level, for Equipment Management and Sustainability Survey conducted by World Organisation for Animal Health, 2019.



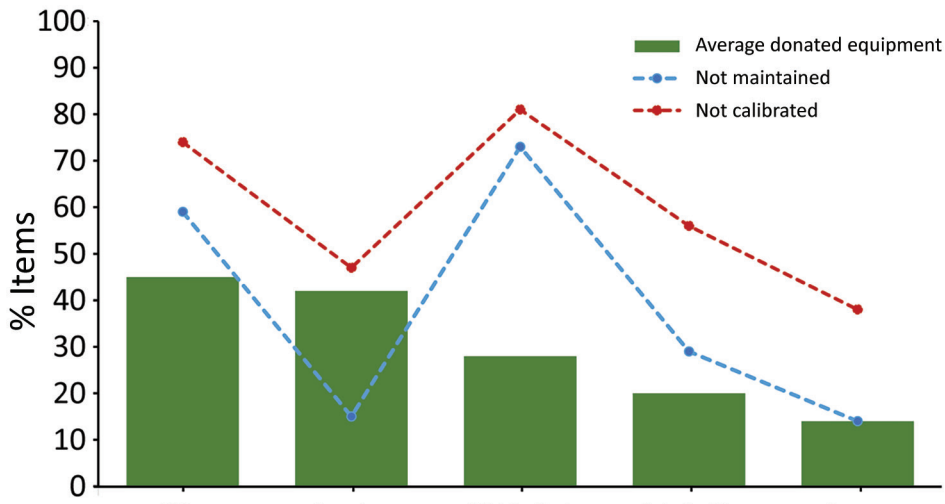
**Figure 5.** Reported estimated proportion of donated equipment and proportion not properly maintained or calibrated, by World Bank income level, for Equipment Management and Sustainability Survey conducted by World Organisation for Animal Health, 2019.

|                 |     |     |     |     |     |
|-----------------|-----|-----|-----|-----|-----|
| Average donated | 45% | 57% | 38% | 22% | 1%  |
| Not maintained  | 59% | 74% | 57% | 23% | 16% |
| Not calibrated  | 74% | 80% | 72% | 54% | 40% |

Developing local capacity, as in the case of biosafety cabinet certification in Southeast Asia (29), is the ideal option and is the target of many development efforts, but it has been challenging to sustain locally because it is too often reliant on external donor funding, lacking sustainable domestic financing. Developing in-house and local capacity is adversely affected by brain drain because skills are attractive and in demand across sectors. However, given the

risks of emerging disease outbreaks and pandemics, as demonstrated by COVID-19, governments' investment in this resource is critical to ensuring that laboratory systems are sustainably resourced, prepared, and equipped to face future challenges (1).

Accreditation of quality management systems (QMS), with a focus on the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) 17025:2017 (<https://www.>



**Figure 6.** Reported estimated proportion of donated equipment and proportion not properly maintained or calibrated equipment, by World Organisation for Animal Health region, for Equipment Management and Sustainability Survey conducted by World Organisation for Animal Health, 2019.

|                 |     |     |     |     |     |
|-----------------|-----|-----|-----|-----|-----|
| Average donated | 45% | 42% | 28% | 20% | 14% |
| Not maintained  | 59% | 15% | 73% | 29% | 14% |
| Not calibrated  | 74% | 47% | 81% | 56% | 38% |

**Table 4.** Key results from the Equipment Management and Sustainability Survey conducted by WOA, 2019\*

| Results   |
|---|
| <ul style="list-style-type: none"> <li>• A total of 136 (75%) of 182 WOA Member Countries responded; detailed data were received from 223 veterinary laboratories in all 5 WOA Regions,</li> <li>• A total of 68,455 items of laboratory equipment were reported with an approximate value of 264.4 million €.</li> <li>• Globally, 22% of the equipment reported was not properly maintained, and 46% was not correctly calibrated.</li> <li>• Low-income countries had the smallest proportion of equipment but had the highest proportions of improperly maintained (74%) and calibrated (80%) equipment.</li> <li>• Globally, competencies to maintain and calibrate equipment existed in-house for 18% of equipment and within one's country for 74% of equipment. In Africa, competencies to maintain and calibrate equipment existed in-house for only 10% of equipment and within one's country for 47% of equipment.</li> <li>• Globally and for all laboratory equipment combined, 11% of equipment reported was out of service.</li> <li>• Low-income countries estimated that 57% of their equipment was donated, followed by lower-middle (38%), upper-middle (22%) and high (1%) income countries.</li> <li>• Full analysis available at <a href="https://www.woah.org/en/what-we-offer/emergency-and-resilience/sustainable-laboratories/laboratory-equipment-management-and-sustainability/">https://www.woah.org/en/what-we-offer/emergency-and-resilience/sustainable-laboratories/laboratory-equipment-management-and-sustainability/</a></li> </ul> |

\*WOAH, World Organisation for Animal Health.

iso.org/isoiec-27001-information-security.html) for testing and calibration laboratories, has become an ideal for veterinary laboratories worldwide (30). Laboratories in the human health sector have made great strides in achieving QMS accreditation to international standard ISO/IEC 15189:2012. Accreditation of a diagnostic laboratory requires 3 components: independent or third-party assessment; suitably validated tests performed by proficient laboratory operators in an adequately equipped laboratory; and ongoing internal and external quality control. Those components provide confidence in test outcomes and demonstrate competency and ability to produce technically valid diagnostic results that meet the needs of customers and decision-makers involved in health and surveillance programs (30). Incumbent on the success of

QMS in diagnostic laboratories is the ability to calibrate equipment to meet the requirements of the ISO/IEC standards, thus exacting an economic effect on low-income countries. Our results indicate a lack of local calibration expertise, insufficient resources to cover costs, and an unwillingness to implement QMS. Nevertheless, high rates of uncalibrated equipment, especially in limited resource settings, do not provide confidence in the laboratory results, calling into question the intrinsic value of the testing performed and the return on investment. Therefore, it is incumbent on international organizations, funding agencies, and national regulatory agencies to demand that all laboratories producing diagnostic results meet international QMS requirements.

Equipment donation provides critical support to

**Table 5.** Actions laboratories can take to address sustainability challenges through improved equipment maintenance and calibration for Equipment Management and Sustainability Survey conducted by World Organisation for Animal Health, 2019

| Action  |
|---|
| Prioritize the equipment used most, with a particular focus on equipment needed most in an emergency to detect emerging diseases, such as African swine fever, African horse sickness, avian influenza, and coronavirus disease |
| Check annual operating budgets for equipment maintenance and calibration resources  |
| Plan how to mobilize resources  |
| Act to mobilize resources   |
| Make/update list of calibration and maintenance service providers by equipment type, ready for an emergency   |
| Offer calibration or preventive and corrective maintenance services to neighboring laboratories, if capacity exists   |
| Train neighboring laboratories to conduct calibration or preventive and corrective maintenance, if capacity exists  |
| Perform preventative maintenance on prioritized equipment without delay.  |
| Plan the next check of prioritized equipment, and then do it on a regular basis   |
| Train staff on proper preventative maintenance of prioritized equipment   |
| Cultivate relationships with service providers  |
| Have prioritized equipment calibrated without delay   |
| Plan the next calibration verification of prioritized equipment, and then do it on a regular basis  |
| Train staff to calibrate simpler prioritized equipment  |
| Cultivate relationships with service providers  |
| Have prioritized equipment repaired without delay   |
| Plan the next check and calibration of prioritized equipment, and then do it on a regular basis   |
| Train staff to do simple repair of prioritized equipment  |
| Cultivate relationships with service providers  |
| Perform equipment inventory review without delay  |
| Plan the next equipment inventory and act to conduct on a regular schedule  |



