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Structured assessment of healthcare facilities and knowledge, attitudes and practices of healthcare workers regarding tuberculosis infection control in Moyen-Ogooué, Gabon

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Dedication

To my parents, who encouraged me to explore the world.

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Abbreviations

AC	-	Air conditioning
ACSM	-	Advocacy, communication and social mobilization for tuberculosis control
AIDS	-	Acquired immune deficiency syndrome
BCG	-	Bacille Calmette-Guérin
BELE	-	Base d'épidémiologie
CDC	-	Centers for Disease Control and Prevention
CDT	-	Centre de Traitement
CERMEL	-	Centre de Recherches Médicales de Lambaréné
CHRGR	-	Centre Hospitalier Régional "George Rawiri"
CNAMGS	-	Caisse Nationale d'Assurance Maladie et de Garantie Sociale
CNSS	-	Caisse Nationale de Sécurité Sociale
CTA	-	Centre de Traitement Ambulatoire
DOTS	-	Directly Observed Therapy Short course
DRS	-	Directeur Régional de la Santé
DR-TB	-	Drug-resistant tuberculosis
DST	-	Drug sensitivity testing
ED	-	Emergency department
EPTB	-	Extrapulmonary tuberculosis
FAST	-	Find cases Actively by cough surveillance and rapid molecular sputum testing, Separate safely and Treat effectively
GNI	-	Gross National Income
HAS	-	Hôpital Albert Schweitzer
HCW	-	Healthcare workers
HIV	-	Human immunodeficiency virus
IM	-	Internal medicine ward
KAP	-	Knowledge, Attitude and Practice

LTBI	-	Latent tuberculosis infection
MDR-TB	-	Multi-drug resistant tuberculosis
MT	-	MDR-TB treatment unit
MTB	-	*Mycobacterium tuberculosis*
NA	-	Not applicable
OPD	-	Outpatient Department
PD	-	Pediatric ward
PNLT	-	Programme Nationale de Lutte contre la Tuberculose
PPE	-	Personal protective equipment
PTB	-	Pulmonary tuberculosis
RH	-	Rifampicin and Isoniazide
RHRU	-	Reproductive Health and HIV Research Unit of the University of the Witwatersrand, South Africa
RHZE	-	Rifampicin, Isoniazide, Pyrazinamide and Ethambutol
RR-TB	-	Rifampicin-resistant tuberculosis
SDG	-	Sustainable development goals
TB	-	Tuberculosis
TBIC	-	Tuberculosis infection control
UVGI	-	Ultraviolet germicidal irradiation
WHO	-	World Health Organization
XDR-TB	-	Extensively drug-resistant tuberculosis

1. Introduction

1.1 Tuberculosis

Tuberculosis (TB) is an infectious disease that caused more deaths in the last 200 years than any other infectious disease [1]. Throughout history TB has been known as a disease of poverty and is until today affecting the most vulnerable populations in the world [2, 3].

In 1993 the World Health Organization (WHO) declared TB as a public health emergency and since then global efforts have been made to control the disease. With the human immunodeficiency virus (HIV) pandemic fuelling the spread of TB disease and furthermore the emergence of drug-resistances, even greater challenges in the fight against TB have come up. Although the United Nation's Millennium Development Goal of "halting and reversing" TB incidence by 2015 was achieved on a global level, the global decline of the incidence rate is still slow and TB remains one of the deadliest infectious diseases in the world [4].

1.1.1 Introduction to the disease

Tuberculosis is an infectious disease that in most cases affects the lungs and is then called pulmonary TB. It is caused by genetically similar mycobacteria, which are together referred to as *M. tuberculosis* (MTB) complex. The MTB complex includes *M. tuberculosis*, which is the most frequent cause of TB in humans, *M. bovis*, *M. africanum, M. microti* and *M. canetti [5]*.

TB is predominantly transmitted through infectious droplet nuclei in the air, which are produced by infected individuals while coughing, sneezing or talking. These aerosolized expectorations contain MTB and can remain in the air for several hours and once inhaled by another person, they can cause TB infection. The infectiousness of a person with TB depends amongst other factors on the bacillary load found in the sputum. Furthermore, the probability of transmission depends on the duration of exposure, the immune status of the person exposed and the environment where the exposure took place.

Most immunocompetent individuals are able to clear the infection or remain in an inactive stage, which is asymptomatic and not contagious. This is referred to as latent tuberculosis infection (LTBI). It is estimated that one third of the world population are infected with TB in this latent stage [6]. The lifetime risk of the infection progressing to active TB is estimated to be 5-15% for an immunocompetent person. In individuals that are immunocompromised due to HIV-coinfection, malnutrition or other immunosuppressive causes, the risk of developing an active symptomatic TB infection is much higher. For example, in HIV-infected persons, the risk of developing progressive disease is 20-30 times higher than in healthy individuals. It is estimated that a person with active TB disease can infect 10-15 other people within one year [7].

Typical symptoms of active pulmonary TB are persistent cough, weight loss, fever, night sweats and hemoptysis [8]. In case of extrapulmonary TB (EPTB), the clinical manifestation depends on the respective location and can involve a wide range of symptoms.

The standard treatment regimen of drug-susceptible pulmonary TB is a six months course, comprising a two months initial phase with rifampicin, isoniazide, pyrazinamide and ethambutol (RHZE) and a four months continuation phase with rifampicin and isoniazid (RH) [9].

In case of rifampicin-resistant TB or multidrug-resistant TB, treatment with second line drugs is necessary.

1.1.2 Diagnostic tests

The main diagnostic tests for active TB include Chest X-rays, sputum smear microscopy and culture. In addition, since 2010 the WHO endorses a new molecular diagnostic test called Xpert® MTB/RIF assay.

Chest x-rays are often used as a first indicator if active TB in presumed cases, since the majority of patients with pulmonary TB shows typical radiographic abnormalities.

Sputum smear microscopy is the oldest and most frequently used method to diagnose pulmonary TB, particularly in low- and middle-income countries. The acid-fast mycobacteria need special staining. The Ziehl-Neelsen stain is the most conventional staining for the detection of mycobacteria and slides can be read with an ordinary microscope. Although this method is very specific, it has with 54 – 64% a comparatively low sensitivity [10]. A more sensitive and equally specific method is the fluorochrome staining with auramine. However, this method requires special fluorescence microscopes.

Culture remains the gold standard for diagnosing TB. However, it takes several weeks for a definite result. Culture also allows Drug sensitivity testing (DST) and is therefore indispensable for the diagnosis of drug-resistant TB.

