The Design and In-Country Evaluation of TB Diagnostic Laboratory Kits

2004–2006
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About RPM Plus

RPM Plus works in more than 20 developing and transitional countries to provide technical assistance to strengthen medicine and health commodity management systems. The program offers technical guidance and assists in strategy development and program implementation both in improving the availability of health commodities—pharmaceuticals, vaccines, supplies, and basic medical equipment—of assured quality for maternal and child health, HIV/AIDS, infectious diseases, and family planning and in promoting the appropriate use of health commodities in the public and private sectors.

About the Global TB Drug Facility

The GDF is a mechanism to expand access to, and availability of, high-quality TB drugs to facilitate global DOTS expansion. The GDF enables governments and nongovernmental organizations to implement effective TB control programs based on the DOTS strategy. By securing the timely supply of quality TB drugs, the GDF complements other activities designed to improve coverage and quality of global TB control. Ensuring an uninterrupted supply of quality drugs through the GDF frees human and financial resources to address management, service delivery, training, supervision, and other services essential for scaling up DOTS. The GDF is housed in WHO headquarters in Geneva and managed by a small team in the Stop TB Partnership secretariat.

Acknowledgments

The authors acknowledge the major contribution of Project Hope in facilitating and providing technical oversight for the piloting of the GDF kits in Tajikistan and for translating documents into Russian.

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Key Words and Terms

Tuberculosis; Laboratory diagnosis; Sputum smear microscopy; Ziehl-Nielsen stain; Diagnostic kits

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Partners, Beneficiaries, and Collaborators

The laboratory kits initiative has been undertaken by the Global TB Drug Facility in partnership with Management Sciences for Health (MSH), through its Rational Pharmaceutical Management (RPM) Plus Program.

The primary long-term beneficiaries of this work are the GDF and the countries it serves. The immediate beneficiaries are the national tuberculosis (TB) programs of the Republic of the Congo, Nigeria, and Tajikistan, which have received and are using the microscopes, equipment, and reagents to provide high-quality TB microscopy.

The provision of laboratory kits is expected to facilitate expansion of DOTS by ensuring standardized, quality laboratory consumables and equipment. The expected outcomes are twofold—

- Improved quality of smear microscopy results, that is, a decrease in the number of false-positive and false-negative results
- Increased TB case finding

The DOTS Expansion Working Group and its Subgroup for Laboratory Capacity Strengthening are major collaborators in this initiative. The members of these groups are expected to be responsible for advocating for and promulgating the use of these kits in their respective regions and countries. The secretariat and members of the DEWG and the SLCS have been kept fully informed of the initiative since its inception in 2003.
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EXECUTIVE SUMMARY

In 2003, the Global TB Drug Facility (GDF), as part of its mandate to contribute to DOTS expansion and at the request of several Stop TB partners, decided to formulate and develop diagnostic laboratory kits for tuberculosis (TB) that it could make available to countries with high TB prevalence. The work on development and formulation of the proposed kits began in March 2004, when an evaluation work team comprised of GDF staff supported by several staff members from Management Sciences for Health piloted and evaluated the kits in three countries—The Republic of the Congo, Nigeria, and Tajikistan—to enable the Stop TB Partnership secretariat and the GDF to decide whether to make these kits regularly available.

Objectives

1. To assess the feasibility for the GDF to supply laboratory equipment and consumables in the form of kits required for diagnosis of TB to countries with high TB prevalence

2. To assess the use of the kits in different settings and their suitability (contents and quantity of materials) for carrying out acid-fast bacilli (AFB) smear microscopy

3. To evaluate the possible effect of the diagnostic laboratory kits on case finding, smear microscopy workload, and quality of sputum smear microscopy results in participating laboratories

Methodology

- A list of contents, with individual item specifications, quantities, and costs was prepared for each of the proposed GDF diagnostic kits—

  1. Consumables kit, with ready-to-use Ziehl-Nielsen (ZN) stains
  2. Sputum collection containers
  3. Equipment starter kit
  4. Microscope kit, with back-up rechargeable battery and accessories

- A specific GDF application form was devised for the laboratory kits, which includes an electronic quantification spreadsheet to enable countries to quantify order requirements for the consumables kits and sputum collection containers.

- Advice and feedback on the kit contents, specifications, and evaluation protocol were obtained from the Stop TB DOTS Expansion Working Group and its Subgroup for Laboratory Capacity Strengthening.

- A protocol for piloting and evaluation of the laboratory kits in selected countries was developed, and data collection tools were prepared for use in the assessments.
• Prototypes of the kits were ordered and purchased from one wholesaler. Before the kits were shipped to the countries, all items were inspected to verify that they met the required specifications and a series of quality control checks were instituted to ensure the performance and quality of the stains.

• Safety regulations for shipping the different classes of chemical reagents in the kit were established, and goods were packed and shipped to the Republic of the Congo, Nigeria, and Tajikistan.

• A baseline situational analysis of the TB microscopy services was conducted at representative central, district, and health center facilities in the Republic of the Congo, Nigeria, and Tajikistan and follow-up visits were made after the kits had been used for approximately six months.

• To assess the effect of providing high-quality reagents and equipment on the quality of the microscopy results, the evaluation team devised a simple quality assurance system to use in each country before the introduction of the kits (baseline) and at three and six months after the introduction of the kits.

In-Country Evaluation Process

The process used to design, pilot, and evaluate the use of the kits in three countries with high prevalence of TB—the Republic of the Congo, Nigeria, and Tajikistan—assessed the following—

• Kit content, specifications, and quality
• Required modifications to the specifications to enhance performance and quality
• Packaging, labeling, and shipping,
• Clearing and in-country storage of kits
• Procurement issues
• Kit costs
• GDF application process for countries to apply for and order kits
• User-friendly quantification process to easily determine the number of kits required
• Briefing of TB program and laboratory staff
• In-country planning for phased implementation of the kits
• Status of the TB microscopy services before and after the implementation of the kits
• Stock control and tracking of kit distribution and use
• Documentation and instructions for using each item in the kits

During the assessment, the local circumstances in the countries also required the GDF to address the following—

• Staff orientation and training on kit use and in ZN staining method
• Need for improved management and organization of laboratories to benefit from the kits
Executive Summary

• In-country supervision and quality monitoring of laboratories
• External monitoring of kit use by the GDF

Findings

This operational study to design and field-test prototype TB laboratory diagnostic kits in the Republic of the Congo, Nigeria, and Tajikistan has shown that the kits are suitable for use in a variety of low-income, high-prevalence settings.

Lessons learned include the following—

• Maximum benefit from the kits can be obtained when all staff members receive orientation on the use of the kits and when the kits are used as intended—that is, as complete kits, rather than as an alternative source of consumables and laboratory equipment.

• An important secondary benefit was the improvement in the morale and motivation of the laboratory staff members who used the kits, particularly those in peripheral laboratories. Overall, laboratory staff satisfaction with the kits was very high, especially because they contributed to improving working conditions for TB microscopy.

• Supplying the kits to countries with high TB prevalence can assist in alleviating the shortage of microscopes, laboratory equipment, stains, and consumables required for sputum smear microscopy.

• The benefit of supplying microscopes with a backup battery for use during power cuts was welcomed in each of the pilot countries. Of all the kits, the microscope kit is most likely to have a major effect on availability of smear microscopy and contribute to increasing case detection.

• Although potentially useful for all laboratories, the consumables kit was shown to be most useful for peripheral laboratories and others that experience difficulties in obtaining supplies of reagents.

• Although the use of the kits has the potential for improving the quality of smear microscopy and increasing case detection, additional strategies to improve working practices and management and organization of the laboratories are required to leverage the benefits of the kits. Additional technical and financial support may be required to achieve this result.

• Piloting the kits in three contrasting settings has enabled the GDF to assess the suitability of the individual items in the kits and to make the necessary modifications to the kit contents and specifications.
Recommendations

The GDF evaluation team recommends that the Stop TB Partnership and the Global TB Drug Facility take action to—

- Rapidly proceed with arrangements to make the following diagnostic kits available for supply to countries with high prevalence of TB—
  - Consumables kit, with ready-to-use ZN stains, containing sufficient materials to process 1,000 sputum specimens
  - Sputum collection containers in packs of 1,000
  - Equipment starter kit
  - Microscope kit, with backup rechargeable battery and accessories
- Adjust the contents and specifications of the kits in line with the results of this study
- Ensure that full instructions for use and the specifications for each item are included in each of the kits, as appropriate—special instructions need to be included in the microscope kit on how to set up and use the microscope, how to charge the battery, and how to use the battery during power cuts; all instructions and the kit labeling need to be provided in a language suitable for the country using the kits
- Because the kits have proven useful for improving the quality of sputum smear microscopy, try to make the kits available both by direct procurement and through grants to eligible countries
- Arrange for pre-implementation country visits and post-implementation annual monitoring visits; to be cost-effective, these visits could be done routinely during the annual drug monitoring visits, where feasible
- Orient all consultants on the laboratory kits, the application process, quantification methodology, and monitoring of their use; in cases of particular need or difficulty, the GDF should consider using the services of laboratory specialists who have received training and orientation from the GDF
- Properly train and orient national TB program (NTP) and laboratory staff and those responsible for supply chain management, before the kit implementation in-country; this training could be done either by GDF consultants or by contracting out to partner organizations
- Consider developing an implementation package for orientation and training of NTP managers, heads of laboratory services, and supply chain managers in countries wishing to use the kits
1. BACKGROUND

The GDF was established by the Stop TB Global Partnership on March 24, 2001, as a new initiative for increasing access to and availability of high-quality tuberculosis (TB) drugs and to accelerate DOTS expansion. Although it is well-recognized that drugs are essential to TB prevention and cure, their proper use depends on the availability of reliable, quality-assured laboratory diagnosis of TB. Sputum smear microscopy for TB diagnosis, an integral component of the DOTS strategy, is a relatively simple laboratory procedure but is often hampered by the lack of appropriate diagnostic equipment and sustainable supplies of high-quality laboratory consumables.

In 2003, the GDF, as part of its mandate to contribute to DOTS expansion and having received several requests from Stop TB partners, carried out some preliminary research to investigate the possibility of supplying laboratory equipment and reagents to countries with a high TB burden. The initial investigations indicated that supplying kits to low-income countries, those undergoing health sector reforms, or those in post-conflict situations could facilitate procurement and control of laboratory supplies for TB microscopy. Therefore, in 2004, the GDF decided to have diagnostic laboratory kits designed and developed with the intention of making available to countries with high TB prevalence.

The GDF\textsuperscript{1} assembled an evaluation team who would pilot and evaluate the kits in three countries to enable the Stop TB Partnership secretariat and the GDF to make a decision on whether to make these kits regularly available. In April 2004, the Republic of the Congo requested the Regional Office for Africa of the World Health Organization (WHO) to provide urgent assistance with laboratory supplies for TB diagnosis because all reagents were completely out of stock in the country. This request was passed on to the GDF, and subsequently the NTP in the Republic of the Congo agreed to pilot the prototype kits in selected health facilities and to participate in the pre- and post-implementation evaluation. Later that year, similar agreements were made between the GDF and the NTPs in Nigeria and Tajikistan.

This report describes the process used to design, pilot, and evaluate the use of the kits in countries with high TB prevalence and discusses the advantages and benefits of using these kits for TB diagnosis and control in laboratories.

\textsuperscript{1} Mundy, C. 2004. \textit{Support to the Global TB Drug Facility to Develop a Mechanism to Supply Laboratory Kits for TB Diagnosis to High Burden Countries}. Arlington, VA: Management Sciences for Health.
2. OBJECTIVES

1. To assess the feasibility for the GDF to supply laboratory equipment and consumables required for diagnosis of TB in kits to countries with high TB prevalence

2. To assess the use of the kits in different settings and their suitability (contents and quantity of materials) for carrying out AFB smear microscopy

3. To evaluate the possible effect of the diagnostic laboratory kits on case finding, smear microscopy workload, and quality of sputum smear microscopy results in participating laboratories
3. THE DIAGNOSTIC KITS ASSESSMENT: METHODOLOGY

3.1 Determination of Kit Contents and Costs

A list of contents, with individual item specifications, quantities, and costs was prepared for each of the proposed GDF diagnostic kits—

1. Consumables kit, with ready-to-use ZN stains
2. Sputum collection containers
3. Equipment starter kit
4. Microscope kit, with backup rechargeable battery and accessories

3.2 Development of the GDF Application and Quantification Processes for the Laboratory Kits

A specific GDF application form for the laboratory kits was developed, generally based on the format of the GDF application form for drugs, with the intention of making the form available on the GDF website.

An electronic quantification spreadsheet to enable countries to quantify order requirements for the consumables kits and sputum collection containers, based on the number of smear-positive cases detected annually and the smear positivity rate, was prepared and incorporated in the application form.

3.3 Preparation for Piloting the TB Diagnostic Kits in Selected Countries

The evaluation team developed a protocol for piloting and evaluation of laboratory kits in selected countries.

Questionnaires for NTP managers, national heads of laboratory services, heads of the TB reference laboratory, and laboratory staff members in laboratories where kits were to be piloted were developed to collect all necessary baseline and post-implementation information. The evaluation protocol and questionnaires were translated into French for use in the Republic of the Congo and into Russian for use in Tajikistan. Copies of these questionnaires are available from the GDF.

In October 2004, the prototype kits were displayed at the Stop TB Partnership stand during the UNION conference in Paris to foster worldwide interest and obtain feedback on their content from interested parties.

In addition, advice and feedback on the kit contents, specifications, and evaluation protocol were obtained from both the DOTS Expansion Working Group and its Subgroup for Laboratory
Capacity Strengthening at their respective meetings in Paris in October 2004. Discussions and questionnaires served to obtain opinions and advice of the members from around the world.