**Table 6.** Key findings and implications on capacity building policy and practices affecting sustainability for Equipment Management and Sustainability Survey conducted by World Organisation for Animal Health, 2019**Findings**

- Laboratory equipment has become a consumable commodity that can be readily replaced by partners in case of management challenges, instead of valuable and valued capital investments to be leveraged over time by national authorities.
- Laboratory equipment management is a One Health, cross-sectional, and cross-sectoral issue, often affected by a lack of coordination and overinvestment in capital resources like equipment in the laboratory sector.
- No equivalent study has been performed in public health or clinical laboratory settings, but equipment-related challenges, like limited local capacity and sustainable resourcing, are common to all health laboratories.
- High rates of uncalibrated equipment do not provide confidence in laboratory results, calling into question the intrinsic value of the testing performed and the return on investment.
- Poor equipment maintenance and calibration threaten safety, security, business continuity, quality, accuracy, and timeliness of results, with a measurable impact on human health, animal health, and environmental health, and, therefore, people's livelihoods and economies.
- The proliferation of high-containment laboratories in locations where specialized equipment and infrastructure services are difficult or impossible to access has meant that donation recipients neither have the financial nor human capital to maintain the laboratory and its equipment, leading to inevitable engineering failures and increasing the potential for inadvertent laboratory releases of dangerous pathogens.
- New strategies are needed to sustain capacity built, including long-term planning, balancing investments from capital to operating expenses, and setting priorities to maintain strengthened infrastructure and capability, especially in low-resource settings, which may involve public-private partnerships, where local business and expertise are supported through subsidies, incentives, or agreements to encourage the development of local service provision and not just on in-house expertise.
- Partners of health laboratories must agree on more rigorous, evidence-based, best practices and standards.
- Demand for maintenance and calibration services across the health laboratory sector is large and should be consolidated to support local service providers by cost sharing and bulk ordering.
- Investment from the national government and private sector will be required in the One Health context.
- The waste of precious resources should be met with innovative and pragmatic solutions that focus on getting back to management basics, rational supply and demand thinking, and building coherent systems that are appropriately sized and fit for purpose.
- Given that challenges encountered in veterinary laboratories are described and agreed to be similar in public health laboratory settings, action aiming toward sustainable health laboratory systems in the One Health space to improve pandemic preparedness is needed.
- Organizations that invest in laboratory capacity building or strengthening may hold similar, although unexploited, data and could provide precise and robust measurements along these same metrics across health sectors.

laboratories in low-resource settings. Unfortunately, the issue of donated equipment is fraught with good intentions. Donated equipment requires sufficient funds to ensure maintenance, calibration, repair, and replacement, but those funds are not usually built into national laboratory budgets. Partners often make decisions in isolation without proper consultation with the end users and national authorities (31). There is the potential, therefore, that the item does not meet the end users' needs or match their environmental realities. Furthermore, partners often purchase equipment without consideration of available local service provision and availability. In the event of failure, repair might not be locally available, making the item unusable when it might have been easily and cheaply repaired elsewhere. It is acknowledged by partners that most of these national laboratories rely on external aid to function and may be unsustainable (32).

Paradoxically, resources provided to low-income and middle-income countries in the decades before COVID-19 enabled laboratories in those countries to be better equipped than ever before to join the response to COVID-19. All laboratory-system partners should agree on more rigorous standards for evidence-based best practices for equipment dona-

tion. Guidelines have been developed by the World Health Organization in medical equipment donation (33); adaptation of these guidelines to the laboratory setting across sectors in a One Health approach is required and should be adopted by all partners. It is therefore necessary to learn from this study, examine gaps in capacity, and ensure that donors and international organizations avoid providing support on an individual or haphazard basis but do so in a coordinated manner that is ongoing, purposeful, and contiguous.

A perverted result of equipment donation to low-resource laboratories is the accumulation of malfunctioning and obsolete equipment in the laboratory itself. This study demonstrated that 96% of reported nonfunctional equipment was labeled out of service on the bench, put into laboratory storage, or isolated in the laboratory. This equipment therefore goes unused, is useless, and contributes to the electronic waste (or e-waste) disaster for human, animal, and environmental health, reaching 2.9 million tons in 2019 in the Africa Region, according to the Global E-waste Monitor 2020 (34). Laboratory e-waste has processed dangerous and infectious pathogens, thus adding increased safety and security risks. Efforts

to reduce waste of precious resources should be focused on innovative reselling, refurbishing, recycling, and repair schemes across laboratory sectors to reduce waste, creating a do-it-yourself culture of preventive and corrective maintenance by using social media, promoting electronics right-to-repair communities, and engaging manufacturers to support those initiatives.

In the context of the COVID-19 pandemic, veterinary laboratories played a critical role by providing surge capacity for the human health sector for diagnostic testing response (35,36). As found in the EMSS, in veterinary laboratories, 175 (11.6%) of 1,513 pieces of equipment for conventional and real-time PCR were out of service globally as of August 2019. That lost surge capacity is tangible, given the pressure on this technology during the COVID-19 pandemic. A post-pandemic follow-up study to determine the effect of lost capacity attributed to poorly maintained equipment would provide valuable insights. The pandemic has also created worldwide waves of shortages of critical supplies, parts, and materials needed to support complex machinery; the laboratory sector will continue to be adversely affected by those critical shortages.

Given the enormity of this global project and the requirements for providing in-depth data over a lengthy questionnaire, there is the potential for inaccuracy, including recall bias, nonresponse, and social acceptability. However, despite those limitations, a high response rate (75%) was recorded, and 79% of laboratories completed the full survey, demonstrating a high degree of stakeholder interest.

A total of 93% of respondents worked in laboratory settings at the time of the survey and therefore were best placed to respond accurately to the questionnaire. The response rate was similar across different groups (i.e., World Bank Income Level, WOA region), providing relative accuracy across strata. Despite the inherent limitations of a large-scale survey, the information received from the respondents was considered reliable. However, following up on the results of this questionnaire as standard practice for any laboratory capacity building project will be imperative to confirm the results, build on the knowledge base, and monitor progress.

Much can be learned about equipment management and sustainability from the EMSS about veterinary laboratories. Given that challenges encountered in veterinary laboratories are largely described as and agreed to be similar in human health laboratory settings, results should initiate much-needed research, discussions and action aiming toward sustainable laboratory systems in the One Health space

to improve pandemic preparedness across sectors. These results represent the first attempt on a global scale to determine the status of equipment in the public veterinary diagnostic laboratory setting. Furthermore, organizations that invest in laboratory capacity building or strengthening may hold similar, although unexploited, data and could provide precise and robust measurements along these same metrics across health sectors.

Veterinary laboratories attract investments from stakeholders, including security, human health, One Health, agriculture, trade, and development. Those stakeholders are interested in the best outcomes for laboratories and their smooth management. Laboratory equipment management is a One Health, cross-sectional, and cross-sectoral issue, often affected by a lack of coordination and overinvestment in capital resources such as equipment in the laboratory sector. Poor equipment maintenance and calibration threaten safety, security, business continuity, quality, accuracy, and timeliness of results, with a measurable effect on human health, animal health, and environmental health, and, therefore, on livelihoods and economies. The value of the global laboratory equipment and consumables market across all sectors is estimated at US \$30.6 billion in 2020 (37) which forces reflection on how to mitigate the challenges encountered by end users and countries who benefit from external investment at all levels and across all sectors.

Results from the EMSS will contribute to WOAH integrating key performance indicators for laboratory equipment into its capacity-building programs and strict limits on provision of equipment, with the expectation that its partners will follow suit when considering further donation and investment in laboratory capacity building. Additional partners should join the efforts of international organizations such as WOAH and the World Health Organization to sensitize key donors and to build consensus that equipment donation should be tied to an achievable installation, calibration, and maintenance plan with a secured, long-term budget commitment, by either the donor or preferably the recipient government.