The Xpert® MTB/RIF assay allows the detection of MTB complex and rifampicin resistance by nucleic acid amplification within two hours. The sensitivity for sputum smear-positive cases is 98%. If used as an additional test after a negative microscopy result, Xpert® MTB/RIF has a sensitivity of 67% and increases TB detection among culture-positive cases by 23% [11]. Thus, Xpert® MTB/RIF is an excellent add-on test, but cannot replace sputum smear microscopy, culture or clinical evaluation of the patient. It is particularly recommended for testing people living with HIV and children, who have often sputum smear-negative results. In combination with the simultaneous testing for rifampicin resistance, which can serve as a proxy for MDR-TB, Xpert® MTB/RIF can contribute to the rapid detection of TB and thus early effective treatment initiation, which consequently reduces the risk of TB transmission (see section 1.5.3).

1.1.3 Global epidemiology

In 2016, there were 10.4 million incident TB cases worldwide, out of which 10% were among people living with HIV. In the same year, there were 490 000 new cases of TB that is resistant to the two major anti-tuberculosis drugs rifampicin and isoniazide, so-called multidrug-resistant TB (MDR-TB). In addition, 110 000 people were diagnosed with rifampicin-resistant TB (RR-TB). Out of the total of

600 000 of drug-resistant TB cases, which are eligible for second line treatment, only 22% were enrolled [12].

The number of new TB cases reported to the WHO increased between 2013 and 2016, which can be attributed to higher notification rates, most notably in India. However, there is still a 4.1 million gap between the estimated incidence and notified cases.

Despite decreasing absolute numbers of TB deaths since the year 2000, TB remains the world's deadliest disease from a single infectious agent and is a leading cause of death in people infected with HIV. In 2016, it killed an estimated 1.3 million people and another 374 000 people living with HIV [12].

1.2 Strategies to fight TB

1.2.1 Patient-focused strategies

After TB had been declared as a public health emergency, the WHO introduced 1994 the so-called DOTS strategy, which is a framework for effective TB control and stands for "Directly Observed Therapy, Short course". One of its key operations is to establish directly supervised treatment services and patient education in primary health care facilities. Other operations include the establishment of national TB programs, standardized recording and reporting systems and regular supply of drugs and diagnostic material [13].

1.2.2 Global strategies

In 2015, a new era of global efforts to fight the TB epidemic has begun. In September 2015, 17 Sustainable Development Goals (SDGs) were adopted by the United Nations (UN) for the period of 2016 to 2030. In the SDG3 target 3.3 the goal to "end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases" by 2030 was set [14].

In 2000, the *Stop TB partnership*, an international organization linked to the World Health Organization (WHO), was founded and the Stop TB Strategy developed, which was succeeded by the End TB strategy in 2015. In the wake of the SDG and as a new post-2015 Global TB Strategy; the End TB strategy,

spanning the 2016 to 2035 period was elaborated and approved unanimously by the World Health Assembly in 2014. This strategy is closely linked to the SDGs and shares the overall target to end the global TB epidemic. The final targets are to reduce the absolute number of TB deaths and the incidence by 95% and 90% respectively by 2035 and to ensure that no household faces catastrophic costs due to TB from the first milestone in 2020 onwards [15].

The End TB strategy is hinging on three main pillars:

- Pillar 1: Integrated, patient-centered TB care and prevention
- Pillar 2: Bold policies and supportive systems
- Pillar 3: Intensified research and innovation

One of the key components of pillar 2 is to strengthen health policies and systems to prevent and end TB and to support the implementation of regulatory frameworks for, amongst others, infection control.

1.3 Gabon's healthcare system

1.3.1 Introduction to the country

Gabon is located at the equator in central Africa and has a population of 2 million inhabitants, of which about 87% live in urban areas. Approximately 88.5% of the country is covered by rain forest, which makes transport and access outside the main road axes difficult [16].

Gabon's economy is mainly based on the export of oil and tropical woods. Because of its high gross national income (GNI) per capita, the World Bank classifies Gabon as an upper middle-income country [17]. However, one third of the population is living below poverty level and the national income is extremely unequally distributed [18].

Life expectancy is 65.8 years for women and 63.1 years for men [16]. Despite the increasing burden of non-communicable diseases like cancers, cardiovascular and chronic respiratory diseases, infectious diseases like HIV/AIDS, Malaria and TB are still amongst the leading causes of death [19].

1.3.2 Administrative structure of the healthcare system

The healthcare system in Gabon comprises ten sanitary regions (Libreville-Owendo, Ouest, Sud-Est, Centre, Centre-Sud, Sud, Est, Centre-Est, Maritime and Nord) and 52 sanitary districts.

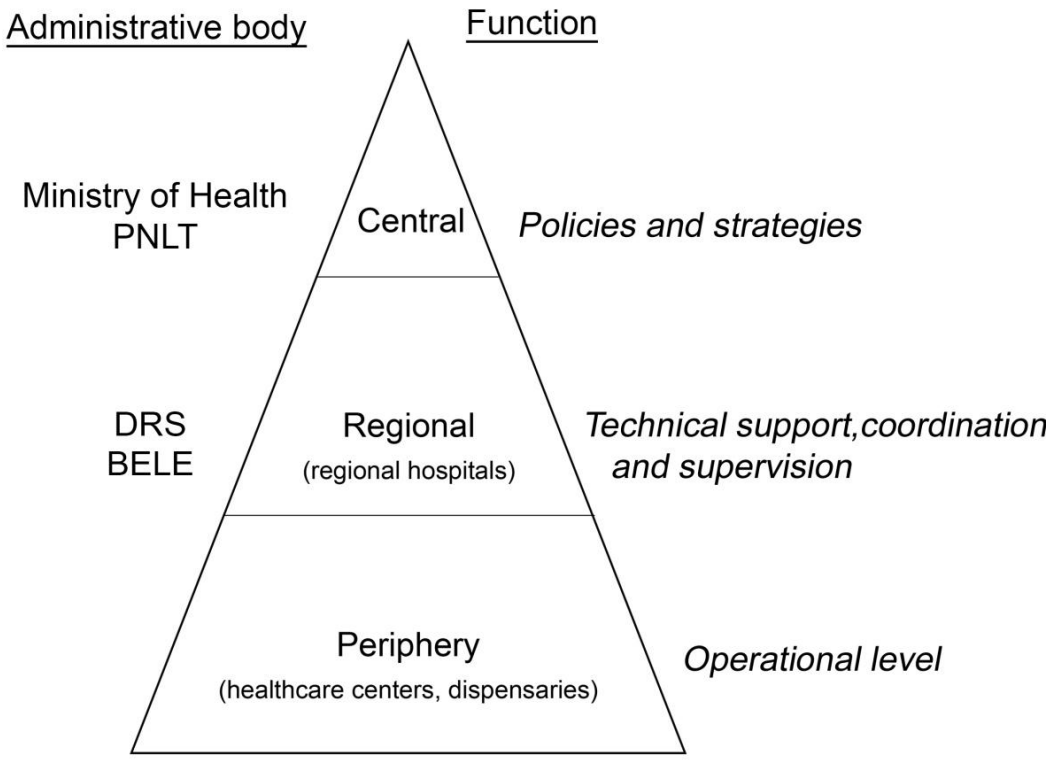
The healthcare system is organized in three sectors: the public sector, encompassing civil and military healthcare structures, the para-public sector, represented by the Caisse Nationale de Sécurité Sociale (CNSS) and the private sector, comprising the profit oriented, non-profit and traditional healthcare sectors.