3.4 Procurement and Shipping of the Prototypes of the Kits to the Republic of the Congo, Nigeria, and Tajikistan

The GDF application form for laboratory kits was sent to the NTP manager in each country. The form was used to ascertain the country needs and to enable the GDF to assess the user-friendliness and relevance of the application process.

Prototypes of the kits were ordered and purchased from one wholesaler, who assembled and packed the items acquired from several manufacturers. All items in the kits were inspected to verify that they met the required specifications.

Before the kits were dispatched to the countries, a series of quality control checks were instituted. A sample of each reagent was sent to one of the SGS Chemical Laboratories for analysis to verify that it met the specifications. The TB Department of the Prince Leopold Institute of Tropical Medicine, testing at the Prince Leopold Institute of Tropical Medicine in Antwerp, Belgium, was performed courtesy of Dr. A. Van Deun. Because considerable variation occurs in the content and quality of fuchsin available to prepare the carbol fuchsin stain, an additional study was conducted in Antwerp to compare the efficacy of the carbol fuchsin in the kit with other carbol fuchsin stains of established quality. The results from these quality assessments indicated that the quality of the stains was sufficient and that when compared with reference standards, they could perform well if correctly used.

Safety regulations for shipping the different classes of chemical reagents in the kit were established, and goods were then packed and shipped to the Republic of the Congo, Nigeria, and Tajikistan.

3.5 Pre- and Post-implementation Country Assessments in the Republic of the Congo, Nigeria, and Tajikistan

The evaluation protocol and a draft program for the in-country assessments, both pre- and post-implementation of the kits, were prepared and sent to the three countries.

The following data collection tools were prepared for use in the country assessments—

- Questionnaires on the status of TB laboratory services for TB program managers, heads of laboratory services, and laboratory staff using the diagnostic kits

- User-friendliness of the GDF application process

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2 Testing at the Prince Leopold Institute of Tropical Medicine in Antwerp, Belgium, was performed courtesy of Dr. A. Van Deun.
3 Copies of the data collection tools are available from the GDF.
The evaluation team conducted a baseline situational analysis of the TB microscopy services at representative central, district, and health center facilities in the Republic of the Congo, Nigeria, and Tajikistan. During the team’s visits, information on the design and contents of the diagnostic kits was provided to the NTP managers, heads of the national TB laboratories, and laboratory staff members who would use the kits. The team also discussed the likely effect and implications of introducing the kits at the laboratories and ascertained their willingness to make the necessary adjustments to their working practices. Assistance was given to each NTP to draw up a comprehensive plan for phased introduction of the kits and the post-implementation assessment in their respective countries.4

After the kits had been used for approximately six months, the team revisited the laboratories visited during the baseline assessment in the Republic of the Congo, Nigeria, and Tajikistan. In each country, visits were also made to the medical stores to review the storage conditions and procedures for stock management of the laboratory kits.

To assess the impact of providing high-quality reagents and equipment on the quality of the microscopy results, the team devised a simple system and made practical arrangements to randomly select a sample of positive and negative smears from participating laboratories for blinded microscopic re-reading before the introduction of the kits (baseline) and at three and six months after the introduction of the kits.5 Where available, the results of similar quality assessment exercises done locally were also reviewed.

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4 Originally, the intent was to select control laboratories (where GDF kits would not be provided) to compare with those in which the kit was introduced to help assess the effect of the GDF kits on laboratory performance and identifying other factors influencing performance. In the Republic of the Congo, no laboratory carrying out TB microscopy had the necessary materials to continue this test. Therefore, for ethical reasons, the kits could not be denied to any laboratory because this would effectively stop the diagnosis of TB. In Nigeria and Tajikistan, it was not practical to do the comparison. Therefore, the effect of the kits was assessed only against the baseline situation.

5 The quality control methodology has limitations, and therefore the results of this exercise need to be interpreted with caution. Although monitoring the change in the number of false-positive and false-negative results after the introduction of the kits was considered desirable, the methodology assesses only the capability of laboratory technicians to examine smears under the microscope and identify whether AFB are present using the available materials and equipment. It does not assess the quality of the specimen collection, smear preparation, or staining and therefore has limited value. A true and accurate measure of quality requires assessment of the stained smears by an external control laboratory with facilities to restain the smears with high-quality ZN stain before reexamination with well-functioning microscopes. However, resources were not available to the GDF for this type of study.
4. DESIGN AND COST OF THE KITS: PRELIMINARY CONSIDERATIONS

4.1 Kit Design and Content

Four kits were designed, field-tested, and evaluated by the GDF—

1. Consumables kit, with ready-to-use ZN stains
   Each kit contains 5 × 1 liter of ready-to-use ZN stains plus other consumables (for example, glass slides, filter paper, immersion oil, lens cleaning tissue) sufficient to process 1,000 sputum specimens. The GDF requested a minimum shelf life of three years for the stains and other consumables.

2. Sputum collection containers
   Each pack contains 1,000 screw-capped, wide-mouth, disposable sputum collection containers. The decision was taken to make this kit distinct and separate from the laboratory consumables to permit independent ordering and direct distribution in-country to health facilities attended by potential and existing TB patients for collection of sputum specimens. Sputum specimens can then be forwarded to the nearest microscopy center.

3. Equipment starter kit
   Each kit contains minor equipment items (for example, slide storage boxes, a staining rack, forceps, spirit lamp, slide drying rack) required to process and stain sputum specimens for AFB. This kit is intended to be used in conjunction with the consumables Kit and provides a complete set of materials sufficient to set up a new microscopy center. The materials are anticipated to be robust enough to last for at least three years.

4. Microscope kit
   The microscope kit contains one binocular microscope suitable for use both with a country’s main electricity supply and with a mirror and external light source. Accessories in the kit include a 12-volt battery, a charger (to charge the battery from the main electricity supply), a mirror unit, an external lamp for use with the battery and mirror unit, a surge protector, spare bulbs, and fuses. Many countries have unreliable or intermittent power supplies. Voltage fluctuations, spikes, brownouts, and sudden power cuts are common. In practice, these conditions mean that the microscope may be damaged and cannot be used until repaired, or the ability to read smears may be intermittent depending on power supply. Use of a mirror and sunlight is not practical when reading large numbers of smears on a regular basis or in certain climates. Hence, the inclusion of the surge protector, battery, and external lamp to provide a backup power supply is considered essential. The battery can be charged either from the main electricity supply or from a solar panel.

Annex 1 contains a complete list of the contents of each kit. The lists have been modified and updated based on the feedback and findings from the assessments in the three countries.
The consumables kit is packed in two boxes in line with the safety regulations for the different classes of chemical reagents. The other three kits are each packed in a single box, which facilitates easy handling, storage, and transport because the total volume of each kit is less than the collective volumes if all the items were purchased individually.

4.2 Intended Use of Kits

The kits were designed to facilitate and promote DOTS expansion in countries with a high TB burden. In many of these countries, much of the rural population has limited access to reliable microscopy services. Country-level decisions to decentralize TB microscopy services to make them more equitable and accessible need to be balanced with efforts to ensure quality. The first consideration in ensuring the quality of smear microscopy is the provision of a constant supply of high-quality laboratory stains and consumables and the availability of robust, functioning microscopes.

With these requirements in mind, the kits have been designed specifically to meet the needs of laboratories at the periphery of the health system, that is, those at district and subdistrict level. Those laboratories commonly experience severe problems with supply management. In addition, they often do not have reliable electricity and water supplies, or the expertise, equipment, and materials required to prepare good-quality stains. The concept of receiving all requirements in one box is intended to facilitate easier ordering and distribution and to ensure the availability of a complete set of standardized, high-quality commodities.

The kits are not primarily intended for use in laboratories at central and intermediate levels, which generally have better facilities and expertise. Although individual countries may decide to use them in such laboratories, preparing bulk reagents and procuring other supplies as needed may be more practical and cost-effective. This decision will depend on the price and local availability of dry stain powders and other chemicals needed to prepare the stains.

4.3 Optimum Size of the Consumables Kit

Each consumables kit contains sufficient stains, slides, and other consumables to process and stain 1,000 sputum specimens. This number takes into account the well-recognized norm that a direct relationship exists between workload, number of microscopists required, and the quality of microscopy. The UNION recommends that the number of sputum specimens that can be processed and examined properly by one person, if she or he has no other duties, should not exceed 20 per day. It is recognized that maintaining proficiency in reading ZN smears requires examining a minimum of 10–15 slides per week, that is, 2–3 examinations per day.6 Microscopy centers with workloads less than this level are not considered viable. In high-prevalence countries, one microscopy center per 50,000–150,000 population is usually sufficient to attain the target of 2–20 ZN smears per day.

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Examination of the minimum of 2–3 sputum specimens per day translates into an annual workload of 500–750 sputum examinations per year. Given that the minimum shelf life of the consumables kit is three years, a microscopy center performing the recommended minimum workload would consume all of the stains before that time. In other words, such centers would require one consumables kit every 18–24 months. This requirement is in contrast with those processing 20 sputum specimens per day, equivalent to an annual workload of 5,000 sputum examinations per year, which would require five consumables kits each year.

### 4.4 Cost of the Prototype Kits

The costs of the prototype kits piloted in the Republic of the Congo, Nigeria, and Tajikistan are shown in Table 1. The GDF expects that these prices (given in U.S. dollars [USD]) will decrease with the floating of an international tender.

<table>
<thead>
<tr>
<th>Kit Type</th>
<th>Cost per Prototype Kit (USD)</th>
<th>Cost per Sputum Specimen Examined (USD)</th>
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<tr>
<td>Consumables kit (all requirements for processing 1,000 specimens)</td>
<td>190.00</td>
<td>0.19</td>
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<tr>
<td>Sputum collection containers (1,000)</td>
<td>65.00</td>
<td>0.065</td>
</tr>
<tr>
<td>Equipment starter kit</td>
<td>300.00</td>
<td>N/A</td>
</tr>
<tr>
<td>Microscope kit (with battery and accessories)</td>
<td>1,370.00</td>
<td>N/A</td>
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Following shows the costs in U.S. dollars (USD) of the prototype consumables per sputum specimen using the ZN staining method when compared with the costs in other low-income, high prevalence countries.

- GDF Prototype Consumables Kit—0.25 USD
- 2005-District Hospital, Katete, Zambia 1997/987—0.25 USD
- Ntcheu District Hospital, Malawi 1997/988—0.23 USD
- Tamil-Nadu, India, 20029—0.22 USD

The cost of consumables (including the sputum collection containers) per sputum examination using the GDF prototype kits was USD 0.25. Those responsible for laboratory commodity management and for preparing national tenders may be concerned that purchasing ready-made

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stains may be more expensive than purchasing the component reagents for preparation in the laboratory. In industrialized countries, this is generally the case; there have been few detailed cost analyses of laboratory service provision in low-income countries for comparison. However, the cost of the GDF prototype consumables (2005) per sputum specimen examined compares favorably with those cited in costing studies from Zambia (1997), Malawi (1997), and India (2002) (Table 2). Moreover, the ZN stains used in these studies were prepared from component stains and chemicals and were not purchased ready-made.

The microscope supplied in the GDF prototype microscope kit appears to be more expensive than other commercially available microscopes. However, it is important to note that the microscope kit also contains a 12-volt battery, charger, external light source to be used with the battery, mirror unit, surge protector, spare bulbs, and fuses (see Annex 1). These accessories allow work to continue in facilities with unreliable or limited electricity. The evaluation team members are not aware of other microscope manufacturers who supply a good-quality, robust microscope with all these accessories at a competitive price.

But value for money and cost-effectiveness of the kits are not the only economic factors that need to be considered when comparing costs with those of other commercial products or with those costs incurred in other low-income countries. They include the costs caused by reporting of false-negative or false-positive smear results because of the use of poor-quality reagents or substandard microscopes and costs resulting from delays in TB diagnosis because of nonavailability of consumables and microscopy, resulting in further spread of TB in the community. Using high-quality microscopes and reliable stains saves laboratory considerable staff time in identifying AFB. Using ready-to-use stains and reagents also reduces the staff time needed to prepare reagents, while maintaining standards and quality.

For those who are interested in the diagnostic capacity of the consumables kit, data on the number of smear-positive cases detected per kit, the costs of a patient examination, and the costs per smear-positive case detected are shown in Tables 2 and 3.

Table 2. Number of Smear-Positive Cases Detected per Consumables Kit

<table>
<thead>
<tr>
<th>Three-smear strategy—10 percent of examined TB suspects are smear positive</th>
<th>33</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three-smear strategy—15 percent of examined TB suspects are smear positive</td>
<td>48</td>
</tr>
<tr>
<td>Three-smear strategy—20 percent of examined TB suspects are smear positive</td>
<td>67</td>
</tr>
</tbody>
</table>

*Assumptions—
1. When 10 percent of examined TB suspects are smear positive, 30 smears will be examined to detect one smear-positive case. For each smear-positive case, there will be nine smear-negative suspects, each of which will have 3 smears examined.
2. When 15 percent of examined TB suspects are smear positive, 21 smears will be examined to detect one smear-positive case. For each smear-positive case, there will be six smear-negative suspects, each of which will have 3 smears examined.
3. When 20 percent of examined TB suspects are smear positive, 15 smears will be examined to detect one smear-positive case. For each smear-positive case, there will be four smear-negative suspects, each of which will have 3 smears examined.
Table 3. Cost in USD of All Consumables Per Examination and Per Case Detected

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost per sputum specimen examined</td>
<td>0.25</td>
</tr>
<tr>
<td>Cost of a diagnostic examination (three-smear strategy)</td>
<td>0.75</td>
</tr>
<tr>
<td>Cost of a follow-up examination (two-smear strategy)</td>
<td>0.50</td>
</tr>
<tr>
<td>Cost per smear-positive case detected: three-smear strategy—10 percent of</td>
<td>7.50</td>
</tr>
<tr>
<td>examined TB suspects are smear positive</td>
<td></td>
</tr>
<tr>
<td>Cost per smear-positive case detected: three-smear strategy—15 percent of</td>
<td>5.25</td>
</tr>
<tr>
<td>examined TB suspects are smear positive</td>
<td></td>
</tr>
<tr>
<td>Cost per smear-positive case detected: three-smear strategy—20 percent of</td>
<td>3.75</td>
</tr>
<tr>
<td>examined TB suspects are smear positive</td>
<td></td>
</tr>
</tbody>
</table>

4.5 Estimation of Individual Country Needs

**Consumables (Including Sputum Collection Containers)**

Programs wishing to quantify the number of consumables kits required for their country should refer to the Calculation Tool in Annex 2. This tool takes into account the number of smears required for diagnosis and follow-up and is based on the number of smear-positive cases detected in the previous year and the smear-positive case detection rate. Because reliable laboratory workload and consumable consumption data are often not available in many countries, this tool facilitates NTPs in accurately forecasting their annual requirements for laboratory consumables. The GDF intends to make this tool available electronically on its website as part of the application process for the laboratory kits. The number of kits required in a particular country, region, or province will be calculated automatically when the number of smear-positive cases detected annually and smear-positive case detection rate for that particular area, have been entered. No mathematical calculation will be needed.