The current global context has demonstrated that laboratory preparedness is essential and that regular laboratory equipment maintenance and calibration are critical. Veterinary laboratories played a crucial role in the COVID-19 pandemic, armed with their experience in combatting outbreaks among large populations (such as for highly pathogenic avian influenza), in providing expertise on disease origin and evolution, population medicine, scientific research on the susceptibility of animals, surge capacity for the

human health sector, and human antibody response to vaccination. We expect that our findings will inform national authorities to understand the challenges they face related to equipment management and to better plan to sustain investments made by resource partners; influence partners to reconsider investments in light of the sustainability challenges faced by national authorities and to design effective investments based on real needs of laboratories; and encourage manufacturers, researchers, innovators, and engineers in their efforts toward effective and more sustainable designs that are fit-for-purpose in low-resource settings.

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# Global Veterinary Diagnostic Laboratory Equipment Management and Sustainability and Implications for Pandemic Preparedness Priorities

## **Appendix**

The following pages show the WOAHA Equipment Management and Sustainability Survey that was used in 2019 to assess the status of laboratory equipment maintenance, calibration, and repair in veterinary diagnostic laboratories globally.

## Laboratory Equipment Status Questionnaire for Maintenance/Repair/Calibration - Part I

### Background

The main objective of the survey is to assess the status of laboratory equipment maintenance, repair, and calibration for the purposes of a policy paper on "Investment Needs for Sustainable Laboratories". The intention of that policy paper is to provide an evidence-base for investments in the good management of laboratories with a view to sustainable laboratory biosafety and biosecurity.

In addition to this paper, the OIE will enhance the PVS Sustainable Laboratories Tool recognizing that equipment maintenance, repair and calibration are critical components for sustainable laboratory biosafety and biosecurity. The paper will also explore how such investments could encourage local market development to respond to laboratory needs for sustainable laboratory biosafety and biosecurity to mitigate the security and health risks associated with a lack of sustainable resources for veterinary laboratories.

You are requested to collect information on laboratory equipment inventory and maintenance practices from the laboratory where you work. If you don't work in a laboratory, please send the questionnaire to be filled by the laboratory management of the public veterinary laboratories in your national network. Some questions should be answered about the whole national laboratory network in your country, while others should be answered about the laboratory where you work. The differences between these questions are clearly stated.

Unless otherwise stated, questions should be answered for 2018, or the most recent year for which you have information.

For any issues or for clarification, please contact the Sustainable Laboratories Team for support at [b.nyange@oie.int](mailto:b.nyange@oie.int).

Please complete the questionnaire by 17 May 2019.

### Definitions

These definitions are proposed for the purposes of this survey.

**Maintenance:** For the purposes of this survey, 'maintenance' refers to preventive maintenance which is carried out in accordance with a specified time schedule, involving functional checks and servicing, replacement of consumables, etc.

**Repair :** Corrective maintenance carried out after failure or detection of a fault, in order to restore equipment to working order, including repairing or replacing parts of the equipment

**Calibration:** Precise adjustments made to laboratory equipment to ensure accurate measurement for a particular function and to establish the metrological traceability of the reported results

**Malfunctioning:** Equipment not working properly, that may require maintenance, repair, or calibration  
**Local service provider:** A service provider within a country

**Local service provider:** A service provider within a country

**External service provider:** A service provider outside a country

**National laboratory network:** All laboratories working in the veterinary domain in a country; for the purposes of this survey, only public laboratories

**Central veterinary laboratory:** The most advanced laboratory in a country; in some cases, the national reference laboratory of one or more diseases, and often in the administrative capital of a country

**On loan equipment:** Equipment that is provided by a manufacturer, supplier, university, partner, or other organisation for a limited

Custom Data 1

### A. Respondent Identification

First Name

Last Name

|  |  |
|--|--|
| Country  |  |
| Are you the OIE National Laboratory Focal Point nominated by the OIE Delegate? |  |
| Job Title  |  |
| At which level is the veterinary laboratory where you work?                    |  |
| Other (please specify)   |  |

**B. National Laboratory Network**

*As a Focal Point, Information you provide in this section will allow us to understand the size of your country's national laboratory network.*

|   |  |
|---|--|
| How many public veterinary laboratories were operating in your national laboratory network in 2018?           |  |
| How many public veterinary laboratories are there at the central, federal, or national level in your country? |  |
| How many public veterinary laboratories are there at the provincial or state level in your country?           |  |
| How many public veterinary laboratories are there at the district or local level in your country?             |  |
| Are you currently working in a laboratory ?   |  |

*Some responses in the questionnaire should be provided by personnel working day-to-day on laboratory resource management and equipment inventory. If you are not currently working in a laboratory, please forward this excel file to laboratory directors of all public veterinary laboratories in your country so that they may complete the questionnaire. Please feel free to circulate to any and all laboratory management in your national veterinary laboratory network.*

|  |  |
|--|--|
| At which level is the veterinary laboratory where you work?        |  |
| Other (please specify)   |  |
| What types of testing/procedures are performed at your laboratory? |  |

**C. Equipment Inventory**

*Information you provide in this section will allow us to understand the inventory practices in your country's national laboratory network.*

|   |  |
|---|--|
| How often is the laboratory equipment inventory done per year in your laboratory? |  |
| Do you have "on loan" equipment in your laboratory?                               |  |
| What percentage of equipment in your laboratory is "on loan"?                     |  |
| Do you have donated equipment in your inventory?                                  |  |
| What percentage of equipment in your laboratory is donated?                       |  |

| <b>D. Barriers to service procurement for laboratory equipment maintenance</b>  |                          |
|---|--------------------------|
| <i>Information you provide in this section will inform on barriers to procurement of preventive maintenance, calibration, and repair services for laboratory equipment.</i> |                          |
| Please choose the <b>top 3 causes</b> of malfunctioning or not working equipment that need <b>repair</b> in your laboratory   |                          |
| Over usage of equipment   | <input type="checkbox"/> |
| Software/technology problems of the equipment   | <input type="checkbox"/> |
| Equipment not maintained according to schedule  | <input type="checkbox"/> |
| Power/electricity problems  | <input type="checkbox"/> |
| Improper usage of equipment   | <input type="checkbox"/> |
| Poorly trained personnel using the equipment causing it to break  | <input type="checkbox"/> |
| Physical accidents (dropped, water damage, etc)   | <input type="checkbox"/> |
| Staff don't know how to use, start, or operate  | <input type="checkbox"/> |
| Other   | <input type="checkbox"/> |
| Other (please specify)  |                          |
|   |                          |
| Please choose the <b>top 3 reasons</b> why you procure <b>maintenance</b> services for laboratory equipment?  |                          |
| The equipment show signs of malfunction, but is still working   | <input type="checkbox"/> |
| Preventive maintenance is required by law   | <input type="checkbox"/> |
| To keep accreditation/certification status  | <input type="checkbox"/> |
| Routine maintenance is scheduled according to time/date of last service   | <input type="checkbox"/> |
| High demand for analyses linked to particular equipment, so it is important that equipment works properly   | <input type="checkbox"/> |
| To satisfy clients and maintain revenue   | <input type="checkbox"/> |
| To ensure accurate results  | <input type="checkbox"/> |
| Planned/scheduled according to the SOP  | <input type="checkbox"/> |
| Planned/scheduled according to usage/number of analyses run   | <input type="checkbox"/> |
| Other   | <input type="checkbox"/> |
| Other (please specify)  |                          |
|   |                          |
| Please choose the <b>top 3 reasons</b> why you procure <b>calibration</b> services for laboratory equipment?  |                          |
| The equipment shows signs of malfunction, but is still working  | <input type="checkbox"/> |
| Calibration is required by law  | <input type="checkbox"/> |
| To keep accreditation/certification status  | <input type="checkbox"/> |
| Routine calibration is scheduled according to time/date of last service   | <input type="checkbox"/> |