The non-profit private sector is represented principally by the Albert Schweitzer Hospital in Lambaréné in the Moyen-Ogooué province (Centre) and the evangelist missionary Hospital of Bongolo in Lebamba, in the province of Ngounie (Centre Sud).

As shown in Figure 1, the public civil sector is organized as a pyramidal system comprising the central, regional and periphery care levels. National policies and strategies are developed at the central level, coordinated by the Ministry of Health and, as far as TB control is concerned, by the director of the national TB control program (PNLT).

The sanitary region is the intermediate level, responsible for technical support coordination and supervision of the sanitary districts**.** Its authority comprises the regional health directorate (DRS), the regional hospital and the Base d'épidémiologie (BELE), which is in charge of collecting epidemiological data and implementing the national TB strategies.

The sanitary districts represent the most peripheric operational care unit in the healthcare pyramid and are therefore closest to the population. Their operating facilities comprise various healthcare centers and dispensaries.



Graph 1 'Healthcare pyramid' of Gabon

PNLT: Programme Nationale de Lutte contre la Tuberculose, DRS: Directeur Régional de la Santé, BELE: Base d'épidémiologie

The sanitary region Centre corresponds to the Moyen-Ogooué province and is sub-divided into the sanitary departments Ogooué et Lacs and Abanga Bigne. According to the latest unpublished data from 2016 (provided by the DRS), the sanitary region Centre comprises 55 healthcare facilities, including two hospitals, one HIV clinic, two medical centers, three health centers, thirteen infirmaries, 31 dispensaries and three other healthcare facilities.

1.3.3 Deficits and challenges

Healthcare in Gabon is highly centralized. In rural communities, dispensaries provide the only direct access to primary healthcare, and resources are very limited. Due to the insufficient budget allocated to these facilities, basic material is often missing and maintenance is not performed. In most dispensaries, there is only one assistant nurse in charge for consultations and there are no

diagnostic means available. A small range of medication such as analgesics, anti-malarial drugs and certain antibiotics can be provided by the dispensary. However, patients who need special diagnostics and care have to be referred to the next hospital, which is often far to reach. Since transport is expensive and not affordable for a large part of the rural population, access to healthcare is often delayed or even impossible.

The lack of comprehensively trained healthcare staff is another challenge in Gabon. Especially outside the capital, there is an urgent need for physicians and trained nurses. As mentioned above, consultations in dispensaries are often performed by assistant nurses, who are not adequately trained. The correct recognition of severe medical conditions such as TB at a periphery level and thus the need of referral to a higher-level hospital is therefore highly questionable.

Furthermore, hospitals and laboratories are often insufficiently equipped. Many diagnoses are only clinically based, as often no adequate laboratory procedures or other diagnostic tests are available. In addition, drug-stock outs are common, posing unique challenges for long term treatment, such as for HIV or TB.

1.4 TB control in Gabon

1.4.1 Epidemiology

Alongside HIV and malaria, TB is one of the leading causes of death in Gabon and a major threat to public health. With an estimated incidence of 485 per 100,000 population in 2016 [12], Gabon is among the ten countries with the highest TB incidence in the world.

Only little systematic data on TB epidemiology in Gabon is available and reporting systems are not consistent. Consequently, most data available can only be regarded as estimates and do not necessarily depict the real situation.

In 2016 there were a total of 6,036 TB cases notified, of which 92% were pulmonary TB. Out of the latter 47% were bacteriologically confirmed and an estimated 230 were MDR/RR-TB cases, for which the resistance was laboratory

confirmed in 30 cases only. The total treatment coverage was estimated to be 58% [20].

According to the WHO, 54% of the TB patients in 2016 had been tested for HIV and 21% were found to be co-infected with HIV. However, for 46% of the TB patients the HIV status was unknown [20]. A retrospective study conducted in Lambaréné, evaluating 729 hospitalized TB patients between 2008 and 2011 found a co-infection rate of 34 % [21] and the so-called Panepi study, which was conducted by Bélard et al. in Lambaréné between 2012 and 2014 revealed an even higher rate of 42% [22]. This emphasizes the enormous impact of HIV co-infection on TB control.

1.4.2 National tuberculosis program

Gabon's national TB control program "*programme national de lutte contre la tuberculose*" (PNLT) was founded in 1997 and has as its general objective to reduce the TB mortality, morbidity and transmission until TB stops posing a threat to Gabon's public health, in line with the global Stop TB strategy [23].

The PNLTs specific objectives are:

- To detect at least 70% of TB cases
- To cure at least 85% of detected TB cases
- To reduce the lost-to-follow-up rate to under 5%
- To reduce the mortality rate to under 5%
- To ensure clinical and psycho-social support in cases of co-infection TB/HIV
- To ensure the support of MDR-TB
- To ensure TB infection control

Although the PNLT officially adapted the Stop TB strategy, it failed to implement DOTS in the country. However, the PNLT aims to contribute to the strengthening of the healthcare system in terms of human resources, finances and improved reporting systems, to ensure comprehensive data collection. The

provision of adequate training for healthcare personnel and the promotion of research are indicated as further key activities of the PNLT.

The PNLT's strategy targets all levels of the healthcare system. While healthcare centers on the central and regional level are responsible for diagnosis, management of TB drug supplies and case notifications, the periphery facilities represent the operational care level. Hence, they play a crucial role in TB control and need to be equipped accordingly. According to the PNLT, their tasks include the identification of patients with symptoms suggestive of TB, their referral to a diagnosis and treatment center (CDT), contact screening of index cases, treatment surveillance and social mobilization in the communities.

1.4.3 Major challenges in TB control

1.4.3.1 Limited access to diagnostics and care

A great part of the population has no access to primary healthcare services due to a lack of financial means. As in most provinces of the country there are no CDTs for TB, the access to diagnostic and treatment initiation is very limited. The often long distance accompanied by high transport costs to the closest treatment center has a strongly negative impact on the treatment adherence. A far distance to the treatment center has been associated with treatment interruption and identified as a risk factor for unfavorable treatment outcome in the Panepi cohort [22]. To enable the implementation of DOTS, adequate community based TB care would have to become available.

Although case notification rates for all forms of TB are increasing, a considerable part is still based exclusively on clinical diagnosis. There is an urgent need for a comprehensive laboratory network covering all provinces of Gabon.