**Equipment Starter Kits**

These kits are intended for use in setting up new microscopy sites or for equipping existing sites that do not have the necessary basic requirements. Therefore, the number of kits to be ordered needs to be decided at the country level.

**Microscope Kits**

The number of microscope kits required is also a country-level decision. However, as a guideline in high-prevalence countries, one functioning microscope is required per 100,000 population. This figure guides programs on the number of kits required.

**Costs of Kits and Shipping**

The GDF kit prices do not include shipping or clearing costs, which will vary from country to country.
Photographs*

1. Consumables kits in CENAMES (Medical Store), the Republic of the Congo
2. Microscope operated with battery in Talangai Hospital, the Republic of the Congo
3. Filtering the stains before use, Dushanbe, Tajikistan
4. Unpacking the kits, Dushanbe, Tajikistan
5. Consumables kit A, showing labeled packing box and some of the contents
6. Wall chart, stains, and equipment ready for use, Dushanbe, Tajikistan
7. Staining rack and tray, Tajikistan
8. Staining TB smears by heating the carbol fuchsín
9. Stains, slides, and disinfectant from the consumables kit
10. Sputum specimens awaiting smear preparation, au centre antituberculeux de Brazzaville, the Republic of the Congo
11. Microscopist with the Project Hope supervisor, Vosse TB Center, Tajikistan
12. Change in quality of ZN-stained smears, Tajikistan. Bottom row: before staff training on ZN method and use of the kits; Top row: after staff training on ZN method and use of kits

*Courtesy of H. Vrakking and C. Mundy.
Design and Cost of the Kits: Preliminary Considerations

1

2

3
Prototypes of the diagnostic kits were piloted in three countries with contrasting needs and conditions—the Republic of the Congo, Nigeria, and Tajikistan. Two assessment visits were made to each country. At the initial visits, the evaluation team determined the state of the laboratories and TB microscopy services and ascertained the urgency and likely applicability of using diagnostic laboratory kits. The visits also provided the opportunity to discuss how to use the kits and how their use would be assessed by the GDF. The follow-up visits were made after the kits were used for approximately six months in the implementing laboratories to assess their impact on case detection and quality of microscopy services.

Questionnaires and structured interviews with NTP and laboratory staff members were used to obtain factual information and their views and opinions on their needs, use and suitability of the kits, and suggestions for modifications and improvements. The NTP selected representative laboratories for site visits to observe laboratory practice and verify information collected from the interviews and questionnaires. A summary of the findings from each country follows.

5.1 The Republic of the Congo

The baseline assessment in the Republic of the Congo was conducted in November 2004 and included site visits to five representative laboratories in Brazzaville and three in Pointe-Noire. All laboratories in Brazzaville and Pointe-Noire that had been using the kits were revisited for the follow-up assessment in January 2006.

**TB Control in the Republic of the Congo**

The Republic of the Congo is a small, low-income country (population 3,882,947). In 2004, DOTS coverage was estimated at 80 percent. The TB profile for this year follows.


- Incidence (all cases/100,000 pop/yr)—377
- Trend in incidence rate per year—2.6 percent
- Incidence (SS+/100,000 pop/yr)—163
- Prevalence (all cases/100,000 pop)—464
- Mortality (deaths/100,000 pop/yr)—71
- Prevalence of HIV in adult TB patients aged 15–49 years—23 percent
- New cases multidrug-resistant TB—1.5 percent
- Previously treated cases multidrug-resistant TB—8 percent

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10 Copies of these questionnaires are available from the GDF.
12 SS+ = sputum smear positive


Republic of the Congo Surveillance and DOTS Implementation (2004)\textsuperscript{13}

- Notification rate (new and relapse/100,000 pop/yr)—251
- Notification rate (new SS+/100,000 pop/yr)—106
- Case detection rate (all cases)—67 percent
- Case detection rate (new SS+)—65 percent
- DOTS notification rate (new and relapse/100,000 pop/yr)—251
- DOTS notification rate (new SS+/100,000 pop/yr)—106
- DOTS case detection rate (new and relapsed)—67 percent
- DOTS case detection rate (new SS+)—65 percent
- DOTS treatment success (2003 cohort)—69 percent

Financial and Technical Support for the National TB Control Program

Before the three-year civil war that took place between 1997 and 1999, the National TB Program received financial support from L’Agence Française de Coopération. As part of this support, laboratory consumables were regularly supplied to the microscopy centers. Because of the war, the NTP’s activities were disrupted and 80 percent of laboratory resources were destroyed. In 2002, L’Agence Française de Coopération, UNION, and the World Health Organization (WHO) provided support for the development of a five-year strategic plan to improve TB control services. A proposal to scale up this plan was submitted to the Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM) in 2004, but it was not approved—therefore, the additional budget support needed for TB control activities was not realized. The effective budget for TB control activities in 2004 thus was only 227,000 U.S. dollars (USD) (equivalent to USD 25 per notified patient). At the time of the first visit (November 2004), the only external support for TB control activities was from the GDF, which is supplying TB drugs to the whole country. Although WHO had previously supplied basic equipment (a microscope, centrifuge, and water bath) to 14 rural laboratories, no external support was given to improve or sustain the TB diagnostic services.

There is no operating budget for laboratory services. Any available consumables for sputum examinations have been purchased using monies collected from patient fees, equivalent to USD 1 per patient attending for TB diagnosis.

Organization of TB Services and Microscopy Sites

In November 2004, TB services with microscopy facilities were being provided by one central laboratory (University Hospital, Brazzaville), seven district hospitals (Hôpitaux de Base), and 16 rural and urban health centers. In addition to these sites, the NTP has a number of treatment centers (without laboratories) to facilitate easier access to treatment.

TB culturing and sensitivity testing are not available in the Republic of the Congo. Although a national public health laboratory exists, it is engaged mainly in research; at the time of the visit, it did not carry out any TB-related activities. In practice, the management of TB microscopy

services is fragmented. The NTP directly manages laboratories attached to DOTS clinics but does not have jurisdiction over the hospital laboratories or the national public health laboratory.

**Staffing and Microscopy Workload**

In all the laboratories visited, trained technicians (who had attended either a two-year or three-year recognized training program) were responsible for TB microscopy. No untrained or ancillary staff handled specimens or performed laboratory tests. The capacity of the technicians to undertake microscopy varied considerably. Refresher training has not been readily available in the Republic of the Congo, though two of the more senior staff members had attended a course on TB microscopy in Senegal (conducted by the UNION) within the previous 12 months.

Each TB suspect has three sputum specimens examined, and smear-positive patients have one follow-up specimen examined three times during treatment at two, five, and eight months. Although each laboratory maintains a TB register with records of all suspects and follow-up patients who have sputum examined for TB, the workload data are not regularly collated or submitted to the NTP manager. The workload is high, particularly at the Centre Antituberculeux (CAT) in Brazzaville and the CAT in Pointe-Noire, both of which examine sputum from more than 8,000 persons each year (Table 5).

All the laboratories visited felt that they did not have enough staff to cope with the workload. However, before implementation of the kits, laboratories found making the best use of their staff difficult because they did not have adequate numbers of working microscopes and other necessary materials to examine the specimens.

**Table 4. Baseline Workload and Staffing Data from Three Representative Hospitals in the Republic of the Congo, January–June 2004**

<table>
<thead>
<tr>
<th>Workload and Staffing</th>
<th>CAT Brazzaville</th>
<th>CAT Pointe-Noire</th>
<th>Talangai Hôpital de Base, Brazzaville</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of people who had sputum tested</td>
<td>4,011</td>
<td>4,226</td>
<td>684</td>
</tr>
<tr>
<td>Number of suspects tested</td>
<td>2,451</td>
<td>2,671</td>
<td>450</td>
</tr>
<tr>
<td>Number of suspects with two or three positive smears</td>
<td>446</td>
<td>611</td>
<td>101</td>
</tr>
<tr>
<td>Smear positivity rate, %</td>
<td>18.2</td>
<td>22.9</td>
<td>22.4</td>
</tr>
<tr>
<td>Number of follow-up patients</td>
<td>1,392</td>
<td>1,555</td>
<td>234</td>
</tr>
<tr>
<td>Total number of smears examined</td>
<td>8,745</td>
<td>9,568</td>
<td>1,584</td>
</tr>
<tr>
<td>Number of trained laboratory technicians available for TB microscopy</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Total number of smears that could be examined properly in six months with current staffing level (20 smears/technician/working day)</td>
<td>10,400</td>
<td>7,800</td>
<td>5,200</td>
</tr>
<tr>
<td>Number of additional staff required for workload</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
Laboratory Premises and Safety

During the initial visit, the evaluation team observed that premises with basic facilities for TB microscopy—adequate working space, ventilation, sink, and waste disposal—were available in several of the laboratories. But the facilities currently used for TB microscopy in the Hôpital de Makélékélé (Brazzaville) and Hôpital de Tie-Tie (Pointe-Noire) laboratories were not adequate, and the need to improve these to use the kits was discussed with the NTP manager.

All laboratory technicians had white coats but none had gloves or disinfectant. None were currently disposing of sputum specimens appropriately because of a complete absence of incinerators, autoclaves, and disinfectant. The need to decontaminate sputum specimens before they leave the laboratory and the need to ensure that they are burned were fully discussed with the staff at each laboratory visited.

TB Microscopy Methods, Current Laboratory Practice, and Constraints

Before introduction of the GDF kits, the ZN staining method and grading scheme recommended by UNION had not been introduced. All laboratories used a cold-staining technique (Tan Thiam Hok [TTH]) with Kinyoun and Gabett stains. Batches of slides were stained in staining troughs. Because of the scarcity of materials, the Kinyoun stain (carbol fuchsin) a staining trough and used daily for at least one month without being changed or filtered. The evaluation team observed considerable deterioration and build-up of deposits in some of the staining troughs. The time for changing the Gabett stain (combination of decolorizer and methylene blue counterstain) varied among individual laboratories from one to six weeks. This method is unsuitable for examining large numbers of sputum samples and highlighted the urgency of providing sufficient quantities of quality reagents.

The NTP has a written instruction manual with the procedures for the TTH staining technique and the grading of the smears. However, the scarcity of stains and the lack of other items of equipment prevented the staff from following these procedures. There were no sputum collection containers and therefore, ingeniously, some of the laboratories used film cartridges, obtained from a local photographic shop, as collection bottles, while others required the TB suspects to find their own containers. This deficiency meant that obtaining good-quality specimens was very difficult, and an unusually high proportion of saliva specimens were observed. None of the specimens were labeled with the name of the patient. Although each laboratory had devised its own system of numbering and recognizing which sputa matched each request, the potential for mixing up specimens or making clerical errors was considerable.

None of the laboratories visited had good-quality, clean glass slides. All appeared to be dirty. The evaluation team was informed that some of the slides purchased from local suppliers were not new but were recycled slides imported from other West African countries. Generally, all other necessary equipment for smear microscopy was lacking.

All of the laboratories visited had at least one binocular electric microscope. None was in good condition, making it difficult to examine the smears adequately. Fungal growth on the lenses and objectives was a common problem. This condition was so bad on two microscopes (at Hôpital de
Makélékélé and Hôpital de Tie-Tie) that viewing the stained sputum smears was impossible. Yet these microscopes continued to be used and TB microscopy results reported.

All laboratories reported a severe problem with electricity supply. Often, they are without power for several days at a time, resulting in delayed microscopy. The evaluation team was informed that piped water is generally available in urban health facilities but not in rural facilities. However, the evaluation team observed one urban laboratory (Hôpital de Makélékélé, Brazzaville) that did not have any water supply or sink in the laboratory for staining or for hand washing. The importance and possible mechanisms for providing a staining sink and water supply in all laboratories (both urban and rural) were discussed with the NTP manager.

Although the NTP has designed an official laboratory form, they were out of stock throughout the country. Laboratory requests and reports were made on small scraps of paper. All laboratories had and were using a standard TB laboratory register, although the evaluation team observed variations in how patient information and smear results were entered. The importance of maintaining complete and proper records was discussed with the NTP manager.

**Quality Assurance and Supervision**

The evaluation team learned that the senior technician at CAT Brazzaville is officially responsible for the supervision and quality control of the TB microscopy centers. However, it became apparent that the technician has not received sufficient training in the quality assurance methods recommended and promulgated by WHO and UNION.

As a result of the civil war, it had not been logistically possible for the NTP to provide regular supervision or any type of quality control program for several years. At the time of the team’s visits, no vehicles were assigned for the use of the NTP to carry out supervision. Although the NTP has three documented protocols for quality control, none of the laboratories has either the capacity to act as the national reference center or the facilities to organize and manage the materials used for quality control. Thus, the quality of the microscopy results and the performance of the laboratories were not known.