|  |                          |
|--|--------------------------|
| High demand for analyses linked to particular equipment, so it is important that equipment works properly  | <input type="checkbox"/> |
| To satisfy clients and maintain revenue  | <input type="checkbox"/> |
| To ensure accurate results   | <input type="checkbox"/> |
| Planned/scheduled according to the SOP   | <input type="checkbox"/> |
| Planned/scheduled according to usage/number of analyses run  | <input type="checkbox"/> |
| Other  | <input type="checkbox"/> |
| Other (please specify)   |                          |
| Please choose the <b>top 3 barriers</b> you encounter to procuring <b>maintenance, repair, and calibration</b> services for your laboratory equipment.                     |                          |
| Services are too expensive   | <input type="checkbox"/> |
| There are no local service providers   | <input type="checkbox"/> |
| Insufficient budget allocated  | <input type="checkbox"/> |
| No in-house expertise  | <input type="checkbox"/> |
| Not prioritized in management activities   | <input type="checkbox"/> |
| Don't know which service providers to use  | <input type="checkbox"/> |
| Expertise is not available   | <input type="checkbox"/> |
| Spare parts are not available  | <input type="checkbox"/> |
| Consumables (filters, etc) are expensive   | <input type="checkbox"/> |
| Procurement of external services is difficult  | <input type="checkbox"/> |
| Other  | <input type="checkbox"/> |
| Other (please specify)   |                          |
| If you have two pieces of equipment that need to be repaired, but only enough budget to repair one piece of equipment, which <b>top 3 factors</b> influence your decision? |                          |
| High demand for analyses linked to equipment   | <input type="checkbox"/> |
| Loss of profit if equipment is out of service for long period of time  | <input type="checkbox"/> |
| Loss of capacity to process high sample throughput   | <input type="checkbox"/> |
| Spare parts are available for one and not the other  | <input type="checkbox"/> |
| Age of equipment   | <input type="checkbox"/> |
| Availability of local service provider   | <input type="checkbox"/> |
| Cost of service to repair  | <input type="checkbox"/> |
| Availability of alternative testing method   | <input type="checkbox"/> |
| Other  | <input type="checkbox"/> |
| Other (please specify)   |                          |
| What do you do with obsolete, damaged, or outdated equipment? ( Up to 3 choices possible )   |                          |

|   |                          |
|---|--------------------------|
| Put into storage/move out of the laboratory | <input type="checkbox"/> |
| Label 'Out of Service – Do Not Use'         | <input type="checkbox"/> |
| Isolate equipment in the laboratory         | <input type="checkbox"/> |
| Nothing; staff know it doesn't work         | <input type="checkbox"/> |
| Put in trash/waste                          | <input type="checkbox"/> |
| Incinerate                                  | <input type="checkbox"/> |
| Other                                       | <input type="checkbox"/> |
| Other (please specify)                      |                          |

### E. Service Providers

*Information you provide in this section will help to inform on the service providers you use.*

|  |                          |
|--|--------------------------|
| Do you have a preventive maintenance programme in your laboratory?   |                          |
| Do you have in-house competencies for equipment maintenance and minor repairs?   |                          |
| Do you have in-house competencies for calibration of laboratory equipment?   |                          |
| In your opinion, is there sufficient local service expertise and providers for laboratory equipment maintenance, calibration, and repair in your country?  |                          |
|  |                          |
| In your opinion, what proportion of all maintenance, repair, and calibration services is provided by each of the types of services providers listed below? |                          |
| In-house competencies (fill in %)  |                          |
| Local service providers (fill in %)  |                          |
| External service providers (fill in %)   |                          |
| Other (fill in %)  |                          |
| In your opinion, what percentage of all laboratory equipment in your laboratory is not in proper working order for any reason?                             |                          |
|  |                          |
| What is your level of satisfaction with <b>local</b> service providers?  |                          |
| What factors contribute to your satisfaction? ( 3 choices possible )   |                          |
| Price  | <input type="checkbox"/> |
| Quality of service   | <input type="checkbox"/> |
| Superior technical expertise   | <input type="checkbox"/> |
| Easy to contact  | <input type="checkbox"/> |
| Available to do work   | <input type="checkbox"/> |
| Donor recommendation/requirement   | <input type="checkbox"/> |
| Proximity  | <input type="checkbox"/> |
| Quick service  | <input type="checkbox"/> |
| Other  | <input type="checkbox"/> |
| Other (please specify)   |                          |

|  |                          |
|--|--------------------------|
| What is your level of satisfaction with <b>external</b> service providers? |                          |
| What factors contribute to your satisfaction? ( 3 choices possible )       |                          |
| Price  | <input type="checkbox"/> |
| Quality of service   | <input type="checkbox"/> |
| Superior technical expertise   | <input type="checkbox"/> |
| Easy to contact  | <input type="checkbox"/> |
| Available to do work   | <input type="checkbox"/> |
| Donor recommendation/requirement   | <input type="checkbox"/> |
| Proximity  | <input type="checkbox"/> |
| Quick service  | <input type="checkbox"/> |
| Other  | <input type="checkbox"/> |
| Other (please specify)   |                          |

|  |                          |
|--|--------------------------|
| <b>F. BUDGETING</b>  |                          |
| <i>Information you provide in this section will help to understand the budgetary context in which you work and procure services related to laboratory equipment.</i> |                          |
| Are maintenance, repair, and calibration services generally included in your annual operational budget?  |                          |
| What percentage of your annual budget allocation in 2018 was dedicated to equipment maintenance, calibration, and repair? (%)  |                          |
| In your opinion, is your annual budget allocation for equipment maintenance, calibration, and repair sufficient?   |                          |
|  |                          |
| Who typically funds your laboratory and/or its activities? Check all that apply.   |                          |
| Government/Veterinary Services   | <input type="checkbox"/> |
| Government/Other   | <input type="checkbox"/> |
| Bilateral donors   | <input type="checkbox"/> |
| Private investors  | <input type="checkbox"/> |
| Non-governmental Organizations (NGO)   | <input type="checkbox"/> |
| International organizations  | <input type="checkbox"/> |
| Other  | <input type="checkbox"/> |
| Other (please specify)   |                          |

|   |                          |
|---|--------------------------|
| Who typically funds maintenance, calibration, and repair of laboratory equipment? Check all that apply. |                          |
| Government/Veterinary Services  | <input type="checkbox"/> |
| Government/Other  | <input type="checkbox"/> |

|                                      |                          |
|--------------------------------------|--------------------------|
| Bilateral donors                     | <input type="checkbox"/> |
| Private investors                    | <input type="checkbox"/> |
| Non-governmental Organizations (NGO) | <input type="checkbox"/> |
| International organizations          | <input type="checkbox"/> |
| Other                                | <input type="checkbox"/> |
| Other (please specify)               |                          |

|   |  |
|---|--|
| Thank you for your time spent providing answers to Part 1 of this questionnaire.<br>Please proceed to Part 2 of the questionnaire |  |
|---|--|

## Laboratory Equipment Status Questionnaire for Maintenance/Repair/Calibration - Part I

### Background

The main objective of the survey is to assess the status of laboratory equipment maintenance, repair, and calibration for the purposes of a policy paper on "Investment Needs for Sustainable Laboratories". The intention of that policy paper is to provide an evidence-base for investments in the good management of laboratories with a view to sustainable laboratory biosafety and biosecurity.