1.4.3.2 Insufficient case management and treatment outcomes

With a treatment success rate of only 50% in 2015 [20], rates are still far from the PNLTs minimum target of 85%. Limited access to TB care and frequent

drug stock-outs [24] contribute to this situation. With 32% in 2016 (unpublished PNLT data) the rate of TB patients lost to follow up is high and still far from the target of 5% the PNLT is aiming for. The Panepi study [22] showed, despite active follow up, a lost-to-follow-up rate of 16.9% and while 53% of the enrolled patients successfully completed their treatment, only 8% could be considered as cured by smear- and/or culture-negative sputum. Furthermore, the Panepi study showed that case management was often not optimal, e.g. in terms of deviations from the treatment regimen foreseen in the national guidelines. This indicates that the national guidelines are not yet fully implemented throughout the country.

1.4.3.3 Emergence of drug resistance

Although the rate of MDR-TB is estimated to be 2.8% and 13.0% among new and retreated TB cases respectively [20], there was no consistent capacity for MDR-TB testing in the country until 2015. Diagnosis was based exclusively on clinical suspicion and patient history [24]. However, as capacity to perform DST and rapid testing for RR using the Xpert® MTB/RIF was built up, emergence of drug resistance became evident [22, 25]. In addition, there was no second line treatment available in the country until 2015, contributing to active transmission in the community. Furthermore in 2016, the first extensively drug-resistant tuberculosis (XDR-TB) case was notified in the country (unpublished laboratory data).

A national drug resistance survey is needed to understand the true burden of MDR-TB and XDR-TB in Gabon. In addition, DST and second line treatment must become available throughout the country, as the surge of drug-resistant TB (DR-TB) threatens to deteriorate TB control in Gabon.

1.4.3.4 Childhood TB

Data on childhood TB is scarce and a recent retrospective study conducted by Flamen et al. suggests that the prevalence might be a lot higher than the numbers reported [26].

The PNLT reports a proportion of 1 to 2 % of TB cases in patients below 15 years and most are based on clinical diagnosis [27]. The Panepi study showed a rate of 15 % cases in patients aged less than 18 years in their cohort, out of which 36 % were bacteriologically confirmed through microscopy and 6 % had EPTB [22].

Due to the difficult diagnosis and inconsistent notification systems, the true burden of childhood TB in Gabon remains unclear.

1.4.3.5 Lack of financial support

Although Gabon ranks among the countries with the highest incidence rate globally, it has, due to its small population, a low incidence in absolute numbers. In combination with the country's classification as a middle-income country, this puts Gabon in a suboptimal position and leads to disadvantages concerning financial support and funding in TB control. However, to be able to control TB globally, more attention needs to be paid to such countries.

1.5 TB infection control in healthcare settings

1.5.1 Background

Healthcare workers (HCW) all over the world have been shown to be at higher risk to be infected and develop active TB than the general population [28-30]. A recent meta-analysis regarding the prevalence of LTBI in seven high burden countries showed a pooled prevalence of 47% amongst HCW [31]. A high rate of LTBI among HCW was also observed in a cross-sectional study conducted in Rwanda, in which, with a prevalence of 62%, HCW were found to have a significantly higher rate of LTBI than the control group of school workers (39%) from the same region [32]. Cases of active TB are similarly increased among HCW. For example, a retro- and prospective cohort study conducted in southern India revealed a 3.1 higher incidence of active TB than the general population amongst postgraduate residents working in a tertiary care teaching hospital [33]. Particularly in high prevalence countries, TB infection control

(TBIC) measures are therefore crucial, as HCW are at high risk to be exposed to infectious TB patients.

TBIC is a set of measures that aims to prevent TB transmission within a certain population. This complements general infection control efforts and focuses on the reduction of the transmission of airborne infections. The importance of TBIC in healthcare facilities was for a long time underestimated, and consequently neglected in the policies of TB control. However, the emergence of drug-resistances and accumulating evidence of MDR-TB and XDR-TB transmission in hospitals [34-36] has raised increasing awareness towards this topic, and efforts have been made to elaborate and implement TBIC strategies in many countries.

Particularly in settings where there is a high prevalence of HIV-infection, the avoidance of TB transmission in healthcare settings is of paramount importance. In often crowded areas of healthcare facilities such as waiting areas or emergency rooms, HCW as well as other patients are likely to be exposed to infectious TB patients, who are often not yet recognized as such. Therefore managerial, administrative and environmental infection control measures should be well implemented, and adequate personal protective equipment should be made available and used, in order to protect HCW from occupational exposure and other people in the healthcare environment from nosocomial spread.

TBIC in healthcare settings implies fast recognition, diagnosis and treatment initiation of TB cases and can thus be considered as a core activity of TB control in general. In addition, infection control states one of the pillars of the End TB strategy [4].

1.5.2 WHO policy on TBIC in healthcare settings

The following description of TBIC activities in healthcare settings refers to the respective WHO policy on TBIC in healthcare settings [37], if not otherwise noted.

1.5.2.1 Managerial activities

A managerial framework is the foundation for any TBIC activity and has therefore to be provided at a national, sub-national and facility level, in order to enable health facilities to implement TBIC measures effectively. This includes creating a specific TBIC coordinating body, which will amongst others provide guidance regarding appropriate facility designs and ensure the surveillance of TB incidence among HCW. It is recommended to assess and monitor TBIC measures continuously at all levels of the healthcare system.

Another component of the managerial activities is the development of a budget and human resource plan required for the implementation of infection control strategies. Therefore, gaps regarding human resources need to be identified and professional competence of HCW at all levels of the health system ensured.

The general recommendations need to be adapted to the requirements and socioeconomic background of individual countries. In addition, the activities should build on already existing national infection prevention and control policies and coordinate closely with TB, HIV and occupational health programs.

1.5.2.2 Administrative controls

Administrative controls demonstrably reduce the risk of TB transmission in healthcare facilities and their implementation should therefore be of first priority. In general, administrative infection control measures aim to minimize the generation of infectious aerosols in the facility and provide prevention and care packages for HIV-positive HCW. Administrative TBIC measures include the following key components:

- Triage and separation

  In order to reduce the time TB infected patients spend in the facility and thus the risk of spreading infectious droplets in the air, presumed TB cases must be promptly identified, diagnosed and started on anti-tuberculous treatment as fast as possible. Therefore triage, i.e. prioritizing patients with symptoms indicative of TB is crucial. In any

case, presumed TB cases and confirmed TB patients have to be separated from other patients; particularly from those who are especially susceptible to TB such as young children or immunocompromised persons. Presumed TB cases in outpatient departments should be placed in well ventilated possibly separate waiting areas and their diagnosis should be treated as a matter of priority. For hospitalized TB patients, especially in cases with confirmed drug-resistances, isolation rooms should be available.