Observations made during the initial visit of the sputum collection process, labeling, documentation, smear preparation, and staining indicated that several major procedural and quality issues existed. Observation of the stained smears under the microscope confirmed these concerns. The laboratory staff had become used to using dirty, poorly functioning microscopes and looking at badly stained smears, making recognition and differentiation of AFB from other bacteria very difficult. The evaluation team concluded that the likelihood of false-negative and false-positive results was high. Standard materials for ZN staining and equipment were not available to compare with the method used throughout the Republic of the Congo for verifying the level of quality.

**Potential Usefulness of GDF Diagnostic Kits in the Republic of the Congo**

The baseline assessment carried out in the Republic of the Congo highlights the extreme difficulties experienced by the laboratory staff in a low-income country with high TB prevalence.
as they attempt to provide a sputum smear microscopy service for TB diagnosis without the basic resources required for this work. The NTP manager and laboratory staff members agreed that supplying the GDF diagnostic kits in the Republic of the Congo would serve to alleviate the complete absence of appropriate stains, reagents, equipment, and functioning microscopes in existing TB microscopy centers and would permit the introduction of TB microscopy in additional laboratories to provide increased coverage.

However, the NTP and laboratory staff agreed that other strategies to improve working practices and management and organization of the laboratories would be required to leverage the benefits of the kits and maximize productivity. These included the following—

- Development and implementation of a plan for phased introduction of the kits
- Arrangements for proper storage and distribution of the kits
- Training of all laboratory staff in the ZN method and in the use of the kits
- Supervision of the laboratories
- Workload and quality monitoring of microscopy at three-monthly intervals after introduction of the kits
- Improved cooperation and collaboration between all laboratories and the NTP to mount a concerted effort to increase case detection

The situation in the Republic of the Congo highlighted the urgent need for the NTP to identify and obtain external technical and financial support to complement the current assistance from the GDF with supplies of pharmaceuticals and laboratory kits. Without this support, the laboratory kits will have limited effect on improving case detection and the quality of microscopy results.

**Ordering, Delivery, Storage, and Distribution of Kits**

The NTP manager successfully completed the GDF application process for the kits and reported that he experienced no problems with this process. The prototype kits were ordered from the GDF in November 2004 and received in the Republic of the Congo in April 2005. Because the kits were to be dispatched first, additional time was needed in Europe to ensure that items classified as “dangerous goods” were suitably packaged in line with airline regulations and to negotiate their acceptance for shipment by the airline.
Table 5. Kit Ordering, Delivery, and Distribution in the Republic of the Congo

<table>
<thead>
<tr>
<th>Kit Type</th>
<th>Number Ordered from GDF</th>
<th>Date Ordered, 2004</th>
<th>Number Received from GDF</th>
<th>Date Received at Port, 2005</th>
<th>Date Cleared and Moved to Central Store, 2005</th>
<th>Number of Kits Distributed to Laboratories by January 2006</th>
<th>Number in Stock at CENAMES in January 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumables kits (each to stain 1,000 slides)</td>
<td>252</td>
<td>Nov.</td>
<td>251</td>
<td>April 20</td>
<td>May 3</td>
<td>32</td>
<td>219</td>
</tr>
<tr>
<td>Sputum collection containers (1,000)</td>
<td>252</td>
<td>Nov.</td>
<td>252</td>
<td>April 27</td>
<td>May 12</td>
<td>32</td>
<td>220</td>
</tr>
<tr>
<td>Equipment starter kits</td>
<td>20</td>
<td>Nov.</td>
<td>20</td>
<td>20 April 05</td>
<td>May 3</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Microscope kits</td>
<td>15</td>
<td>Nov.</td>
<td>12</td>
<td>April 27</td>
<td>May 12</td>
<td>12</td>
<td>0</td>
</tr>
</tbody>
</table>

*Note: CENAMES = Centrale Nationale d’Achats de Médicaments, vaccins et consommables médicaux essentiels [Brazzaville]*

The NTP manager informed us that there were no problems clearing the kits. The entire stock was held at Centrale Nationale d’Achats de Médicaments, vaccins et consommables médicaux essentiels (CENAMES, the central medical stores) in Brazzaville, and a portion was sent from there to the medical stores in Pointe-Noire. The kits were gradually distributed to laboratories carrying out TB microscopy (see Table 6 and Annex 3). Because the kits do not require refrigeration, storage and transport were easy.

The NTP manager authorized and managed distribution of the kits to individual laboratories. In CENAMES, the evaluation team observed documentary evidence of the number and destination of kits distributed, but this information was inadequate for proper stock management. In contrast, the Medical Store in Pointe-Noire did not keep records, making management and tracking of the kits difficult. Because the individual laboratories do not keep stock cards or have any other form of record-keeping for supply management, no documentary evidence was available of the number of kits received by individual laboratories or how many had been used in comparison with the workload. This situation represents a major management deficiency that needs to be addressed not only in the Republic of the Congo but also in any country applying for kits from the GDF.

**Suitability of Diagnostic Kits**

**Accuracy of Kit Contents, Superfluous or Missing Items**

With a few exceptions, all the items received in the kits were in line with the original design specifications and packing list. The evaluation team was informed that some items were missing...
from some of the kits, for example, spare bulbs and fuses for the microscope. This information was not consistent between the laboratories and could not be verified because of the lack of documentation and poor organization in the laboratories.

**Quantity, Quality, and Suitability of Items in Kits**

All the laboratory staff interviewed were more than happy with the kits and indicated that they made their work easier. Although the consumables kits were designed to contain sufficient materials to process and stain 1,000 sputum specimens, it was not possible (because of poor laboratory record-keeping) to verify how many sputa had actually been processed with one consumables kit. All staff members made suggestions for minor changes or modifications to improve the suitability of individual items (for example, the design of the staining rack and the size of the spirit lamp), and all asked for gloves and masks to be added to the kits. Although the evaluation team explained that the latter will not provide protection against infection with tubercle bacilli, they requested these supplies to assist with handling of malodorous specimens.

**Instructions on Kit Use**

The instruction books on TB microscopy and illustrated wall poster with the ZN staining method, included in the equipment starter kit were in English. Unfortunately, they are unsuitable for use in francophone countries. This problem highlighted the importance for the GDF to arrange for all instructions to be available to cover the main language groups where the kits are expected to be used.

Instructions were requested in the kit specifications but were not provided with the microscope kit on how to set up the microscope, how to charge the battery, or how to use it during power cuts. Ensuring that this information is provided when supplying these kits to other countries will be crucial for the GDF.

**Staff Orientation and Training in Kit Use**

Before reception of the kits, refresher training programs in the ZN staining method were conducted in Brazzaville and Pointe-Noire for laboratory staff who would receive the kits. However, no orientation was provided by the NTP on the new concept of kits, how to use the items in the consumables and equipment starter kits, or how to set up the microscope and charge and use the battery.

**Introduction and Use of Laboratory Kits and Effect on Laboratory Practice**

Most of the laboratory staff members reported that they started using the kits as soon as they received them in the laboratory. It was observed that some of the items in the various kits had not been unpacked and were therefore not in use because of the lack of staff orientation at the time of the kit delivery. Only a few staff members had worked out how to use the microscope battery and battery charger. Because of the frequent power cuts during working hours, these items are essential to ensure continuity of microscopy services. Therefore, orientation on their use was
provided during the follow-up site visits to allow the laboratory staff to make full use of the microscope kits.

The understanding, and therefore consequent use of the kits, varied considerably between Brazzaville and Pointe-Noire and among individual laboratories in both cities. The implementing laboratories in Brazzaville used the kits for their intended purpose as complete sets of items to process and examine sputum specimens. However, with the exception of two health center laboratories, this did not happen in Pointe-Noire. At the CAT in Pointe-Noire, the boxes were kept in a storeroom used by the Expanded Programme for Immunization and laboratory staff removed individual items from the boxes as and when they wanted to use them. Thus, many boxes had been opened, but none had been used as a complete kit. It was not clear whether the items removed had been used for TB smear microscopy or for other laboratory use. Overall the kits were seen to be of most benefit and best used in the small, peripheral laboratories.

**Effect of the GDF Kits on Quality, Workload, and Time Management**

**Quality of Smear Microscopy**

In Brazzaville, the head of the CAT laboratory had organized interlaboratory re-readings of a sample of stained positive and negative smears from each of the three laboratories: CAT-Brazzaville, Talangai Hôpital de Base, and Hôpital de Makélékélé. The first exercise was conducted in January 2005 before the introduction of the kits, and the second in November 2005, approximately three months after the kits had been introduced. When the controller found discrepant results, a second re-reading was carried out.

The results of these simple quality assurance (QA) exercises showed that before the introduction of the kits, each laboratory reported a small number of false-positive and false-negative results (less than 10 percent). After the introduction of the kits, no false-positive or false-negative results were recorded. During the second visit, as a means of verifying the QA results, the evaluation team arranged to collect sets of positive and negative smears in each of these three laboratories for the staff to repeat the exercise. Again the discrepancies were minor and there were no false-positive or negative results. This exercise has limited value because it only measures the ability of the laboratory technicians to identify the presence or absence of acid fast bacilli but does not take into account the quality of the sputum collection, smear preparation, or staining. Therefore, in each laboratory visited, the evaluation team examined smears to observe the quality of the staining to see if any changes had occurred since the first visit. Whereas originally identifying AFB in the smears stained by the TTH method was difficult, those stained with the ZN stains from the GDF kit were much improved with clear red AFB easily distinguishable from other non-AFB and debris. The laboratory staff members also reported the improvements in staining quality that made examining the slides much easier.

This QA exercise could not be conducted in Pointe-Noire because the slides had not been stored properly and all of the positive and negative microscopy results from each sputum specimen examined had not been entered in the TB laboratory register.
**Workload and Staff Time Management**

The evaluation team had intended to assess the effect of the kits on laboratory workload and staff time management but could not do so because an unusual situation had arisen that was outside the control of the laboratory. While the laboratories were piloting the kits, the NTP experienced a shortage of medicines for treatment caused by ordering problems. This in turn affected the laboratories because many TB suspects did not present themselves for diagnosis when they thought that treatment was not available. This effect is illustrated in Table 6, which clearly shows that the smear microscopy workload fell by almost 50 percent from when the evaluation team conducted the baseline studies and the time the laboratory kits were introduced. A small increase in the smear positivity rate occurred after the introduction of the kits, but because of the workload change the evaluation team could not interpret the significance of this finding.

**Table 6. Comparative Workload Data from CAT Brazzaville, Pre- and Post-Kit Implementation**

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Total number of people who had sputum tested</td>
<td>4,011</td>
<td>2,282</td>
</tr>
<tr>
<td>Number of suspects tested</td>
<td>2,451</td>
<td>1,109</td>
</tr>
<tr>
<td>Number of suspects with two or three positive smears</td>
<td>446</td>
<td>241</td>
</tr>
<tr>
<td>Smear-positive case detection rate, %</td>
<td>18</td>
<td>22</td>
</tr>
<tr>
<td>Number of follow-up patients</td>
<td>1,392</td>
<td>1,173</td>
</tr>
<tr>
<td>Total number of smears examined</td>
<td>8,745</td>
<td>4,629</td>
</tr>
</tbody>
</table>

The introduction of the kits also appeared to affect staff morale and motivation in some laboratories. For example, the evaluation team found that the medical director in the Hôpital de Makélékélé had refurbished a new room for the laboratory to provide adequate space and working conditions for smear microscopy. This action was a result of the discussions held with him during the baseline assessment.

**Lessons Learned from the Republic of the Congo**

Although the introduction of the GDF kits has the potential to markedly improve the quality and reliability of smear microscopy and case detection, improvements to several management and organizational aspects of the laboratory service and NTP need concurrent attention. Of particular note are the need to provide training and orientation of TB program and laboratory staff members in the proper use of the kits, the need for quality monitoring and supervision of laboratories, and in collaboration with medical stores staff, the institution of a commodity management system to track and document the distribution and use of the kits. The last is important for transparency and to ensure continued donor support.
5.2 Nigeria

The initial visit to Nigeria was conducted in January 2005 and the follow-up visit in May 2006. The methodology used was similar that used in the Republic of the Congo, and site visits were made to five representative laboratories, two in Lagos and three in Abuja, the states where the National TB and Leprosy Control Programme (NTLCP) planned to pilot the kits.

**TB Control in Nigeria**

With a population of almost 129 million, Nigeria ranks fourth among the 22 TB high-burden countries (HBC). Yet in 2004, the case detection (21 percent) and treatment success rates (59 percent) were among the lowest for any HBC. The TB profile for Nigeria follows.

All 36 states and the Federal Capital Territory (FCT) in Nigeria are presently implementing DOTS in at least three to five local government areas (LGAs). The phased expansion of DOTS is being implemented in selected LGAs.

**Nigeria TB Burden (2004 Estimates)**\(^\text{14}\)

- Incidence (all cases/100,000 pop/yr)—290
- Trend in incidence rate (yr)—2.6 percent
- Incidence (SS+/100,000 pop\(^\text{15}\)/yr)—125
- Prevalence (all cases/100,000 pop)—531
- Mortality (deaths/100,000 pop/yr)—82
- Prevalence of HIV in adult TB patients aged 15–49 years—27 percent
- New cases multidrug-resistant TB—1.7 percent
- Previously treated cases multidrug-resistant TB—7.6 percent

**Nigeria Surveillance and DOTS Implementation (2004)**\(^\text{16}\)

- Notification rate (new and relapse/100,000 pop/yr)—44
- Notification rate (new SS+/100,000 pop/yr)—26
- Case detection rate (all cases)—15 percent
- Case detection rate (new SS+)—21 percent
- DOTS notification rate (new and relapse/100,000 pop/yr)-44
- DOTS notification rate (new SS+/100,000 pop/yr)—26
- DOTS case detection rate (new and relapse)—15 percent
- DOTS case detection rate (new SS+, %)—21
- DOTS treatment success (2003 cohort)—59 percent

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\(^\text{15}\) Pop=population

Financial and Technical Support for the National TB and Leprosy Control Programme

Each of the three tiers of the Nigerian government (federal, state, and local) sustains laboratory services by providing infrastructure, laboratory reagents, and other materials.