In addition to this paper, the OIE will enhance the PVS Sustainable Laboratories Tool recognizing that equipment maintenance, repair and calibration are critical components for sustainable laboratory biosafety and biosecurity. The paper will also explore how such investments could encourage local market development to respond to laboratory needs for sustainable laboratory biosafety and biosecurity to mitigate the security and health risks associated with a lack of sustainable resources for veterinary laboratories.

### Instructions for the Survey

You are requested to collect information on laboratory equipment inventory and maintenance practices from the laboratory where you work. If you don't work in a laboratory, please send the questionnaire to be filled by the laboratory management of the public veterinary laboratories in your national network.

Some questions should be answered about the whole national laboratory network in your country, while others should be answered about the laboratory where you work. The differences between these questions are clearly stated.

Unless otherwise stated, questions should be answered for 2018, or the most recent year for which you have information.

For any issues or for clarification, please contact the Sustainable Laboratories Team for support at [b.nyange@oie.int](mailto:b.nyange@oie.int).

Please complete the questionnaire by 17 May 2019.

### Definitions

These definitions are proposed for the purposes of this survey.

**Maintenance:** For the purposes of this survey, 'maintenance' refers to preventive maintenance which is carried out in accordance with a specified time schedule, involving functional checks and servicing, replacement of consumables, etc.

**Repair :** Corrective maintenance carried out after failure or detection of a fault, in order to restore equipment to working order, including repairing or replacing parts of the equipment

**Calibration:** Precise adjustments made to laboratory equipment to ensure accurate measurement for a particular function and to establish the metrological traceability of the reported results

**Malfunctioning:** Equipment not working properly, that may require maintenance, repair, or calibration  
Local service provider: A service provider within a country

**Local service provider:** A service provider within a country

**External service provider:** A service provider outside a country

**National laboratory network:** All laboratories working in the veterinary domain in a country; for the purposes of this survey, only public laboratories

**Central veterinary laboratory:** The most advanced laboratory in a country; in some cases, the national reference laboratory of one or more diseases, and often in the administrative capital of a country

**On loan equipment:** Equipment that is provided by a manufacturer, supplier, university, partner, or other organisation for a limited amount of time for trial, testing, or research, while always belonging to the lender.

**Donated equipment:** Equipment that is given by a partner for an unlimited amount of time and belongs to the beneficiary laboratory.

### A. Respondent Identification

|  |  |
|--|--|
| First Name   |  |
| Last Name  |  |
| Country  |  |
| Are you the OIE National Laboratory Focal Point nominated by the OIE Delegate? |  |
| Job Title  |  |
| At which level is the veterinary laboratory where you work?                    |  |
| Other (please specify)   |  |

### B. National Laboratory Network

|  |  |
|--|--|
| <i>As a Focal Point, Information you provide in this section will allow us to understand the size of your country's national laboratory network.</i> |  |
| How many public veterinary laboratories were operating in your national laboratory network in 2018?  |  |
| How many public veterinary laboratories are there at the central, federal, or national level in your country?  |  |
| How many public veterinary laboratories are there at the provincial or state level in your country?  |  |
| How many public veterinary laboratories are there at the district or local level in your country?  |  |
| Are you currently working in a laboratory ?  |  |

*Some responses in the questionnaire should be provided by personnel working day-to-day on laboratory resource management and equipment inventory. If you are not currently working in a laboratory, please forward this excel file to laboratory directors of all public veterinary laboratories in your country so that they may complete the questionnaire. Please feel free to circulate to any and all laboratory management in your national veterinary laboratory network.*

|  |  |
|--|--|
| At which level is the veterinary laboratory where you work?        |  |
| Other (please specify)   |  |
| What types of testing/procedures are performed at your laboratory? |  |

| <b>C. Equipment Inventory</b>   |  |
|---|--|
| <i>Information you provide in this section will allow us to understand the inventory practices in your country's national laboratory network.</i> |  |
| How often is the laboratory equipment inventory done per year in your laboratory?   |  |
| Do you have "on loan" equipment in your laboratory?   |  |
| What percentage of equipment in your laboratory is "on loan"?   |  |
| Do you have donated equipment in your inventory?  |  |
| What percentage of equipment in your laboratory is donated?   |  |

| <b>D. Barriers to service procurement for laboratory equipment maintenance</b>  |                          |
|---|--------------------------|
| <i>Information you provide in this section will inform on barriers to procurement of preventive maintenance, calibration, and repair services for laboratory equipment.</i> |                          |
| Please choose the <b>top 3 causes</b> of malfunctioning or not working equipment that need <b>repair</b> in your laboratory   |                          |
| Over usage of equipment   | <input type="checkbox"/> |
| Software/technology problems of the equipment   | <input type="checkbox"/> |
| Equipment not maintained according to schedule  | <input type="checkbox"/> |
| Power/electricity problems  | <input type="checkbox"/> |
| Improper usage of equipment   | <input type="checkbox"/> |
| Poorly trained personnel using the equipment causing it to break  | <input type="checkbox"/> |
| Physical accidents (dropped, water damage, etc)   | <input type="checkbox"/> |
| Staff don't know how to use, start, or operate  | <input type="checkbox"/> |
| Other   | <input type="checkbox"/> |
| Other (please specify)  |                          |

|  |                          |
|--|--------------------------|
| Please choose the <b>top 3 reasons</b> why you procure <b>maintenance</b> services for laboratory equipment? |                          |
| The equipment show signs of malfunction, but is still working  | <input type="checkbox"/> |
| Preventive maintenance is required by law  | <input type="checkbox"/> |
| To keep accreditation/certification status   | <input type="checkbox"/> |
| Routine maintenance is scheduled according to time/date of last service                                      | <input type="checkbox"/> |
| High demand for analyses linked to particular equipment, so it is important that equipment works properly    | <input type="checkbox"/> |
| To satisfy clients and maintain revenue  | <input type="checkbox"/> |
| To ensure accurate results   | <input type="checkbox"/> |
| Planned/scheduled according to the SOP   | <input type="checkbox"/> |
| Planned/scheduled according to usage/number of analyses run  | <input type="checkbox"/> |
| Other  | <input type="checkbox"/> |
| Other (please specify)   |                          |

|  |                          |
|--|--------------------------|
| Please choose the <b>top 3 reasons</b> why you procure <b>calibration</b> services for laboratory equipment? |                          |
| The equipment shows signs of malfunction, but is still working   | <input type="checkbox"/> |
| Calibration is required by law   | <input type="checkbox"/> |
| To keep accreditation/certification status   | <input type="checkbox"/> |
| Routine calibration is scheduled according to time/date of last service                                      | <input type="checkbox"/> |
| High demand for analyses linked to particular equipment, so it is important that equipment works properly    | <input type="checkbox"/> |
| To satisfy clients and maintain revenue  | <input type="checkbox"/> |
| To ensure accurate results   | <input type="checkbox"/> |
| Planned/scheduled according to the SOP   | <input type="checkbox"/> |
| Planned/scheduled according to usage/number of analyses run  | <input type="checkbox"/> |
| Other  | <input type="checkbox"/> |
| Other (please specify)   |                          |

|  |                          |
|--|--------------------------|
| Please choose the <b>top 3 barriers</b> you encounter to procuring <b>maintenance, repair, and calibration</b> services for your laboratory equipment. |                          |
| Services are too expensive   | <input type="checkbox"/> |
| There are no local service providers   | <input type="checkbox"/> |
| Insufficient budget allocated  | <input type="checkbox"/> |
| No in-house expertise  | <input type="checkbox"/> |
| Not prioritized in management activities   | <input type="checkbox"/> |
| Don't know which service providers to use  | <input type="checkbox"/> |
| Expertise is not available   | <input type="checkbox"/> |
| Spare parts are not available  | <input type="checkbox"/> |
| Consummables (filters, etc) are expensive  | <input type="checkbox"/> |
| Procurement of external services is difficult  | <input type="checkbox"/> |
| Other  | <input type="checkbox"/> |
| Other (please specify)   |                          |