- Cough etiquette and respiratory hygiene

  Another way to minimize the production of infectious droplet nuclei from TB patients is the practice of cough etiquette and respiratory hygiene. This includes covering mouth and nose when sneezing or coughing and generally contributes to the control of respiratory infections. Pieces of cloth, tissues or surgical masks can be used as physical barriers for this purpose. If not available, patients, visitors as well as HCW themselves should be instructed to cover their mouth and nose with their arm or hands, which then must be washed immediately. Although there is little evidence about the benefit of placing surgical masks on coughing patients, the WHO highly recommends this practice based on current understanding of TB transmission and a strong theoretical basis. Hence, these practices should be promoted amongst all persons attending the health facility, including staff. Educational materials such as posters depicting cough hygiene should be prominently placed e.g. in waiting areas and consultation rooms.

- Minimizing time spent in healthcare facilities

  It is generally recommended to manage TB patients as outpatients, in order to minimize the risk of nosocomial spread. If hospitalization is required due to certain medical conditions or complications, patients should be separated from susceptible patients.

  To ensure that infectious patients spend as little time as possible in the facility, diagnostic delays should be minimized. Furthermore, HCW should avoid placing such patients in poorly ventilated and crowded

areas. The priority should be a community-based approach for the management of TB patients, in terms of educating household members and other close contacts on TBIC.

- Prevention and care for HCW

  All HCW should be provided with educational material and encouraged to undergo TB diagnostic evaluation if they have symptoms indicative of TB. Equally important is that they are offered confidential HIV testing and counseling. This is particularly recommended in settings with high prevalence of HIV. If HCW are diagnosed with HIV, they should be provided with antiretroviral therapy as well as regular screening for active TB. If HIV-positive HCW are working in areas with a high risk of exposure to infectious TB patients, they should be relocated to a position with lower risk of infection. In addition, HIV-positive HCW should be put on isoniazide preventive therapy, as this has been shown to significantly reduce the incidence of active TB in people living with HIV [38].

1.5.2.3 Environmental controls

Environmental controls in terms of natural, mixed-mode and mechanical ventilation play an essential role in controlling airborne infections and are strongly recommended for preventing spread of TB in healthcare facilities. In general, they serve to reduce the concentration and spread of infectious particles in the air. The type of ventilation system used strongly depends on the facility structure, climatic and socioeconomic conditions.

In limited-resource settings, expensive environmental measures such as ultraviolet germicidal irradiation (UVGI) and negative pressure rooms are often difficult to implement and maintain. However, opening windows and doors in order to increase the natural ventilation can be a simple alternative. This has even been shown to be more effective than costly mechanical ventilation, particularly in rooms with high ceilings and large windows [39]. Natural ventilation can be optimized by ensuring open windows on opposite walls and should always be maximized before taking into account other ventilation systems.

1.5.2.4 Personal protective equipment

Personal protective equipment (PPE) stands lowest in the TBIC measure hierarchy. However, the usage of particulate respirators such as N95 or FFP2 respirators in high risk areas is strongly recommended by the WHO as well as the Centers for Disease control and Prevention (CDC) [40]. Although available evidence is low, adequate respirators can theoretically prevent HCW from inhaling infectious aerosols. They should be worn by HCW for example during sputum induction procedures or when caring for potentially infectious MDR-TB and XDR-TB patients. Accordingly, HCW should receive training in the correct use of these respirators and fit testing should be considered.

1.5.3 FAST strategy

The FAST strategy [41] is another administrative approach to infection control in healthcare settings and is particularly feasible in limited-resource settings. FAST stands for: Find cases Actively by cough surveillance and rapid molecular sputum testing, Separate safely, and Treat effectively. It focuses on the fast recognition of presumed TB cases, since untreated and not-yet-evaluated TB infected patients pose the biggest risk of transmission.

The strategy is based on the idea that once a patient is identified as a presumed TB case, control measures can be put in place, and intervention in terms of treatment makes transmission unlikely. It is assumed that coughing patients with unsuspected TB or unsuspected drug-resistance are the most frequent cause of institutional spread of TB. In addition, several studies have shown that active case finding reveals a higher rate of TB amongst patients attending the facility [42, 43]. FAST therefore focuses on the enhanced case finding through cough surveillance, testing with rapid molecular sputum tests such as Xpert® MTB/RIF and following effective treatment. This reduces the time spent in the facility; and the fast recognition of rifampicin resistance allows the initiation of effective treatment immediately, whereas conventional DST would take months to identify DR-TB cases.

Although there is yet no evidence that this strategy reduces TB transmission, we can logically conclude that due to the reduced duration of exposure, institutionally acquired TB infections can be decreased proportionately.

2. Methods

2.1 Study rationale

There is a high prevalence of TB in Gabon, aggravated by accumulating evidence of a high MDR-TB prevalence [22] posing an even greater challenge for effective disease control. As aforementioned, literature indicates that TB infection rates among HCW are higher than in the average population. We can therefore assume that in Gabon, HCW are similarly at greater risk for TB infection. In line with this, TB cases, including MDR-TB, have been notified among HCW in the country during recent years, and there is a report of at least one fatal case. Additionally, HIV prevalence is estimated at 4.1% in the general population amongst adults aged 15-49, reaching 5.8% in the Moyen-Ogooué province [44]. This rate can presumably be still higher amongst those attending or admitted to a hospital. In such settings, it is particularly vital to avoid the spread of TB within healthcare environments.

In the province of Moyen-Ogooué, as in the rest of the country, resources are limited and prevention of institutional transmission of TB is a challenge. However, as indicated above, there are good low-cost alternatives such as optimizing natural ventilation [39] and implementing the FAST strategy [41]. Although the PNLT includes infection control as one of its specific objectives [23], there are currently no national guidelines available for TBIC. Consequently, it is assumed that TBIC is not optimal. Furthermore, due to a lack of evidence of formal TB and TBIC training, it is suspected that health care workers are not adequately prepared to take appropriate precautions during the management of presumed TB cases.

It is of paramount importance to ensure that TBIC guidelines are elaborated, institutional managerial frameworks designed and corresponding infection control measures implemented. Furthermore, knowledge about TB, mode of transmission and its clinical presentation is crucial among HCW, in order to enable them to identify presumed TB cases and manage them adequately early.

The TB infection control evaluation (TB-ICE) study therefore aims to conduct a baseline assessment of TBIC in health facilities at different levels of the healthcare system in the Moyen-Ogooué province and to provide insight into the knowledge, attitudes and TBIC practices of HCW. Findings will form the factual basis for the design, implementation, follow up and monitoring of future TBIC interventions in Gabon and help to advise about training curricula for healthcare personnel.