The following cooperating partners have supported the NTLCP: German Leprosy Relief Association (14 states), Damien Foundation of Belgium (2 states), Netherlands Leprosy Relief Association (4 states), U.K. Department for International Development (2 states), Canadian International Development Agency (CIDA) (3 states), UNION (1 state), and WHO and CIDA (11 states). These partners have provided technical and financial support, including vehicles, anti-TB drugs, laboratory reagents, and supplies to facilitate DOTS expansion. Currently, the GDF supplies anti-TB drugs to most of the country.

Organization of TB Services and Microscopy Sites

The head of the laboratory services at NTLCP central unit coordinates all the TB laboratory activities. At each level of laboratory services, a laboratory TB focal person oversees activities. Nigeria has two National Reference Laboratories and 18 Zonal Reference Laboratories where TB cultures and drug susceptibility testing are done.

Staffing and TB Microscopy Workload

In all the laboratories visited, trained biomedical scientists, microbiologists, or laboratory technologists were responsible for TB microscopy. No untrained staff handled specimens or
performed laboratory tests. Refresher training has been readily available in Nigeria, and at least one or two staff members at each site visited had been trained in the ZN method for TB microscopy within the previous 12 months.

In Lagos State, only two sputum specimens per suspect are examined because of the high workload, whereas for those in Abuja Federal State three specimens are examined. Smear-positive patients have one follow-up specimen examined three times during treatment at two, five, and eight months. Each laboratory maintains a TB register with records of all suspects and follow-up patients who have sputum examined for TB. The workload data are collated quarterly and submitted to the state TB control officer. The urban workload is high, particularly at the Lagos Mainland and Lagos Island Hospitals, both of which examine sputum from more than 5,000 persons each year. However, all the laboratories visited had enough staff to deal with the workload, with the exception of Lagos Island Hospital.

**Laboratory Premises and Safety**

Premises with basic facilities for TB microscopy—adequate working space, ventilation, sink, and waste disposal—were available in some of the laboratories visited. The facilities currently used for TB microscopy in Maintana and Nyanyan Hospital laboratories in Abuja were not adequate. In many hospitals, one room is used for smear preparation without any safe laboratory practices (poor ventilation and waste disposal system) and another room, usually a distance away, is used for smear microscopy examination. These arrangements demonstrate a lack of laboratory organization and poor workflow and pose a danger to both staff and patients. The need to improve the laboratory facilities to make optimal use of the kits was discussed with the state TB control officer.

All laboratory personnel had white protective coats, gloves, and disinfectant, but the system for disposing of sputum specimens was inadequate. The need to decontaminate sputum specimens before they leave the laboratory and ensure they are burned was fully discussed with the staff in each laboratory visited.

**TB Microscopy Methods, Current Laboratory Practice, and Constraints**

In Nigeria, the ZN staining method and grading scheme, recommended by UNION and WHO, are used. Therefore, it was not anticipated that the laboratories would have any technical problems in using the diagnostic kits. The NTLCP has a written manual of standard operating procedures (SOPs) which, at the time of visiting, were available on the laboratory benches. The quality of TB smear microscopy observed in the laboratories visited was found to be good. Only one laboratory was not using a properly functioning microscope. However, all laboratories reported erratic electricity supply that affects their work and delays microscopy results. The value of having the GDF-supplied microscopes with a backup battery, which can be charged when the main electricity power supply is on, to provide light when the power is off, was welcomed and recognized as crucial.

Most of the laboratories in Lagos reported a problem with erratic water supply and could not use a water distiller because the water pressure was low. Therefore, most of the stains were prepared
locally using tap water (instead of distilled water), which may be contaminated with environmental AFB, thus affecting the reliability of the microscopy results. The TB request forms were available in all laboratories visited. All laboratories had and were using a standard TB laboratory register, although the evaluation team observed variations in the way in which they were filled out. The importance of maintaining complete and proper records was discussed with the head of the TB laboratory.

**Quality Assurance and Supervision**

The quality assurance system was not well established in the centers visited, but the evaluation team was informed that guidelines have been developed and are being disseminated before implementation and roll out of the system. All the microscopy centers receive quarterly supervisory visits.

**Potential Usefulness of GDF Diagnostic Kits in Nigeria**

The baseline assessment carried out in two states in Nigeria indicates that microscopy services are reasonably well organized and resourced. But the situation in these states and in the facilities visited is not necessarily representative of the situation throughout Nigeria, making an assessment of the country’s true needs difficult.

Nigeria faces several challenges in relation to its TB microscopy services. These include the decentralization of the procurement of laboratory supplies required for microscopy and the establishment of national supervisory and external quality assessment systems. The plan to expand DOTS to 200 LGAs, providing DOTS services in an additional 5,000 health facilities, will require an increased number of microscopy centers. The use of diagnostic kits may facilitate this expansion and increase case detection, particularly in peripheral rural units.

The request to the GDF to supply the kits was agreed to on the condition that Nigeria participates in the assessment, prepares an implementation plan, and conducts a baseline quality assessment of smear microscopy with a three-monthly repeat exercise during the pilot period in each of the participating laboratories.

**Ordering, Delivery, and Storage of Kits**

The lead time from ordering to delivery of kits was between two and six weeks, and the pre-shipment documents took between four and eight weeks to arrive. After clearance, the kits were received and stored at the Federal Medicines Store, Oshidi, Lagos. The number of kits ordered and those remaining in the store in May 2006 are shown in Table 7.
Table 7. Status of Kits in the Federal Medicines Store, Lagos, Nigeria, May 2006

<table>
<thead>
<tr>
<th>Kit Type</th>
<th>Number of Kits Ordered from GDF</th>
<th>Number of Kits Received, September 2005</th>
<th>Number of Kits Distributed by May 2006*</th>
<th>Number of Kits Remaining in Store, May 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumables Kits (for 1,000 slides)</td>
<td>288</td>
<td>288</td>
<td>251</td>
<td>37</td>
</tr>
<tr>
<td>Sputum collection Containers (1,000)</td>
<td>288</td>
<td>288</td>
<td>178</td>
<td>114</td>
</tr>
<tr>
<td>Equipment Starter kits</td>
<td>45</td>
<td>45</td>
<td>45</td>
<td>0</td>
</tr>
<tr>
<td>Microscope kits</td>
<td>45</td>
<td>45</td>
<td>43</td>
<td>2</td>
</tr>
</tbody>
</table>

* Although only five laboratories were selected to take part in the assessment, the kits were distributed to other microscopy centers in Nigeria. Those data were not made available to the GDF.

Kit Management at the Federal Medicines Store, Oshodi, Lagos

The concept of the kits had not been sufficiently understood by the staff at the store. The individual items inside the kits had been entered in the ledgers; likewise, when issuing kits, all the individual items had to be signed out instead of a kit as a whole.

Because the kits are an unusual item, no bin cards were opened for them, and the quantities in stock could only be established by calculating from the in/out ledgers and converting the number of loose items into kits again, or by making a physical count of the remaining kits in the stores. Fortunately, the kits in the stores had not been unpacked (except for some consumables kits, of which the two inner boxes had been removed from their outer carton), nor had they been broken down into loose items. As far as could be ascertained, the kits had been issued as whole units, despite the way they were recorded in the ledgers.

Several kits were stored upside down despite the marker on the kits, which could be detrimental to the consumables kits if the reagents leak.

The warehouse staff suggested the following improvements in the labeling and packing of the kits—

- Clear indication of the expiry date of the item with shortest shelf life in the kit on the label
- Gross weight and storage conditions noted on the outside of the kits
- Indication of how high boxes can safely be stacked (for example, “do not stack more than six cartons”)
- Use of plastic wrapping for the outside of the kits to prevent damage by rainwater
- Use of straps around the kits to provide additional strength and prevent premature opening by unauthorized workers
• Strengthening of the outer packing of the sputum containers carton, which is too weak

**Suitability of Diagnostic Kits**

**Accuracy of Kit Contents, Superfluous or Missing Items**

Staff at all five sites visited stated that the kits contents were accurate with no superfluous or missing items. Asokoro and Lagos Island Hospital laboratories suggested that disposable gloves, applicator sticks, and spare objectives and eyepieces for the microscope kit be included in the kit.

**Quantity, Quality, and Suitability of Items in Kits**

Only one site (Asokoro) was supplied with all the complete kits; the other four sites received only selected items from the kits when needed or when these items were not available from other sources. All staff reported that the kit items were good quality.

They suggested that the strength of carbol fuchsin be indicated on the label and the concentration of methylene blue be reduced from 3 percent to 1 percent.\(^{17}\) They felt the quantities of some reagents and items were not enough and that increased quantities are needed of methylated spirit, filter paper, lens cleaning tissue, acid alcohol, slide-holding storage boxes, and forceps. However, their needs were difficult to verify because for the most part, they received only individual items from the kit rather than a whole kit.

Some of the items were not suitable for use; for example, the staining rack was too small and could not fit on the laboratory sink,\(^{18}\) the oil dropper bottle had no lid, allowing the oil to dry quickly and block the mouth of the dropper, and the spirit lamp was too small. The microscope light was not bright enough—staff would prefer the Olympus Microscope Model CX31, which is more expensive but known to be of better quality and more suitable for diagnostic laboratories examining large numbers of smears.

**Instructions on Kit Use**

Only four of the five sites received verbal instructions on kit use which were not well understood by the staff. The manuals and wall charts were received in the equipment starter kits, but were not placed on the benches for use. No instructions came in the microscope kit on how to set up the microscope or on how to use the battery and battery charger.

**Staff Orientation and Training in Kit Use**

At one site, only a few laboratory staff members were trained on the use of the kits and because of the rapid staff turnover, those who had been trained were no longer at that laboratory and the new staff were not oriented on the kit. The team observed that all staff members would benefit from refresher training in TB sputum smear microscopy and in use of the kits.

\(^{17}\) NB: The GDF specification to the supplier for the methylene blue stain was 3 grams per liter, equivalent to 0.3 percent. This stain strength was supplied in the kits.

\(^{18}\) The staining rack was not in line with the specifications of the GDF.
Kit Use and Its Impact on Laboratory Practice

The laboratory staff reported that they welcomed the introduction of the kits and that they were of good quality and user-friendly. The ready-to-use stains saved time and were in line with the NTP SOP manual because they used the standard ZN staining method, recommended by the UNION and WHO.

In Lagos, the water supply is erratic and therefore laboratory staff members are unable to prepare distilled water required for stain preparation. Thus, the provision of ready-to-use stains is very welcome. All laboratories reported erratic electricity supply that severely affects their work. The value of using the GDF microscopes with a backup battery that can be charged when the power is on to provide light when the power is off, was welcomed and recognized as crucial. However, because of the lack of orientation in use of the kit, only one site was actually using the battery at the time of our visit.

Effect of the GDF Kits on Quality, Workload, and Time Management

Quality of Smear Microscopy

A quarterly quality assurance system was established and supervisory visits were conducted to improve the quality of smear results, thus reducing the rate of discordant false negatives and false positives, and feedback was given during quarterly meetings. In each of the five laboratories, the QA results indicated that the numbers of false-negative and false-positive results were reduced following the use of the GDF kits. Three hospitals showed improvements in the smear positivity rate, though this result could not be directly attributed to kit use.

Workload and Staff Time Management

The workload and staffing data of the five laboratories visited are shown in Table 8. Assessing the effect of the kits on the change in workload is difficult because the laboratory staff in the Abuja FCT (Asokoro, Maintana, and Nyanya Hospitals) were on strike during November 2005, which accounts for the low workload in the three months before implementation of the kits.

Based on the UNION recommendation that each technician can process and examine 20 sputum specimens per day if he or she has no other duties, the evaluation team concluded that each laboratory had adequate numbers of staff to cope with the smear microscopy workload. After the kits were introduced, laboratory staff were able to reduce the turnaround time for smear microscopy from 96 hours to 48 hours and eliminate backlogs in work. This improvement was partly caused by the easier and quicker reading of well-stained smears under a good-quality microscope and partly by the savings in time originally used to prepare reagents.
### Lessons Learned from Nigeria

The situation in the laboratories visited in Lagos and Abuja States indicates that the use of the laboratory kits, particularly the consumables kit with ready-to-use stains and the microscope kit with a backup battery, would alleviate many of the problems experienced in trying to provide a quality-assured smear microscopy service. However, because the concept of kit use was poorly understood by NTP, laboratory, and stores staff, the maximum benefit was not realized. This finding highlights the need to ensure that the NTP understands and subscribes to using kits rather than seeing them as an alternative supply of consumables and laboratory equipment.