|  |                          |
|--|--------------------------|
| If you have two pieces of equipment that need to be repaired, but only enough budget to repair one piece of equipment, which <b>top 3 factors</b> influence your decision? |                          |
| High demand for analyses linked to equipment   | <input type="checkbox"/> |
| Loss of profit if equipment is out of service for long period of time  | <input type="checkbox"/> |
| Loss of capacity to process high sample throughput   | <input type="checkbox"/> |
| Spare parts are available for one and not the other  | <input type="checkbox"/> |
| Age of equipment   | <input type="checkbox"/> |
| Availability of local service provider   | <input type="checkbox"/> |
| Cost of service to repair  | <input type="checkbox"/> |
| Availability of alternative testing method   | <input type="checkbox"/> |
| Other  | <input type="checkbox"/> |
| Other (please specify)   |                          |

|  |                          |
|--|--------------------------|
| What do you do with obsolete, damaged, or outdated equipment? ( Up to 3 choices possible ) |                          |
| Put into storage/move out of the laboratory  | <input type="checkbox"/> |
| Label 'Out of Service – Do Not Use'  | <input type="checkbox"/> |
| Isolate equipment in the laboratory  | <input type="checkbox"/> |
| Nothing; staff know it doesn't work  | <input type="checkbox"/> |
| Put in trash/waste   | <input type="checkbox"/> |
| Incinerate   | <input type="checkbox"/> |
| Other  | <input type="checkbox"/> |
| Other (please specify)   |                          |

|   |  |
|---|--|
| <b>E. Service Providers</b>   |  |
| <i>Information you provide in this section will help to inform on the service providers you use.</i>  |  |
| Do you have a preventive maintenance programme in your laboratory?  |  |
| Do you have in-house competencies for equipment maintenance and minor repairs?  |  |
| Do you have in-house competencies for calibration of laboratory equipment?  |  |
| In your opinion, is there sufficient local service expertise and providers for laboratory equipment maintenance, calibration, and repair in your country? |  |

|  |  |
|--|--|
| In your opinion, what proportion of all maintenance, repair, and calibration services is provided by each of the types of services providers listed below? |  |
| In-house competencies (fill in %)  |  |
| Local service providers (fill in %)  |  |
| External service providers (fill in %)   |  |
| Other (fill in %)  |  |
| In your opinion, what percentage of all laboratory equipment in your laboratory is not in proper working order for any reason?                             |  |

|   |                          |
|---|--------------------------|
| What is your level of satisfaction with <b>local</b> service providers? |                          |
| What factors contribute to your satisfaction? ( 3 choices possible )    |                          |
| Price   | <input type="checkbox"/> |
| Quality of service  | <input type="checkbox"/> |
| Superior technical expertise  | <input type="checkbox"/> |
| Easy to contact   | <input type="checkbox"/> |
| Available to do work  | <input type="checkbox"/> |
| Donor recommendation/requirement  | <input type="checkbox"/> |
| Proximity   | <input type="checkbox"/> |
| Quick service   | <input type="checkbox"/> |
| Other   | <input type="checkbox"/> |
| Other (please specify)  |                          |

|  |                          |
|--|--------------------------|
| What is your level of satisfaction with <b>external</b> service providers? |                          |
| What factors contribute to your satisfaction? ( 3 choices possible )       |                          |
| Price  | <input type="checkbox"/> |
| Quality of service   | <input type="checkbox"/> |
| Superior technical expertise   | <input type="checkbox"/> |
| Easy to contact  | <input type="checkbox"/> |
| Available to do work   | <input type="checkbox"/> |
| Donor recommendation/requirement   | <input type="checkbox"/> |
| Proximity  | <input type="checkbox"/> |
| Quick service  | <input type="checkbox"/> |
| Other  | <input type="checkbox"/> |
| Other (please specify)   |                          |

|  |  |
|--|--|
| <b>F. BUDGETING</b>  |  |
| <i>Information you provide in this section will help to understand the budgetary context in which you work and procure services related to laboratory equipment.</i> |  |

|   |  |
|---|--|
| Are maintenance, repair, and calibration services generally included in your annual operational budget?                       |  |
| What percentage of your annual budget allocation in 2018 was dedicated to equipment maintenance, calibration, and repair? (%) |  |
| In your opinion, is your annual budget allocation for equipment maintenance, calibration, and repair sufficient?              |  |

|  |                          |
|--|--------------------------|
| Who typically funds your laboratory and/or its activities? Check all that apply. |                          |
| Government/Veterinary Services   | <input type="checkbox"/> |
| Government/Other   | <input type="checkbox"/> |
| Bilateral donors   | <input type="checkbox"/> |
| Private investors  | <input type="checkbox"/> |
| Non-governmental Organizations (NGO)   | <input type="checkbox"/> |
| International organizations  | <input type="checkbox"/> |
| Other  | <input type="checkbox"/> |
| Other (please specify)   |                          |

|   |                          |
|---|--------------------------|
| Who typically funds maintenance, calibration, and repair of laboratory equipment? Check all that apply. |                          |
| Government/Veterinary Services  | <input type="checkbox"/> |
| Government/Other  | <input type="checkbox"/> |
| Bilateral donors  | <input type="checkbox"/> |
| Private investors   | <input type="checkbox"/> |
| Non-governmental Organizations (NGO)  | <input type="checkbox"/> |
| International organizations   | <input type="checkbox"/> |
| Other   | <input type="checkbox"/> |
| Other (please specify)  |                          |

Thank you for your time spent providing answers to Part 1 of this questionnaire.  
Please proceed to Part 2 of the questionnaire



## Laboratory Equipment Status Questionnaire for Maintenance/Repair/Calibration - Part II

### Background

The main objective of the survey is to assess the status of laboratory equipment maintenance, repair, and calibration for the purposes of a policy paper on "Investment Needs for Sustainable Laboratories". The intention of that policy paper is to provide an evidence-base for investments in the good management of laboratories with a view to sustainable laboratory biosafety and biosecurity.

In addition to this paper, the OIE will enhance the PVS Sustainable Laboratories Tool recognizing that equipment maintenance, repair and calibration are critical components for sustainable laboratory biosafety and biosecurity. The paper will also explore how such investments could encourage local market development to respond to laboratory needs for sustainable laboratory biosafety and biosecurity to mitigate the security and health risks associated with a lack of sustainable resources for veterinary laboratories.

The aim for this questionnaire is to collect information on the management of laboratories and laboratory equipment, related to their maintenance, repair, and calibration.

### Instructions for the Survey

Laboratory equipment inventory and status information will be required to fill in this questionnaire. Please prepare that information in advance in order to complete the questionnaire.

Questions which cannot be answered during the seminar can be provided in the 7 days following the seminar.

Unless otherwise stated, questions should be answered for 2018 or the most recent year.

For any issues or for clarification, please contact the Sustainable Laboratories Team for support at [b.nyange@oie.int](mailto:b.nyange@oie.int). It will take you 15 minutes to complete this survey.

Please fill out this survey by 17 May 2019.

### Definitions

These definitions are proposed for the purposes of this survey and are adapted from ISO definitions, where available.

**Maintenance:** For the purposes of this survey, 'maintenance' refers to preventive maintenance which is carried out in accordance with a specified time schedule, involving functional checks and servicing, replacement of consumables, etc.