2.2 Study design and objectives

A cross-sectional observational study using two methods was performed: a comprehensive facility assessment and a knowledge, attitude and practice (KAP) survey amongst HCW with regard to TB.

The primary objectives of the study were:

- To conduct a structured assessment of regional healthcare facilities including managerial and administrative, environmental as well as personal protection infection control measures regarding pulmonary TB in comparison to the WHO recommendations
- To identify current knowledge, attitudes and practices of HCW concerning TB and TBIC in regional urban, semi-urban and rural hospitals and dispensaries in the region of Moyen-Ogooué
- To identify factors that could possibly hinder the implementation of effective TBIC guidelines

The secondary objectives were:

- To identify differences with regard to knowledge, attitude and practice between subpopulation groups, e.g. on different health care levels
- To establish a baseline of TBIC at hospital and dispensaries level that will enable a supervision and monitoring framework for the subsequent implementation of infection control activities

2.3 Study setting

2.3.1 Study period

The study started in November 2016 and ended in March 2017. Hospitals were assessed during a period of 4 weeks. Each department selected for assessment was visited over a period of 2 to 3 days for observation and interviews. The dispensaries were evaluated within one day.

2.3.2 Study sites

2.3.2.1 Albert Schweitzer Hospital (HAS)

HAS comprises an outpatient department, an emergency department, an internal medicine ward, a pediatric ward, a surgical ward as well as a maternity ward. It has a total capacity of 150 beds and is therefore the biggest hospital in Lambaréné. Sputum samples of TB patients and suspects are referred to TB laboratory of the Centre de Recherches Médicales de Lambaréné (CERMEL), as the hospital laboratory does not perform TB diagnostic procedures since 2015.

2.3.2.2 Centre Hospitalier Régional „Georges Rawiri" de Lambaréné (GHRGR)

CHRGR has a total capacity of 98 beds and accounted for 12 788 outpatient consultations, as well as 3532 hospitalized patients in 2015. It is therefore the second biggest hospital in Lambaréné and the public reference hospital in the region of Moyen-Ogooué.

In 2015 the first MDR-TB treatment unit in Gabon was set up at the CHRGR in close collaboration with the CERMEL. It was the first site in the country where patients were receiving second line treatment, following the shorter MDR-TB regimen of 9 -12 months, the so-called "Bangladesh protocol" [45].

In addition, the hospital has an outpatient clinic, an emergency department, an internal medicine ward, a tropical diseases ward, including the MDR-TB treatment unit, a surgical ward, a maternity ward and a pediatric ward. Sputum

samples for mycobacterial analysis are routinely referred to the CERMEL's TB laboratory.

2.3.2.3 Centre de Traitement Ambulatoire (CTA)

CTA is the public HIV clinic in Lambaréné, offering outpatient HIV testing, counseling and treatment. HIV/TB co-infected patients are offered ambulatory anti-tuberculous treatment. Sputum samples are analyzed on site with Ziehl-Neelson staining microscopy and are sent to the TB laboratory of the CERMEL for confirmation.

2.3.2.4 Dispensaries

Dispensaries are at the lowest level of the healthcare pyramid and thus the most peripheral operational unit of the healthcare system in Gabon. As patients from rural areas often seek consultation at the local dispensary in the first place, HCW there play a crucial role in TB control. The ability of the respective HCW of recognizing TB suspects and referring the patient to another facility for diagnosis and treatment is of paramount importance.

In the sanitary region Centre, i.e. the province of Moyen-Ogooué, there are in total 31 dispensaries, 25 and six in the departments Ogooué et Lacs and Abanga Bigne respectively. Out of the 25 dispensaries in the Ogooué et Lacs department, 20 were operational during the time of the study (data provided by the DRS). Four of them are located in the city of Lambaréné and are therefore considered as urban dispensaries.

2.4 Sample size and study population

The facilities for the assessment were chosen conveniently. However, it was aimed to select a representative range of facilities from the periphery and intermediate level of the healthcare system. The two hospitals, the CTA and all 17 operational dispensaries on the main road axes Bifoun-Lambaréné and Lambaréné-Fougamou of the Ogooué et Lacs department were selected for assessment.

In the hospitals, the following departments were considered as risk areas for TB transmission and henceforth chosen for the assessment: The outpatient department (OPD), the emergency department (ED), the internal medicine ward (IM) and the pediatric ward (PD). Additionally the MDR-TB treatment unit (MT) of the tropical diseases ward at CHRGR was assessed. The radiology departments were looked at as part of the OPD assessment.

For the KAP survey, HCW were approached during the time of assessment. Thus, all HCW who were present in the respective department or dispensary during the assessment period were asked to participate in the KAP survey. In addition, staff from the radiology department was included as well as any other staff wishing to participate in the survey. Due to a lack of reliable statistical parameters, it was not possible to conduct a sample size calculation in advance. However, all potential participants available during the study period were approached and therefore the maximum number of KAP surveys possible was conducted.

Potential occupational exposure to TB infected patients and/or presumed TB cases was the only criterion for participation in the KAP survey. Consequently, anyone working in a healthcare facility with regular patient contact was eligible.

2.5 Study procedures and variables

2.5.1 Facility assessment

A comprehensive facility assessment tool was developed as a combination of two assessment tools, namely the tool from the WHO guide on the implementation of the WHO policy of TBIC in healthcare settings [46] and from the manual "*Implementing TB infection control in health care facilities*" from the Reproductive Health and HIV Research Unit of the University of the Witwatersrand, South Africa [47]. Small adjustments were made to fit them to the situation in Gabon. For the assessment of dispensaries a shortened version was used. See Annex 1 for the complete assessment tool.

The hospitals, the CTA and the dispensaries were assessed regarding managerial, administrative and environmental infection control measures, patient education and measures of personal risk reduction for HCW.

The facility assessment was conducted through observation, reviewing of available registers and patient files as well as in-depth interviews with the person in charge of infection control or the head of department, if no infection control manager was in place.

Each selected department in the hospitals was visited two to three days. Dispensaries were assessed within one day. Environmental controls, patient management and the facility structure were evaluated through observation. Any other relevant observations made which were not specifically parts of the assessment tool were documented. If available, TB registers and patient files from TB patients who had visited the facility in the past three months were reviewed. In the dispensaries the general patient register was reviewed regarding the number of patients presenting with a cough during the past three months. Procedures and policies that could not be assessed by observation were inquired during the in-depth interviews. If applicable, documentation was requested in order to confirm answers given in the interview.

2.5.2 KAP survey

The KAP survey was conducted using an interviewer-administered semi-structured questionnaire that was developed for this study. Questions were partly adapted from the Advocacy, Communication and Social mobilization (ASCM) for TB control guide to developing KAP surveys [48] and elaborated for this specific purpose after extensive literature review.