---

**Table 8. Comparison of Baseline (October–December 2005) and Postkit Implementation (January–March 2006) Workload and Staffing Data in Five Hospital Laboratories**

<table>
<thead>
<tr>
<th></th>
<th>Ikeja Hospital (L. South)</th>
<th>Lagos Island Hospital</th>
<th>Asokoro General Hospital</th>
<th>Maintana District Hospital</th>
<th>Nyanya General Hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
</tr>
<tr>
<td>Total number of patients (suspects and follow-up) who had sputum tested</td>
<td>598</td>
<td>562</td>
<td>1020</td>
<td>907</td>
<td>107</td>
</tr>
<tr>
<td>Number of suspects tested</td>
<td>359</td>
<td>271</td>
<td>664</td>
<td>634</td>
<td>82</td>
</tr>
<tr>
<td>Number of suspects with two or three positive smears</td>
<td>107</td>
<td>88</td>
<td>205</td>
<td>322</td>
<td>16</td>
</tr>
<tr>
<td>Smear positivity rate (%)</td>
<td>30</td>
<td>32</td>
<td>23</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Number of follow-up patients</td>
<td>239</td>
<td>291</td>
<td>356</td>
<td>274</td>
<td>27</td>
</tr>
<tr>
<td>Total number of smears examined</td>
<td>888</td>
<td>817</td>
<td>1580</td>
<td>1373</td>
<td>268</td>
</tr>
<tr>
<td>Number of trained laboratory staff available for TB smear microscopy</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Maximum number of smears that could be examined properly in three months with the current staffing level (20 smears/lab staff/working day)</td>
<td>3,900</td>
<td>5,200</td>
<td>10,400</td>
<td>10,400</td>
<td>1,300</td>
</tr>
</tbody>
</table>
5.3 Tajikistan

The initial visit to Tajikistan was conducted in April 2005, with the follow-up visit in February 2006. Visits were made to nine representative laboratories both in Dushanbe and in the rural areas. TB program and laboratory staff completed the questionnaires, which were translated into Russian by Project Hope staff.

The evaluation team acknowledges the key role and input from Project Hope in helping pilot the GDF kits in Tajikistan and actively participating in the assessments. Project Hope provided key information on TB control in Tajikistan and the status of the laboratories, which has been included in this report. Project Hope currently provides major financial and technical support to the national TB programs in Tajikistan and the other Central Asian Republics (CARs). Project Hope has a resident regional laboratory specialist who provides technical oversight to the TB laboratory activities in all five CARs. In Tajikistan, Project Hope has seconded a laboratory specialist to assist with the upgrading and reform of the national TB laboratory services, both for microscopy and for culture and sensitivity testing.

TB Control in Tajikistan

Tajikistan is a landlocked, predominantly mountainous republic in Central Asia. It is divided into four oblasts: Sughd Oblast in the north, Central Oblast with the capital Dushanbe, Khatlon Oblast in the southwest, and the mountainous Gorno-Badakhshan Oblast in the west. The total population in 2004 was estimated at 6.4 million. It is the poorest country in the CAR region, with the lowest per capita gross domestic product among all former Soviet republics. More than 60 percent of population is estimated as living in abject poverty. The breakdown of the Soviet Union and the Civil War (1992–1997) damaged the already weak economic structure and seriously affected the existing health care system. The lack of medicines, lack of functioning equipment, and high turnover of qualified staff resulted in an increase in morbidity, especially in communicable diseases. The large, hierarchically organized Soviet health system was unsuitable for providing adequate care. Recognizing this problem, the Government of Tajikistan has introduced a health sector reform program to strengthen primary health care and specialized hospital.
Tajikistan TB Profile for 2004

Tajikistan TB Burden (2004 estimates)\textsuperscript{19}

- Incidence (all cases/100,000 pop/yr)—177
- Trend in incidence rate (yr)—6.8 percent
- Incidence (SS+/100,000 pop/yr)—80
- Prevalence (all cases/100,000 pop)—277
- Mortality (deaths/100,000 pop/yr)—34
- Prevalence of HIV in adult TB patients (15–49 years)—N/A
- New cases multidrug-resistant TB—8.6 percent
- Previously treated cases multidrug-resistant TB—29 percent

Tajikistan Surveillance and DOTS Implementation (2004)\textsuperscript{20}

- Notification rate (new and relapse/100,000 pop/yr)—70
- Notification rate (new SS+/100,000 pop/yr)—16 percent
- Case detection rate (all cases)—40 percent
- Case detection rate (new SS+)—21 percent
- DOTS notification rate (new and relapse/100,000 pop/yr)—27 percent
- DOTS notification rate (new SS+/100,000 pop/yr)—9.3 percent
- DOTS case detection rate (new and relapse)—15 percent
- DOTS case detection rate (new SS+)—12 percent
- DOTS treatment success (2003 cohort)—86 percent

Tuberculosis is one of the major health problems in the country, and notified cases increased rapidly from 32 per 100,000 population in 1996 to 70 per 100,000 in 2004. In February 2002, the Government of Tajikistan officially adopted the DOTS strategy, which included the integration of TB activities into primary health care. DOTS implementation started in two pilot regions: the capital, Dushanbe, and the Rudaki Rayon (district), covering 13 percent of Tajikistan’s population. By 2004, DOTS coverage was estimated at 32 percent, and although treatment success rates met the global target of 85 percent, the case detection rate remained low. The TB profile for 2004 is shown above.

Financial and Technical Support for the National TB Control Program

The functioning of the national TB laboratory service is fully dependent on external financial support for laboratory equipment and supplies. Microscopes and reagents have been provided by international organizations implementing TB and other health projects and were distributed by the reference laboratory. Different nongovernmental organizations (NGOs) have provided equipment, reagents, and supplies and refurbished laboratories in the DOTS pilot sites. These NGOs include Project Hope, MERLIN (Medical Emergency Relief International), and the U.S.

Centers for Disease Control and Prevention (CDC). Financial support for TB control includes grants from GFATM, the U.S. Government, and UNION (Fidelis grant).

**Organization of TB Services and Microscopy Sites**

Coordination and implementation of TB control activities are the responsibility of the Country Coordination Committee, established by the Government of Tajikistan with participation of representatives from all ministries. To facilitate implementation of the DOTS strategy, the Minister of Health appointed the Deputy Minister of Health as the National TB Coordinator. The Republican TB Center in Dushanbe is the leading institution in the implementation of DOTS strategy. The intermediate level is represented by three oblast TB centers and one city TB center. Rayon TB centers or TB cabinets are involved in case finding and treatment delivery at the peripheral level.

In the former Soviet Union, TB laboratory services were provided through a large network of laboratories countrywide. During that time, in Sughd Oblast alone, which has a population of 2 million, 161 clinical laboratories performed smear microscopy. Because of the shortage of reagents, almost all laboratories stopped work permanently; currently, smear microscopy is available only in DOTS pilot sites supported by donors and NGOs. Thus, the TB laboratory network is no longer established countrywide.

Although the smear microscopy laboratories within DOTS pilot sites were established in accordance with the WHO recommendation of one microscopy center per 100,000 population, the distribution of the workload and location of laboratories do not provide good access for the population covered. For example, three smear laboratories in Dushanbe are located in the same place, and patients coming from the city for smear examination prefer to have their examination at the specialized TB laboratory in the TB center rather than in the polyclinic laboratory that is next door. This has resulted in an overload at the TB center laboratory and underuse of the polyclinic laboratory.

The NTP plans to establish a three-tiered network of TB laboratories with a National Reference Laboratory at central level, seven culture laboratories at intermediate level, and smear microscopy centers in all rayons.

Smear microscopy is free only for patients coming from DOTS rayons. Officially, the TB hospital and DOTS polyclinics do not charge economically disadvantaged patients for laboratory examinations, but if patients want their laboratory test to be done properly, they have to pay the laboratory technician. These patient fees are a major source of income for laboratory staff.

**Staffing and Microscopy Workload**

TB laboratories are staffed by laboratory doctors and technicians. Technicians process and stain the specimens while the doctors perform the microscopy.

The high turnover of laboratory staff is a very serious problem for the NTP. The reasons for this turnover are twofold. First, young people are not motivated to work in TB laboratories because
of the poor working conditions and very low salaries. The government salary of a laboratory technician is about USD 5 per month. As already mentioned, this salary is supplemented with patient fees. The second problem is a gender issue. Work in laboratories is considered a female profession; therefore the majority of the laboratory students in medical colleges are female. However, after graduation, many of them get married and do not continue to work. All laboratory technicians in the DOTS pilot sites have received basic training in smear microscopy and have been given Russian translations of the WHO manuals for smear microscopy. However, Project Hope observed that these actions have not improved the quality of smear microscopy. Some of the technicians, especially among the older generation, do not accept the WHO recommendations and continue to use the methods they are used to, for example, smearing the sputum between two slides, instead of using a loop or stick.

**Laboratory Premises and Safety**

Project Hope told the evaluation team that safety conditions in many microscopy laboratories are not satisfactory. Many laboratories have old and nonfunctioning equipment and furniture, limiting the working area to a minimum and making proper cleaning and decontamination impossible. Although laboratory staff members do have protective clothing, basic laboratory safety practices (for example, correct use of protective clothing, hand washing) often are not met. In terms of safety, sputum collection is done properly, either in sputum collection rooms or outdoors, but the quality of collected samples is not always satisfactory.

Almost all laboratories have problems with water and electricity supply, which limit the use of microscopes to a maximum of one hour per day. The situation is even worse during the winter when there is no power available during the working day.

**TB Microscopy Methods, Current Laboratory Practice, and Constraints**

Smear microscopy is not sufficiently used for case finding, and the number of suspects examined in the first three-quarters of 2004 decreased by 50 percent compared with the same period in 2003. X-rays are still commonly used for diagnosis.

The ZN method of staining is used. All laboratories have sufficient quantities of good-quality stains, prepared and distributed by the Reference Laboratory in Dushanbe. However, this arrangement is not satisfactory for peripheral laboratories, which need to place a separate order for each item and may not receive all items together. Laboratory guidelines for smear microscopy, culture, and drug sensitivity testing have been prepared by the Project Hope team in collaboration with national TB team. Most of the microscopes in use have an internal light source and cannot be used during regular working hours because of the irregular electricity supply.

Internationally recommended registers and forms are used in the DOTS pilot sites and are filled in properly, with some minor exceptions. All laboratories have an additional register where they record laboratory examinations for non-DOTS patients; in most laboratories, those patients represent two-thirds of all smear examinations.
Quarterly reports on the numbers of laboratory examinations performed and smear-positive cases detected are prepared by each laboratory at DOTS sites. However, accurate information on the contribution of the laboratory service to case finding cannot be ascertained because the information provided does not match the TB program quarterly reports. The number of smear-positive cases detected by the laboratory service is higher because smear-positive results are confirmed by retesting in several laboratories. Patients found smear positive at primary health care level are referred to the TB laboratories in dispensaries and TB hospitals. Thus, each laboratory reports the same case as a new smear-positive case.

**Quality Assurance and Supervision**

Regional laboratory coordinators conduct quarterly monitoring visits. Because of the high turnover of trained staff, the TB program does not have capacity to expand monitoring activities in line with the DOTS expansion plan. CDC has conducted training in quality assurance and introduced a blinded rechecking program for smear microscopy.

**Potential Usefulness of GDF Diagnostic Kits in Tajikistan**

Plans for piloting the GDF diagnostic kits were negotiated between the TB control program, Project Hope, and the GDF. This decision was influenced by the identified problems with electricity and water supplies and difficulties with distribution to peripheral laboratories. These major constraints, although affecting the functioning of the TB laboratories, could be alleviated with the use of the kits.

**Ordering, Delivery, and Distribution of Kits**

In January 2005, Tajikistan ordered nine consumables kits, nine equipment starter kits, and five microscope kits through Project Hope. Sputum collection containers were not requested. The number of kits ordered was not related to the number of smear-positive cases detected or the laboratory workload; rather, Tajikistan agreed to distribute this number of kits for piloting. The kits were received in August 2005, distributed, and used in nine health facilities as indicated in Table 9. The kits were piloted for the three-month period of September–November 2005.
Table 9. GDF Diagnostic Kits Distribution Schedule

<table>
<thead>
<tr>
<th>Location</th>
<th>Date Delivered, 2005</th>
<th>Consumables</th>
<th>Equipment Starter Kits</th>
<th>Microscope Kits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dangara Central Rayon Hospital</td>
<td>Aug. 30</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Fharkhor Central Rayon Hospital</td>
<td>Aug. 31</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Vosse TB Control Center</td>
<td>Sept. 1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hamadoni Central Rayon TB Hospital</td>
<td>Sept. 2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Kulyab Oblast TB Center</td>
<td>Sept. 3</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Settlement Hospital, Rudaki DOTS-3 Center</td>
<td>Sept. 5</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Republican TB Control Center (National TB Reference Laboratory)</td>
<td>Sept. 5</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Central TB Hospital, Machiton</td>
<td>Sept. 7</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Dushanbe Polyclinic Number 8</td>
<td>Sept. 8</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>9</td>
<td>9</td>
<td>5</td>
</tr>
</tbody>
</table>

Suitability of Diagnostic Kits

Accuracy of Kit Contents, Superfluous or Missing Items

All items listed on the packing slip were in the kits. When the kits were delivered to each laboratory by Project Hope and the head of the Republican TB Control Center laboratory, the laboratory staff members were given a complete list of the contents and each kit was opened and checked to ensure that all items were present. The laboratory technician had to sign a sheet for the receipt of the items, one copy of which remained in the laboratory. This practice should be encouraged in all countries that will use the kits in the future.

Quantity, Quality, and Suitability of Items

All laboratory staff agreed that the microscope quality is good and that using the internal light source and the mirror provide clear microscopic fields and excellent conditions for microscopy. However, some confusion arose on the use of the rechargeable battery because no instructions were provided for charging the battery and connecting it with the external lamp. In one laboratory (Vosse), the evaluation team observed that the battery charger and battery had been damaged because of improper use. The surge protector could not be used because the connection was unsuitable for Tajikistan.

Laboratory staff made several comments on the equipment starter kit items. They found the 500-milliliter wash bottles for dispensing the stains to be impractical and suggested that these be replaced with 250-milliliter staining bottles. The timer was not convenient to use, and the evaluation team observed that it did not function properly in some of the laboratories. Also, the spirit lamp was too small, and the staining rack was unsuitable for the procedures used for staining smears in Tajikistan. Smears are stained over a plastic basin or other suitable container.
so that the liquids collected in the basin from the staining procedure can be disinfected before disposal in a sink. Some staff members requested that the GDF include suitable basins in the kit.