**Repair :** Corrective maintenance carried out after failure or detection of a fault, in order to restore equipment to working order, including repairing or replacing parts of the equipment

**Calibration:** Precise adjustments made to laboratory equipment to ensure accurate measurement for a particular function and to establish the metrological traceability of the reported results

**Malfunctioning:** Equipment not working properly, that may require maintenance, repair, or calibration

**Local service provider:** A service provider within a country

**External service provider:** A service provider outside a country

**National laboratory network:** All laboratories working in the veterinary domain in a country; for the purposes of this survey, only public laboratories

**Central veterinary laboratory:** The most advanced laboratory in a country; in some cases, the national reference laboratory for one or more diseases, and often in the administrative capital of a country

### A. Respondent Identification

|   |  |
|---|--|
| First Name  |  |
| Last Name   |  |
| Country   |  |
| Are you the OIE National Laboratory Focal Point nominated by the OIE Delegate?  |  |
| Job Title   |  |
| Are you currently working in a laboratory ?   |  |
| <i>Some responses in the questionnaire should be provided by personnel working day-to-day on laboratory resource management and equipment inventory. If you are not currently working in a laboratory, please forward this excel file to laboratory directors of all public veterinary laboratories in your country so that they may complete the questionnaire. Please feel free to circulate to any and all laboratory management in your national veterinary laboratory network.</i> |  |
| At which level is the veterinary laboratory where you work?   |  |
| Other (please specify)  |  |

### B. National Laboratory Network

|  |  |
|--|--|
| <i>Information you provide in this section will allow us to understand the size of your country's national laboratory network.</i>                         |  |
| How many laboratories in your national laboratory network have obtained accreditation to ISO 17025 for at least one test?                                  |  |
| How many laboratories in your national laboratory network have a dedicated Quality Manager?  |  |
| In your opinion, what percentage of all laboratory equipment in your national veterinary laboratory network is not in proper working order for any reason? |  |
| In your opinion, what percentage of the annual budget should be allocated for the maintenance, calibration, and repair of equipment?                       |  |

### C. BUDGETING

|   |                          |
|---|--------------------------|
| In your opinion, what are the <b>top 3 reasons</b> why you lack budget for equipment maintenance, repair, and calibration services? |                          |
| <i>Administration doesn't understand importance of equipment maintenance, calibration, and repair to Human and Animal Health</i>    | <input type="checkbox"/> |
| <i>Insufficient budget for operating costs of the laboratory in general, let alone for equipment maintenance</i>                    | <input type="checkbox"/> |
| <i>Too many competing budget priorities</i>   | <input type="checkbox"/> |
| <i>No "culture" for maintenance, repair and calibration in my laboratory or country</i>   | <input type="checkbox"/> |
| <i>Administration doesn't understand importance of equipment maintenance, calibration, and repair to biosafety and biosecurity</i>  | <input type="checkbox"/> |
| <i>Administration doesn't understand importance of equipment maintenance, calibration, and repair to trade</i>                      | <input type="checkbox"/> |
| <i>Expectation/Experience that others will provide resources for equipment maintenance, calibration, and repair</i>                 | <input type="checkbox"/> |

|  |  |
|--|--|
| Other (please specify)   |  |
|  |  |
| In your organisation's procedures and rules, do you have requirements for service provision on the local market for laboratory equipment maintenance, calibration, or repair ? |  |
| <b>D. General Laboratory Equipment Inventory</b>   |  |

**Instructions for the next section**  
The next section of the questionnaire addresses your laboratory equipment status. We will ask questions about each type of general equipment in your laboratory. Please fill in the relevant number of each equipment.

|  |  |
|--|--|
| Do you have Biological <b>Safety Cabinets – Class I</b> in your laboratory?                                |  |
| Please provide the relevant number of <b>biosafety cabinets – class I</b> in your laboratory.              |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many are properly certified by an accredited service provider?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |

|  |  |
|--|--|
| Do you have Biological Safety <b>Cabinet - Class II A1</b> in your laboratory ?                            |  |
| Please provide the relevant number of <b>Biological Safety Cabinet - class II A1</b> in your laboratory.   |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many are properly certified by an accredited service provider?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |

|  |  |
|--|--|
| Do you have any <b>Biological Safety Cabinet - class II A2</b> in your laboratory ?                        |  |
| Please provide the relevant number of <b>Biological Safety Cabinet - class II A2</b> in your laboratory.   |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many are properly certified by an accredited service provider?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |

|  |  |
|--|--|
| Do you have any <b>Fume hoods</b> in your laboratory ?   |  |
| Please provide the relevant number of <b>Fume hoods</b> in your laboratory.                                |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |

|   |  |
|---|--|
| Do you have any type of <b>Incubator</b> ( basic, cooled, humidity, shaking, hybridisation ) in your laboratory ?               |  |
| Please provide the relevant number of <b>Incubators</b> ( basic, cooled, humidity, shaking, hybridisation ) in your laboratory. |  |
| <i>How many do you have in your laboratory?</i>   |  |
| <i>How many are in good working order ?</i>   |  |
| <i>How many are not working and need minor repair ?</i>   |  |
| <i>How many are obsolete or the technology is outdated?</i>   |  |
| <i>How many not working and need major repair ?</i>   |  |
| <i>How many have been properly maintained ?</i>   |  |
| <i>How many have been properly calibrated?</i>  |  |
| <i>Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type?</i>               |  |
| <i>Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?</i>                 |  |
|   |  |
| Do you have any type of <b>Autoclave</b> ( basic, waste ) in your laboratory ?  |  |
| Please provide the relevant number of <b>Autoclaves</b> ( basic, waste ) in your laboratory.                                    |  |
| <i>How many do you have in your laboratory?</i>   |  |
| <i>How many are in good working order ?</i>   |  |
| <i>How many are not working and need minor repair ?</i>   |  |
| <i>How many are obsolete or the technology is outdated?</i>   |  |
| <i>How many not working and need major repair ?</i>   |  |
| <i>How many have been properly maintained ?</i>   |  |
| <i>How many have been properly calibrated?</i>  |  |
| <i>Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type?</i>               |  |
| <i>Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?</i>                 |  |
|   |  |
| Do you have any type of <b>Pipette</b> ( automatic, monochannel or multichannel ) in your laboratory ?                          |  |
| Please provide the relevant number of <b>Pipettes</b> ( automatic, monochannel or multichannel ) in your laboratory.            |  |
| <i>How many do you have in your laboratory?</i>   |  |
| <i>How many are in good working order ?</i>   |  |
| <i>How many are not working and need minor repair ?</i>   |  |
| <i>How many are obsolete or the technology is outdated?</i>   |  |
| <i>How many not working and need major repair ?</i>   |  |
| <i>How many have been properly maintained ?</i>   |  |
| <i>How many have been properly calibrated?</i>  |  |
| <i>Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type?</i>               |  |
| <i>Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?</i>                 |  |
|   |  |
| Do you have any type of <b>Centrifuge or microcentrifuge</b> ( plates, tubes, refrigerated) in your laboratory ?                |  |
| Please provide the relevant number of <b>Centrifuges or microcentrifuges</b> (plates, tubes, refrigerated) in your laboratory.  |  |
| <i>How many do you have in your laboratory?</i>   |  |
| <i>How many are in good working order ?</i>   |  |
| <i>How many are not working and need minor repair ?</i>   |  |
| <i>How many are obsolete or the technology is outdated?</i>   |  |
| <i>How many not working and need major repair ?</i>   |  |
| <i>How many have been properly maintained ?</i>   |  |
| <i>How many have been properly calibrated?</i>  |  |
| <i>Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type?</i>               |  |
| <i>Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?</i>                 |  |
|   |  |
| Do you have <b>Refrigerators</b> in your laboratory ?   |  |
| Please provide the relevant number of <b>Refrigerators</b> in your laboratory.  |  |
| <i>How many do you have in your laboratory?</i>   |  |
| <i>How many are in good working order ?</i>   |  |
| <i>How many are not working and need minor repair ?</i>   |  |
| <i>How many are obsolete or the technology is outdated?</i>   |  |
| <i>How many not working and need major repair ?</i>   |  |
| <i>How many have been properly maintained ?</i>   |  |
| <i>How many have been properly calibrated?</i>  |  |
| <i>Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type?</i>               |  |
| <i>Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?</i>                 |  |
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| Do you have a <b>Water filtration system</b> in your laboratory ?  |  |
| Please provide the relevant number of <b>Water filtration systems</b> in your laboratory.                  |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| Do you have any type of <b>Freezer (-20°C and -80°)</b> in your laboratory ?                               |  |
| Please provide the relevant number of <b>Freezers (-20°C and -80°)</b> in your laboratory.                 |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| Do you have any <b>Ovens</b> in your laboratory ?  |  |
| Please provide the relevant number of <b>Ovens</b> in your laboratory.                                     |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| Do you have a <b>Colony counter</b> in your laboratory ?   |  |
| Please provide the relevant number of <b>Colony counters</b> in your laboratory.                           |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| Do you have a <b>Gas incubator</b> in your laboratory ?  |  |
| Please provide the relevant number of <b>Gas incubators</b> in your laboratory.                            |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| Do you have a <b>Dark field microscope</b> in your laboratory ?  |  |
| Please provide the relevant number of <b>Dark field microscopes</b> in your laboratory.                    |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |

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| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| Do you have a <b>Microtome</b> in your laboratory ?  |  |
| Please provide the relevant number of <b>Microtomes</b> in your laboratory.                                |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| Do you have a <b>Fluorescent microscope</b> in your laboratory ?   |  |
| Please provide the relevant number of <b>Fluorescent microscope s</b> in your laboratory.                  |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| Do you have a <b>Mixer jar</b> in your laboratory ?  |  |
| Please provide the relevant number of <b>Mixer jars</b> in your laboratory.                                |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| Do you have a <b>Trichinoscope</b> in your laboratory ?  |  |
| Please provide the relevant number of <b>Trichinoscopes</b> in your laboratory.                            |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| Do you have a <b>Transilluminator</b> in your laboratory ?   |  |
| Please provide the relevant number of <b>Transilluminators</b> in your laboratory.                         |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |

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| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
| Do you have <b>Real-time PCR</b> in your laboratory ?  |  |
| Please provide the relevant number of <b>Real-time PCRs</b> in your laboratory.                            |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
| Do you have a <b>Thermal cycler/conventional PCR</b> in your laboratory ?                                  |  |
| Please provide the relevant number of <b>Thermal cycler/conventional PCRs</b> in your laboratory.          |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
| Do you have a <b>Electrophoresis machine/power supply</b> in your laboratory ?                             |  |
| Please provide the relevant number of <b>Electrophoresis machine/power supply</b> in your laboratory.      |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
| Do you have a <b>Gel documentation</b> system in your laboratory ?   |  |
| Please provide the relevant number of <b>Gel documentation systems</b> in your laboratory.                 |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
| Do you have a <b>Microplate reader</b> and dedicated computer in your laboratory ?                         |  |
| Please provide the relevant number of <b>Microplate readers</b> & dedicated computer in your laboratory.   |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |

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| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| <b>Do you have a Microplate washer in your laboratory ?</b>  |  |
| Please provide the relevant number of <b>Microplate washers</b> in your laboratory.                        |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| <b>Do you have a Plate shaker in your laboratory ?</b>   |  |
| Please provide the relevant number of <b>Plate shakers</b> in your laboratory.                             |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| <b>Do you have an Inverted light microscope in your laboratory ?</b>                                       |  |
| Please provide the relevant number of <b>Inverted light microscopes</b> in your laboratory.                |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| <b>Do you have a Roller system in your laboratory ?</b>  |  |
| Please provide the relevant number of <b>Roller systems</b> in your laboratory.                            |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| <b>Do you have a Conductometer in your laboratory ?</b>  |  |
| Please provide the relevant number of <b>Conductometers</b> in your laboratory.                            |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |

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| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| <b>Do you have a Distillator in your laboratory ?</b>  |  |
| Please provide the relevant number of <b>Distillators</b> in your laboratory.                              |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| <b>Do you have a Magnetic agitator in your laboratory ?</b>  |  |
| Please provide the relevant number of <b>Magnetic agitators</b> in your laboratory.                        |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| <b>Do you have a Microscope and camera in your laboratory ?</b>  |  |
| Please provide the relevant number of <b>Microscopes and camera</b> in your laboratory.                    |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| <b>Do you have an Ovoscope in your laboratory ?</b>  |  |
| Please provide the relevant number of <b>Ovoscoopes</b> in your laboratory.                                |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
|  |  |
| <b>Do you have a pH meter in your laboratory ?</b>   |  |
| Please provide the relevant number of <b>pH meters</b> in your laboratory.                                 |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |



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| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
| Do you have any type of <b>Shaker</b> ( oscillator/rotative/orbital ) in your laboratory ?                 |  |
| Please provide the relevant number of <b>Shakers</b> (oscillator/rotative/orbital) in your laboratory.     |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
| Do you have a <b>Spectrophotometer</b> – basic in your laboratory ?  |  |
| Please provide the relevant number of <b>Spectrophotometer s</b> – basic in your laboratory.               |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained?  |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
| Do you have a <b>Vacuum pump</b> in your laboratory ?  |  |
| Please provide the relevant number of <b>Vacuum pumps</b> in your laboratory.                              |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
| Do you have a <b>Vortex</b> in your laboratory ?   |  |
| Please provide the relevant number of <b>Vortex</b> in your laboratory.                                    |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |
| Do you have a <b>Water bath</b> in your laboratory ?   |  |
| Please provide the relevant number of <b>Water baths</b> in your laboratory.                               |  |
| How many do you have in your laboratory?   |  |
| How many are in good working order ?   |  |
| How many are not working and need minor repair ?   |  |
| How many are obsolete or the technology is outdated?   |  |
| How many not working and need major repair ?   |  |
| How many have been properly maintained ?   |  |
| How many have been properly calibrated?  |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Is there a local service provider(s) available who can maintain, calibrate, or repair this equipment type? |  |
| Do you have an in-house competency available who can maintain, calibrate, or repair this equipment type?   |  |

| <b>G. Cost of maintenance, repair and calibration services</b>   |  |
|--|--|
| <i>Please collect 3 invoices of three pieces of equipment listed here which were maintained, calibrated, or repaired in the past 10 years.</i> |  |
| <b>INVOICE 1</b>   |  |
| Please select an equipment   |  |
| In what year was the equipment acquired?   |  |
| What was the nature of the service provided?   |  |
| Date of service  |  |
| Cost of service ( USD )  |  |
| Type of Service Provider that performed the service.   |  |
| Country of origin of service provider  |  |
| <b>INVOICE 2</b>   |  |
| Please select an equipment   |  |
| In what year was the equipment acquired?   |  |
| What was the nature of the service provided?   |  |
| Date of service  |  |
| Cost of service ( USD )  |  |
| Type of Service Provider that performed the service.   |  |
| Country of origin of service provider  |  |
| <b>INVOICE 3</b>   |  |
| Please select an equipment   |  |
| In what year was the equipment acquired?   |  |
| What was the nature of the service provided?   |  |
| Date of service  |  |
| Cost of service ( USD )  |  |
| Type of Service Provider that performed the service.   |  |
| Country of origin of service provider  |  |
| Thank you for your time spent providing answers to this questionnaire.   |  |