The questionnaire was validated in a pilot study with ten HCW at the CERMEL, including five nurses, three doctors and two other clinical staff with patient contact such as project coordinators. Participants were asked if the questions were clear and small adjustments were made accordingly. See Annex 2 for the complete KAP questionnaire.

Participation in the study was voluntary. Prior to the interviews, HCW willing to participate were explained the purpose and benefits of the study and reminded that all personal data collected will be kept entirely confidential. After written informed consent was obtained, the interviewer started to read out the questionnaire to the participant and documented his or her respective answers. Interviews were held in a separate environment in order to ensure the confidentiality of the responses. In case of questions, non-leading explanations were given by the interviewer.

The questionnaire was divided into four parts: demographics and information on personal TB history; general knowledge about TB; attitude towards TB and TB-infected patients; and practical experience regarding infection control of pulmonary TB.

2.5.2.1 Demographic and general information

In order to maintain the anonymity of the questionnaires, no personal identifying information was obtained, so that information could not directly be tracked back to the interviewee. HCW were asked about their age, educational level, current job position and professional experience in healthcare. Furthermore their personal and family TB history was obtained.

2.5.2.2 Knowledge

The knowledge part comprised 16 knowledge questions, including ten single answer questions and six questions with multiple correct answers. The basic knowledge was assessed with one question about the cause of TB, one about symptoms, one about diagnostic, three about transmission and prevention, four about treatment, two about risk factors, three about MDR-TB and one about LTBI.

Knowledge questions were elaborated that were considered to cover the minimum basic knowledge required for working with presumed TB cases and TB patients. Correctness of scored answers was ensured by reviewing most recent literature.

The questions were read out to the interviewee as open-ended questions in order to avoid guessing the correct biomedical answer. The answer was recorded by the interviewer in terms of pre-categorized answers on the questionnaire. Interviewees were told if there was more than one correct answer possible. Each correct answer was scored one, incorrect answers were scored zero. In questions with multiple correct answers, each correct answer given was scored one. The maximum score was 27.

For the question about symptoms, a score was given for the following symptoms:

- Cough
- Bloody sputum
- Fever
- Weight loss
- Night sweats

Regarding risk factors and risk groups the following answers were considered as correct:

- People living with HIV/AIDS
- Young children
- Close contacts of a confirmed TB case
- HCW
- Laboratory staff
- People with medical conditions that weaken the immune system (other than HIV)
- People under immunosuppressive therapy
- Undernourished people
- People drinking alcohol
- People smoking
- People using drugs
- Prisoners

Knowledge levels were defined as “poor” (0-10/<40%), “rather poor” (11-16/ 40-60%), “good” (17-21/>60-80%) and “excellent” (22-27/>80%).

2.5.2.3 Attitude

The attitude part consisted of nine yes/no/not sure questions and four additional open questions used to gain more background information about the reason for certain attitudes. Data was synthesized descriptively.

2.5.2.4 Practice

The practice section comprised 10 items stating different infection control practices adapted from the WHO recommendations for TBIC in limited-resource settings [37]. The participants were asked to report their own actual practices in their current work position, regardless of the reasons why something was practiced or not. The response could be given in terms of a four item Likert-Scale (never/sometimes/most of the times/always), which was later converted into dichotomous values (practiced/not practiced) for further analyses. Practices that could not be reported because the respective situation has not yet occurred to the HCW were marked as not applicable.

2.5.3 Minimization of bias

The social desirability of participants, which is a type of response bias, describes the tendency of respondents to give answers which they consider to be socially expected of them. This was minimized by emphasizing during the informed consent process that all responses were strictly confidential and that no personal identifying information will be noted on the questionnaire. In addition, all questionnaires were administered by the same interviewer, ensuring that questions were asked in the same way.

By piloting the questionnaire with HCW from CERMEL prior to the study, it was aimed to minimize potential information bias. Leading or unclear questions were eliminated or rephrased. During the study period, HCW were asked not to talk about the questionnaire with their colleagues until all interviews were held.

2.6 Data management

Data collected with the facility assessment tool was directly converted into color-coded dashboards.

The facility assessment data for the dispensaries was collected in Excel tables.

Data collected with the KAP questionnaires was entered into an online RedCap database. Questionnaires were checked for completeness and consistency of available data was checked. Free text entries were converted into standardized categories.

2.7 Statistical analysis

The facility assessment data was analyzed manually and color-coded dashboards were elaborated. Colors were defined as follows: Infection control measures that were consistently observed or confirmed through documentation are marked green. Measures that were observed to be not in place are marked red. If a certain measure was reported to be practiced by the majority of staff and/or the head of the department, but could not be confirmed nor disproved during the time of assessment due to a lack of presumed TB cases, it was marked yellow. Measures that have been observed to be occasionally practiced, but not fully implemented or are only partly applicable are marked orange.

The KAP survey data was extracted from the database and then checked for completeness and consistency in Excel tables. For statistical calculations IBM SPSS (Version 24) was used. Cross-tabulation was used to compare knowledge levels of different professional groups. In addition, mean scores within these professional groups were calculated. Further categorical variables were tested for influence on knowledge levels using Cross-tabulation and Fisher's exact test. In order to avoid bias, doctors were excluded from these further analyses. Factors chosen to test for association with knowledge levels comprised sex, age, work experience, level of education, facility, family TB history and former training on TB.

Furthermore the influence of knowledge levels on infection control practices was determined. Therefore, the relative amount of items reported to be practiced was calculated for each participant. The cut-off for defining “good practice” was set at 60%. Fisher’s exact test was used to test if good knowledge was a predictive factor of good practice.

The significance level for this study was set at 0.05.

2.8 Ethical aspects

The study was approved by the institutional ethics committee of the CERMEL (Reference No. 008/2016, 29th October 2016) and was authorized by the regional health director of the Moyen-Ogooué province (Reference No. 00458/MSPP/SG/DRSC, 14th November 2016).

Written informed consent was obtained from all participants prior to the interviews. All KAP questionnaires were entirely anonymous as no names or other personal identifying information was recorded on the questionnaire. Informed consent forms and questionnaires were separately stored.

In the end of the study, meetings with the participating hospitals and the regional health director were arranged to discuss the results, laying out a roadmap for further steps to improve TBIC. Briefing on the management of TB suspects and training sessions for staff was provided in order to ensure a direct benefit for the study facilities from the study results.

Informational material such as brochures on TB and posters on cough hygiene were provided for the dispensaries.

3. Results

3.1 Facility assessment

3.1.1 Managerial controls

The assessment revealed a general lack of managerial controls in all facilities. In none of the facilities there was a designated person in charge of infection control and there were no infection control committees. No facility had infection control guidelines and consequently no assessment of their implementation has been conducted.

3.1.2 Administrative controls

The state of implementation of administrative infection control measures in the respective facilities are presented in Table 2. The respective colors are explained in Table 1.