Several comments were made on the quality and suitability of the items in the consumables kit. Some laboratories reported that the carbol fuchsin ignited during heating, though this finding was not consistent in all laboratories using the kits. Laboratory staff also complained that they found decolorizing the smears with the acid alcohol difficult. They needed to make two or even three applications, which increased the volume required in a kit and resulted in a high percentage of false-negative results caused by the overuse of the acid. In one laboratory (Machiton), the laboratory doctor reported that the immersion oil lost its transparency after examining several slides. All staff reported that the slides were high quality. They had no problems with the methylene blue and methylated spirit.

Instructions on Kit Use

No instructions were provided on the use of the microscope kit or on the use of the lysol disinfectant. No general information was included on the content and specifications of the stains and other reagents. The data sheet contained information only on the toxicity of substances and what to do in case of an accident. Instruction books and wall charts were in English—a Russian version of all the instructions is required for use with the kits.

Staff Orientation and Training in Kit Use

Through technical support from Project Hope, all laboratory staff members have been trained in correct procedures for smear microscopy and quality assurance which help. This fact was beneficial for staff members using the kits. When the kits were delivered to each laboratory, they were opened and inspected by the laboratory supervisor and staff together. Interim reviews after three months of kit use were conducted by the supervisors.

Introduction and Use of Kits and Effect on Laboratory Practice

Improved laboratory practice could not be attributed to the kit use. Very likely, the major improvements result from the activities of Project Hope, which has been supplying some equipment and supplies in addition to technical training and quality control. However, discussion with the laboratory staff made apparent that the kits were most appreciated in the peripheral laboratories. Staff in those laboratories welcomed the idea of being able to order and receive all consumables together in one kit. The current ordering process requires a separate form to be completed for each item, and then the items may not arrive together. In contrast, staff in the reference and central laboratories said they preferred to prepare their own stains from component powders and chemicals. The NTP manager’s opinion was that the kits were too expensive for Tajikistan and that the program would prefer to prepare their own reagents. However, because no cost comparison was available, his statement could not be verified.
Effect of the GDF Kits on Quality, Workload, and Time Management

Quality

Project Hope conducted a quality assessment exercise before and after using the kits in the nine implementing laboratories. Table 10 summarizes the microscopy results from these laboratories. The results indicate more low false positives, high false negatives, and low false negatives after introduction of the kits, although the overall level of these errors is low. Although this increase cannot directly be attributed to the quality of the reagents in the kits, some of the laboratory staff suggested that the possible overdecolorization by using two or three applications of acid alcohol may have contributed to some of the false-negative results.

Table 10. Overall QA Results of Smear Microscopy Before and After Kit Implementation

<table>
<thead>
<tr>
<th></th>
<th>Total Smears</th>
<th>Total SS+</th>
<th>Total SS–</th>
<th>High False Positive</th>
<th>Low False Positive</th>
<th>High False Negative</th>
<th>Low False Negative</th>
<th>Q error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before kits, N</td>
<td>243</td>
<td>75</td>
<td>168</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Before kits, %</td>
<td>2.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.41</td>
</tr>
<tr>
<td>After kits, N</td>
<td>287</td>
<td>119</td>
<td>168</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>After kits, %</td>
<td>1.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: SS+ = sputum smear positive; SS– = sputum smear negative.

Workload and Staff Time Management

The introduction of the kits did not appear to directly affect the laboratory workload and management of staff time. All the laboratories visited appeared to have adequate numbers of staff to deal with the smear microscopy workload. The laboratories are well organized and therefore the introduction of the kits did not require any major reorganization of laboratory practice.

Lessons Learned from Tajikistan

In Tajikistan, which has major problems with electricity supplies, the microscope kits with the backup battery are likely to have countrywide application. The consumables kit appears to have particular application for peripheral laboratories and others that experience difficulties with reagent supplies. As Tajikistan expands its laboratory network, the equipment starter kit may assist in establishing new microscopy centers.

The findings on the kits’ contents, particularly the comments about the stains and minor items of equipment, are particularly helpful to the GDF to ensure that these particular items are modified before further production of the kits.
6. DISCUSSION

This operational study to design and field-test prototype TB laboratory diagnostic kits in the Republic of the Congo, Nigeria, and Tajikistan has shown that these kits are suitable for use in a variety of low-income, high-prevalence settings. If used correctly, they can contribute to improving the quality of smear microscopy and increasing case detection. An additional secondary benefit was the improvement in the morale and motivation of members of the laboratory staff who used the kits, particularly those in peripheral laboratories. Overall, laboratory staff satisfaction with the kits was very high because they contributed to improving the working conditions for TB microscopy.

The assessment in Tajikistan showed that maximum benefit from the kits can be obtained when all staff members receive orientation on the use of the kits and when the kits are used properly. This situation contrasted with the situation in some facilities in the other two countries where no orientation was done and where the kit concept was not fully understood. In the Republic of the Congo and Nigeria, the kits were not distributed to all laboratories as complete kits. Rather, some laboratories received individual items from the kits as an alternative supply source and thus the intended benefit of the kits was not realized. This outcome highlights the need for GDF in-country monitoring before and after supplying the kits.

In all countries, the kits were piloted in a range of laboratories at different levels of the health system. Although potentially useful for all laboratories, staff interviewed in all three countries indicated that the kits were most useful for peripheral laboratories.

The evaluation process assessed the following parameters, which are described earlier in the report—

- Kit content, specifications, and quality
- Required modifications to the specifications to enhance performance and quality
- Packaging, labeling, and shipping
- Clearing and in-country storage of kits
- Procurement issues
- Costs of kits
- The GDF application process for countries to apply for and order kits
- A user-friendly quantification process for countries to easily determine the number of kits required
- Briefing of TB program and laboratory staff
- In-country planning for phased implementation of the kits
- Status of the TB microscopy services before and after implementation of the kits
- Stock control and tracking of kit distribution and use
- Documentation and instructions for using each item in the kits

During the assessment, local circumstances in the countries required the GDF also to address the following—

- Staff orientation and training on use of the kits and in the ZN staining method
- Need for improved management and organization of laboratories to get the maximum benefit from the kits
- In-country supervision and quality monitoring of laboratories
- External monitoring of kit use by the GDF

The benefit of supplying microscopes with a backup battery for use during power cuts was welcomed by all laboratory staff members in each of the pilot countries. Of all the kits, the microscope kit is likely to have a major on availability of smear microscopy and thus contribute to increased case detection.

When the kits were being designed, debate took place on whether to supply ready-to-use stains or component powders and chemicals for preparation of the stains in-country. The benefits of ready-to-use stains have been confirmed by the assessment. Many laboratories experience problems with water and electricity supplies and do not have the equipment or facilities for preparing quality-assured stains. In many peripheral microscopy units, laboratory staff members may not have the competency or time to prepare high-quality stains. Laboratories often experience problems with cumbersome ordering procedures and may not receive all the items required to prepare one stain. Having everything in one box, ready-to-use, improves efficiency.

The different organizations and facilities involved in this assessment have suggested that the GDF should also consider supplying dry powders for stain preparation in-country. The other components to prepare the stains would still need to be supplied—phenol crystals, which are hygroscopic and difficult to store at high temperatures; hydrochloric acid; and methanol. Additional items of glassware would need to be included in the equipment starter kit to enable staff to prepare the stains. However, when sufficient experience has been gained with supplying the current kits with ready-to-use stains, the GDF may want to consider the feasibility of supplying kits with preweighed dry components in addition to the kits with ready-to-use stains and to modifying the Equipment Starter kits to facilitate their use.

The practical experience of piloting the kits in three countries and the recommendations received from international specialists on the quality of fuchsin and safety issues relating to the use of xylene, have helped the GDF to make modifications to the kits and to finalize the contents and specifications (see Annex 1). These changes include increasing the quantities of some items, adding or removing others, and improving the specifications of some items of equipment.
Although samples of all the stains and reagents were quality controlled before release of the kits, the in-country experience indicated that the quality of the stains among the total number of kits supplied to the GDF was not consistent. Action has already been taken to remedy this problem, and the GDF has asked the supplier to change the source of the reagents. Another consideration for the GDF is the viability of the kits initiative in light of the new diagnostics being developed by the Foundation for Innovative Diagnostics (FIND). Although a more sensitive test is urgently required to replace smear microscopy, FIND has informed the authors that a rapid test suitable for use in peripheral health facilities will not be available for some years to come. In the meanwhile, improving the quality and availability of TB diagnosis using traditional smear microscopy must be attempted. The GDF diagnostic kits have the potential to contribute to this goal. In addition, the microscope kits and equipment starter kits may have wider application in the laboratory, for example, in malaria diagnosis.
7. RECOMMENDATIONS

Based on the results of this study on the design and evaluation of TB laboratory diagnostic kits in three countries, the GDF evaluation team recommends that the Stop TB Partnership and the Global TB Drug Facility take action to—

1. Rapidly proceed with arrangements to make the following diagnostic kits available for supply to countries with high prevalence of TB—
   - Consumables kit, with ready-to-use ZN stains, containing sufficient materials to process 1,000 sputum specimens
   - Sputum collection containers, in packs of 1,000
   - Equipment starter kit
   - Microscope kit, with backup rechargeable battery and accessories

2. Adjust the contents and specifications of the kits in line with the results of this study.

3. Ensure that full instructions for use and the specifications for each item are included in each of the kits, as appropriate. Special instructions need to be included in the microscope kit on how to set up and use the microscope, how to charge the battery, and how to use the battery during power cuts. All instructions and kit labels need to be provided in a language suitable for the country using the kits.

4. Because the kits have proven useful for improving the quality of sputum smear microscopy, endeavor to make the kits available both by direct procurement and through grants to eligible countries.

5. Arrange for pre-implementation country visits and post-implementation annual monitoring visits. For cost-effectiveness, these visits would normally be done during the annual pharmaceutical monitoring visits, where feasible.

6. Orient consultants to the laboratory kits, the application process, quantification methodology, and monitoring of their use. In cases of particular need or difficulty, the GDF should consider using the services of laboratory specialists who have received GDF training and orientation.

7. Train and orient TB program and laboratory staff members and those responsible for supply chain management before kit implementation in-country. This training could be done either by GDF consultants or by contracting out to partner organizations.

8. Consider developing an implementation package for orientation and training of NTP managers, heads of laboratory services, and supply chain managers in countries wishing to use the kits.
To promote DOTS expansion in countries with high TB prevalence, the GDF will make the following laboratory diagnostic kits available—

- Consumables kit (with ready-to-use ZN stains)
- Sputum collection containers
- Equipment starter kit (to be used in conjunction with the consumables kit)
- Microscope kit (with rechargeable battery, alternative light source, and accessories)

**Labeling**

For each kit, the exact contents and specifications of all items will be indicated on the outside of the packing carton in three languages (English, French, and Russian) with space for a fourth additional local language upon request. The text will be big enough to be easily read.

**Consumables Kit**

Contains materials sufficient to prepare and stain 1,000 sputum smears

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity per Kit</th>
<th>Specifications/Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Ready-to-use ZN stains</td>
<td>Minimum expiry date of three years. Labels indicate name and strength of each stain, expiry date, storage conditions, and temperature. For carbol fuchsin—additional instruction, <em>Filter carbol fuchsin immediately before use.</em></td>
<td></td>
</tr>
<tr>
<td>1a Strong carbol fuchsin</td>
<td>5 × 1 liter</td>
<td>Prepared from— Basic fuchsin powder 3 g/l Phenol detached crystals 45 g/l 95 percent ethyl alcohol 100 ml/l Distilled water Pack in 5 × 1 liter bottles</td>
</tr>
<tr>
<td>1b Acid alcohol 3 percent v/v</td>
<td>7 × 1 liter</td>
<td>Prepared from— Concentrated hydrochloric acid 30ml/l 95 percent% ethyl or methyl alcohol (970ml/l) Packed in 7 × 1 liter bottles</td>
</tr>
<tr>
<td>1c Methylene blue (3 g/l)</td>
<td>5 × 1 liter</td>
<td>Prepared from— Methylene blue chloride powder 3 g/l Packed in 5 × 1 liter bottles</td>
</tr>
<tr>
<td>2 Industrialized methylated spirit (95 percent methanol)</td>
<td>1 × 2.5 liter</td>
<td>For use in spirit lamp and for heating smears Bottle has appropriate hazard warning label</td>
</tr>
</tbody>
</table>

---

21 Modifications and adjustments to the kit contents and specification were made in July 2006 to take into account the findings from the country pilots as well as the suggestions made by international experts and the laboratory staff in the Republic of the Congo, Nigeria, and Tajikistan.
### Table 1: Specifications and Use of Consumables Kit

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity per Kit</th>
<th>Specifications/Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Immersion oil</td>
<td>5 × 20 ml</td>
<td>Nondrying—suitable for tropical countries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Packed in 5 × 20 ml “dropper” bottles, which dispense drops of 0.1 ml</td>
</tr>
<tr>
<td>4 Lysol, 5 percent disinfectant solution</td>
<td>5 × 1 liter</td>
<td>Lysol, 5 percent solution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Instructions for use on label of each bottle</td>
</tr>
<tr>
<td>5 Microscope slides</td>
<td>20 boxes of 50 slides</td>
<td>Microscope slides, washed glass, 76 × 26 mm, 1.1–1.3 mm thick</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Packed in 20 boxes of 50 slides</td>
</tr>
<tr>
<td>6 Filter paper</td>
<td>1 box/100 circles</td>
<td>Whatman no. 1, 24 cm diameter.</td>
</tr>
<tr>
<td>7 Lens cleaning tissue</td>
<td>2 pkts/100 tissues</td>
<td></td>
</tr>
<tr>
<td>8 Waterproof marker pens</td>
<td>2</td>
<td>Black, fine tip</td>
</tr>
<tr>
<td>9 Gloves</td>
<td>3 boxes/100 gloves</td>
<td>Disposable, nonsterile, not powdered; one pair each of small, medium, large</td>
</tr>
<tr>
<td>10 GDF inventory list</td>
<td>2 copies</td>
<td>List of all items in English, French, and Russian</td>
</tr>
</tbody>
</table>
| 11 Instruction leaflet and product information | 1 | Leaflet with details of all items together with instructions for storage and use in English, French, and Russian. The leaflet provides the following information—  
(1) Exact composition and description of each of the stains (carbol fuchsin, acid alcohol, methylene blue)  
(2) Optimal storage conditions (including temperature) for each of the stains  
(3) Instruction that carbol fuchsin must be filtered immediately prior to use  
(4) Instructions for storage and use of the Lysol disinfectant  
(5) Instructions for storage and use of industrialized methylated spirit  
(6) Laboratory procedures  
(7) Indications for use  
| 12 Material safety data sheets    | 1               | Per each product                                                                                                                                                                                         |

### Labeling:

Each item is clearly labeled in English, French, and Russian with space for fourth additional local language upon request. All stains and chemicals have appropriate chemical hazard warning labels.

### Sputum Collection Containers

For each consumables kit ordered, the GDF will automatically supply 1,000 screw-capped, wide-mouth, disposable sputum collection containers, unless the applicant indicates that these are not required. The containers will be packed separately from the laboratory reagents in order to permit direct distribution to health facilities attended by TB suspects and patients for collection of sputum specimens. Sputum specimens can then be forwarded to the nearest microscopy center.
Specifications

- Screw cap, leak-proof, single use, combustible material, translucent with easily labeled wall panel, wide mouth (at least 45 mm in diameter), volume = 50 ml minimum
- Packed in cases of 1,000
- Packing box contains two copies of the GDF Inventory List in English, French, and Russian
- Supplier’s packing list and product specification

Equipment Starter Kit

Minor laboratory equipment for use with consumables kit

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity per Kit</th>
<th>Specification</th>
</tr>
</thead>
</table>
| 1 WHO publications: *Laboratory Services in Tuberculosis Control*  
Books are available in English, French, and Russian. GDF will advise which language is most suitable for each country receiving the kits, so that the appropriate language is supplied with each individual order. |
| 2 Laminated wall chart: ZN staining procedure | 1 | 56 × 43 cm Japan International Cooperation Agency publication. Available in English, French, and Russian. GDF will advise which language is most suitable for each country receiving the kits, so that appropriate language is supplied with each individual order. |
| 3 Beaker | 2 | 250 ml, borosilicate, heavy duty, heavy banded rim, for general laboratory use. |
| 4 Filter funnel 150mm diameter | 1 | Polypropylene |
| 5 Filter funnel 160mm diameter | 1 | Polypropylene |
| 6 Filter funnel 40mm diameter | 2 | Polypropylene |
| 7 Wash bottles | 6 | Polythene, 250 ml capacity, with drip-free spout and screw-on cap. |
| 8 Wire loop holder with heat-resistant handle | 2 | To hold Nichrome wire inoculating loop. |
| 9 Nichrome wire inoculating loops | 75 | Wire loops, volume 2.5 microliters. Internal diameter = 2.5 mm. |
| 10 Spirit lamp | 2 | Glass alcohol lamp with screw-top lid, volume 200 ml with complete cotton wick. |
| 11 Roll of cotton wick for spirit lamp | 1 | Spare wick for spirit lamp |
| 12 Slide holding storage boxes | 6 | Plastic/100 microscope slides per box |
| 13 Slide drying rack | 2 | Plastic racks each to hold 50 slides |
| 14 Diamond slide marker | 1 | With pouch |
### Microscope Kit with Accessories

The microscope is intended to be connected and operated from a country’s main electrical system. Because of continental differences in power supply, two specifications are available—(1) for use with 210/250 volts, and (2) for use with 110/125 volts. In addition, many countries have unreliable or intermittent power supplies. Voltage fluctuations, spikes, brownouts, and sudden power cuts are common. Therefore a robust surge protector, 12-volt battery (to provide a backup power supply), and alternative light source are also included in the kit. A mains charger is provided for charging the battery when the power is on.

For every individual order, the GDF will indicate the electrical specifications in the country of destination and the shape of the plugs. The microscope and all electrical accessories will be fitted accordingly.

**1 × Olympus microscope CX21 BIM set**

*Microscope includes the following items—*

- Microscope stand with dustproof adjustable halogen light source, 6 volt 20 watt
- Revolving quadruple nosepiece
- Mechanical stage with right-hand low drive controls
- General purpose Abbe condenser, NA = 1.25
- Binocular observation tube inclined, 30 degrees with interpupillary distance 50mm–75mm (with constant tube length adjustment)
• 2 eyepieces 10× (FN 18 antifungus), diopter adjustment, suitable for glasses-wearing operators

• 4 plan achromatic objectives with magnification of 4X, 10X, 40X, and 100X with sufficient resolution and flatness in the field to make the microscope suitable for routine diagnostic work, education, and training

• 2 × 6 volt 20 watt spare halogen bulbs

• One gray conductor with a gray plug at both ends

• Transparent microscope cover

• Manufacturer’s instruction manual

### Accessories

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Minimum Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surge protector—automatic voltage protector</td>
<td>1</td>
<td>Automatic voltage protector suitable for use with both microscope and battery charger.</td>
</tr>
<tr>
<td>12 volt battery unit</td>
<td>1</td>
<td>12 volt, 6 amp, maintenance-free lead acid battery unit that, when fully charged, provides approximately three hours of running time for the microscope.</td>
</tr>
<tr>
<td>Charger</td>
<td>1</td>
<td>To charge the 12 volt battery from the main electricity supply. a) 210/250 volt b) 110/125 volt As per microscope specification</td>
</tr>
<tr>
<td>External illumination lamp stand with 12 volt, 21 watt lamp</td>
<td>1</td>
<td>To replace natural sunlight. Terminals of lamp are protected to avoid short circuiting during use.</td>
</tr>
<tr>
<td>Mirror unit</td>
<td>1</td>
<td>Interchangeable with the lamp unit. To be used in conjunction with the external illumination lamp or as an alternative natural light source when neither mains nor battery power is available.</td>
</tr>
<tr>
<td>Spare bulbs for halogen quartz lamp</td>
<td>10</td>
<td>6 volt, 20 watt</td>
</tr>
<tr>
<td>Spare bulbs for external light source</td>
<td>10</td>
<td>12 volt, 20 watt</td>
</tr>
<tr>
<td>Spare fuse for microscope</td>
<td>10</td>
<td>500mA</td>
</tr>
<tr>
<td>Storage box</td>
<td>1</td>
<td>Wooden, lockable</td>
</tr>
<tr>
<td>Self-indicating silica gel</td>
<td>1 × 100 g sachet</td>
<td>In nonwoven cloth with instructions for the user in English, French, and Russian</td>
</tr>
<tr>
<td>Packing list and product specification</td>
<td>1</td>
<td>Specifications of all items in the microscope kit in English, French, and Russian</td>
</tr>
<tr>
<td>Item</td>
<td>Quantity</td>
<td>Minimum Specification</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Instruction manual</td>
<td>12</td>
<td>Detailed, step-by-step instructions in English, French, and Russian, on the following—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1) How to set up the microscope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Routine use of the microscope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3) Routine cleaning and maintenance of the microscope, including changing the bulbs and fuse</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4) Storage of the microscope and use of the silica gel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5) How to charge the battery from the mains</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6) How to care for the battery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(7) How to connect the charged battery to the external lamp</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(8) How to use the external lamp with mirror during power failures.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(9) How to use the mirror when neither mains or battery is available</td>
</tr>
<tr>
<td>GDF inventory list</td>
<td>12</td>
<td>In English, French, and Russian</td>
</tr>
</tbody>
</table>
ANNEX 2. CALCULATION TOOL TO DETERMINE THE QUANTITY OF CONSUMABLES KITS AND SPUTUM CONTAINERS TO BE ORDERED

| Enter the total number of new smear-positive patients diagnosed in the last 12 months | Average smear positivity rate in your country during the last 12 months (select one of the following options: 10%, 15%, 20%). IF THE RATE IS NOT KNOWN, SELECT 10% | Factor | A = Total number of TB laboratory consumables kit A required for 1 year (automatic calculation) | B = Required buffer stock. Multiply A × 1 (automatic calculation) | C = Number of kits with expiry date not less than 1 year in central store | D = Total quantity of kits to be ordered = A + B – C (automatic calculation) | E = Number of sputum containers to be supplied (automatic calculation) |
|---|---|---|---|---|---|---|---|---|
| a | 10% | 36 | \(a \times 36/1,000\) | A | A + B – C | D × 1,000 |
| b | 15% | 27 | \(b \times 27/1,000\) | A | A + B – C | D × 1,000 |
| c | 20% | 21 | \(c \times 21/1,000\) | A | A + B – C | D × 1,000 |

Example:

<table>
<thead>
<tr>
<th>Total number of new smear-positive patients diagnosed in last 12 months</th>
<th>Average smear positivity rate</th>
<th>Factor</th>
<th>A = Total number of TB laboratory consumables kit A required for 1 year (automatic calculation)</th>
<th>B = Required buffer stock. Multiply A × 1 (automatic calculation)</th>
<th>C = Number of kits with expiry date not less than 1 year in central store</th>
<th>D = Total quantity of kits to be ordered = A + B – C (automatic calculation)</th>
<th>E = Number of sputum containers to be supplied (automatic calculation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,000</td>
<td>10%</td>
<td>36</td>
<td>(2,000 \times 36/1,000 = 72) kits</td>
<td>72</td>
<td>0</td>
<td>144</td>
<td>144,000</td>
</tr>
<tr>
<td>2,000</td>
<td>15%</td>
<td>27</td>
<td>(2,000 \times 27/1,000 = 54) kits</td>
<td>54</td>
<td>0</td>
<td>108</td>
<td>108,000</td>
</tr>
<tr>
<td>2,000</td>
<td>20%</td>
<td>21</td>
<td>(2,000 \times 21/1,000 = 42) kits</td>
<td>42</td>
<td>0</td>
<td>84</td>
<td>84,000</td>
</tr>
</tbody>
</table>

The calculations are based on the assumption that 5ml of each stain is needed for each sputum smear. Each kit will contain materials to prepare and stain 1,000 slides. Kits will contain 5,000ml of each stain and 1,000 glass slides. 1,000 sputum collection containers will automatically be supplied for each Consumable A kit ordered unless otherwise specified.

**Assumptions:**

1) **If 10 percent of examined TB suspects are smear positive**, each smear-positive case will have a total of 9 slides examined (3 diagnostic, 2 at 2/12 follow-up, 2 at 5/12 follow-up, and 2 at 7/12 follow-up). For each new smear-positive case, there will be 9 smear-negative cases, each of whom will have 3 smears examined. Therefore for every smear-positive case detected, a total of 36 smears will be examined.
2) If 15 percent of examined TB suspects are smear positive, each smear-positive case will have a total of 9 slides examined (3 diagnostic, 2 at 2/12 follow-up, 2 at 5/12 follow-up, and 2 at 7/12 follow-up). For each new smear-positive case there will be 6 smear-negative cases, each of whom will have 3 smears examined. Therefore for every smear-positive case detected, a total of 27 smears will be examined.

3) If 20 percent of examined TB suspects are smear positive, each smear-positive case will have a total of 9 slides examined (3 diagnostic, 2 at 2/12 follow-up, 2 at 5/12 follow-up, and 2 at 7/12 follow-up). For each new smear-positive case there will be 4 smear-negative cases, each of whom will have 3 smears examined. Therefore for every smear-positive case detected, a total of 21 smears will be examined.
<table>
<thead>
<tr>
<th>TB Microscopy Center</th>
<th>Responsible Institution</th>
<th>Rural/Urban</th>
<th>Number of GDF Consumables Kits</th>
<th>Date Consumables Kits Delivered, 2005</th>
<th>Number of GDF Sputum Container Kits</th>
<th>Date Sputum Containers Delivered, 2005</th>
<th>Number of GDF Equipment Starter Kits</th>
<th>Date Equipment Starter Kits Delivered, 2005</th>
<th>Number of GDF Microscope Kits</th>
<th>Date Microscope Kits Delivered, 2005</th>
<th>How Were Kits Transported to Health Facility?</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAT Brazzaville</td>
<td>PNLT</td>
<td>U</td>
<td>5</td>
<td>June 13</td>
<td>1</td>
<td>June 13</td>
<td>1</td>
<td>June 22</td>
<td>1</td>
<td>June 22</td>
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</tr>
<tr>
<td>Makélékélé</td>
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<td>U</td>
<td>2</td>
<td>Aug. 2</td>
<td>2</td>
<td>Aug. 2</td>
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<td>Car</td>
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<td>July 4</td>
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<td>CSI</td>
<td>U</td>
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<td>Car</td>
<td>Car</td>
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<tr>
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<td>4</td>
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<td>July 4</td>
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<td>July 4</td>
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<tr>
<td>Tie Tie P-N.</td>
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<td>July 4</td>
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<td>Air and car</td>
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<tr>
<td>Mpaka Centre de Santé Intégré, P-N.</td>
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<td>1</td>
<td>?</td>
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<td>Loandjijili Centre de Santé Intégré, P-N.</td>
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<td>Air and car</td>
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<td>TB Microscopy Center</td>
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<td>Rural/Urban</td>
<td>Number of GDF Consumables Kits</td>
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<td>Number of GDF Equipment Starter Kits</td>
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<td>Number of GDF Microscope Kits</td>
<td>Date Microscope Kits Delivered, 2005</td>
<td>How Were Kits Transported to Health Facility?</td>
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<td>Kits in store in Pointe-Noire</td>
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<td>Kits that could not be accounted for at time of follow-up visit</td>
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<td></td>
<td></td>
<td></td>
<td>219 220 5 0</td>
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</tbody>
</table>

* One microscope kit missing in Pointe-Noire.

PNLT = National Tuberculosis Control Program; CSI = Centre de Santé Intégré; CENAMES = Central Medical Store