No facility systematically screened patients for cough as they enter the facility. Presumed TB cases were reported to be prioritized in the ED of HAS and the CTA. However, both could not be confirmed during the assessment due to a lack of coughing patients.

Presumed TB cases and TB patients were observed to be provided with surgical masks in the IM of CHRGR and HAS and partly in CHRGR's OPD, where in some cases it was observed that patients were asked to wear a surgical mask by the consulting physician. Furthermore, this practice was reported but not confirmed in the ED of HAS and at the CTA.

Presumed TB cases and TB patients were separated from other patients in the IM wards of CHRGR and HAS as well as the MT of CHRGR. In the PD of CHRGR isolation of presumed TB cases was reported and in HAS pediatric patients with TB were isolated if hospitalized, but not separated from others in the consultation waiting area. In all facilities sputum samples were either collected at home in case of ambulatory diagnostic or in isolation rooms, which

are separate from others but were only sufficiently ventilated in the MT of CHRGR.

Newly diagnosed HIV-positive patients were systematically screened for TB by chest X-ray in the pediatric ward of HAS and the CTA. In both cases this was confirmed by reviewing patient files.

Educational material for patients about TB was found only in the IM of HAS, where there were informational leaflets in the isolation rooms. No facility had posters instructing patients and visitors on cough hygiene.

The MT of CHRGR screened all staff members for TB regularly by chest X-rays and sputum samples. In all facilities staff had access to confidential HIV counseling and testing on site. IPT for HIV-positive staff was available in none of the facilities. Initial training for new staff members on TBIC practices was reported to be provided for all personnel in the MT of CHRGR and was indicated by the head of the CTA, but was in both cases not documented.

Table 1: Key

	Not applicable
	Not implemented
	Sometimes done
	Reported to be done by staff, but could not be confirmed
	Implemented

Table 2: Implementation of administrative controls

CHRGR: Centre Hospitalier Régional „Georges Rawiri" de Lambaréné, HAS: Hôpital Albert Schweitzer, OPD : Outpatient department, IM: Internal medicine ward, MT: MDR-TB treatment unit, ED : Emergency department, PD: Pediatric ward, CTA: Centre de Traitement Ambulatoire

ADMINISTRATIVE CONTROLS	CHRGR					HAS				CTA
	OPD	IM	MT	ED	PD	OPD	IM	ED	PD	-
1. Are patients screened for cough as they enter the facility?										
2. Are coughing patients/presumed TB cases prioritized?										
3. Are coughing patients/presumed TB cases provided with surgical masks?										
4. Are presumed TB cases/TB patients separated from other patients?										
5. Are there separate and ventilated facilities for sputum collection?										
6. Are all newly diagnosed HIV-positive patients screened for TB?										
7. Are posters about cough hygiene prominently displayed?										
8. Are TB patients given educational materials on TB?										
9. Are personnel tested for TB regularly?										
10. Are staff offered confidential voluntary HIV counseling and testing onsite?										
11. Is isoniazid preventive treatment available for HIV-infected staff members?										
12. Is initial training provided for new staff members about TBIC practices?										

3.1.3 Environmental controls

Rooms were considered to be adequately ventilated if two openings on opposite walls and/or a fan leading the airflow out of a window and away from the HCW were implemented.

Environmental control measures are presented in Table 3. In CHRGR, the OPD's reception hall had high ceilings and was open to all sides and could thus be considered as well ventilated. Other waiting areas such as in front of the pay desk, the radiology or in front of the consultation rooms were not adequately ventilated, as there were no windows, low ceilings and ceiling fans were only partly used. In the consultation rooms windows were kept closed due to the usage of air conditioning (AC) and no fans were available. There was good cross-ventilation in the isolation rooms of the IM and the MT, as windows and doors on the opposite walls were kept open. At the IM ceiling fans were only used occasionally, whilst in the MT fans were observed to be consistently used during patient care; directing the airflow away from the HCW. The ED was not well ventilated, due to narrow hallways and no windows in many rooms. In the waiting area ceiling fans were used. The isolation room had one small window, no fans and the door remained closed. Isolation rooms of the PD where not adequately ventilated.

In HAS there was good cross ventilation in the waiting areas of the polyclinic and the PD. Consultation rooms of the OPD and PD, the ED and isolation rooms of the IM and the PD were not adequately ventilated. Isolation rooms had one window and doors remained closed. In all consultation rooms and the ED windows were kept closed due to the use of AC. Ceilings were higher than 3 m in most areas of the facility. Only in the isolation room of the IM, ceilings were lower. Fans were generally not available in this facility, except if brought by the patients themselves. Ceiling fans in waiting halls were out of order.

The building structure of the CTA was not optimal for infection control of airborne diseases. There were no windows in the waiting area and thus no

cross ventilation. In consultation rooms ACs were used and windows closed. Ceilings were not higher than 3 m and no fans were used.

3.1.4 PPE

As presented in Table 4, adequate PPE was found in two departments only. In both cases the respirators were not provided by the facility itself.

FFP3 masks were found to be regularly available at the MT of CHRGR. The masks were provided by the CERMEL and were observed to be consistently used by all personnel entering the respective unit. N95 respirators were found in the pediatric ward of HAS, but not on a regular basis and not provided by the hospital. In addition, they were not reported to be used frequently. In the CTA no adequate masks were available.

Table 3: Implementation of environmental controls

CHRGR: Centre Hospitalier Régional „Georges Rawiri" de Lambaréné, HAS: Hôpital Albert Schweitzer, OPD : Outpatient department, IM: Internal medicine ward, MT: MDR-TB treatment unit, ED : Emergency department, PD: Pediatric ward, CTA: Centre de Traitement Ambulatoire

ENVIRONMENTAL CONTROLS	CHRGR					HAS				CTA
	OPD	IM	MT	ED	PD	OPD	IM	ED	PD	-
1. Is there cross ventilation in the waiting area/isolation rooms?										
2. Are there high ceilings (> 3m) in the facility?										
3. Are windows kept open and are fans used in the waiting hall/isolation room?										
4. Are windows kept open and are fans used in the consultation rooms?										

Table 4: Implementation of personal protective equipment

CHRGR: Centre Hospitalier Régional „Georges Rawiri" de Lambaréné, HAS: Hôpital Albert Schweitzer, OPD : Outpatient department, IM: Internal medicine ward, MT: MDR-TB treatment unit, ED : Emergency department, PD: Pediatric ward, CTA: Centre de Traitement Ambulatoire

PERSONAL PROTECTIVE EQUIPMENT	CHRGR					HAS				CTA
	OPD	IM	MT	ED	PD	OPD	IM	ED	PD	-
1. Are N95 respirators or equivalent masks available?										
2. Were N95 respirators or equivalent masks used in risk areas this month?										

3.1.5 Patient flow

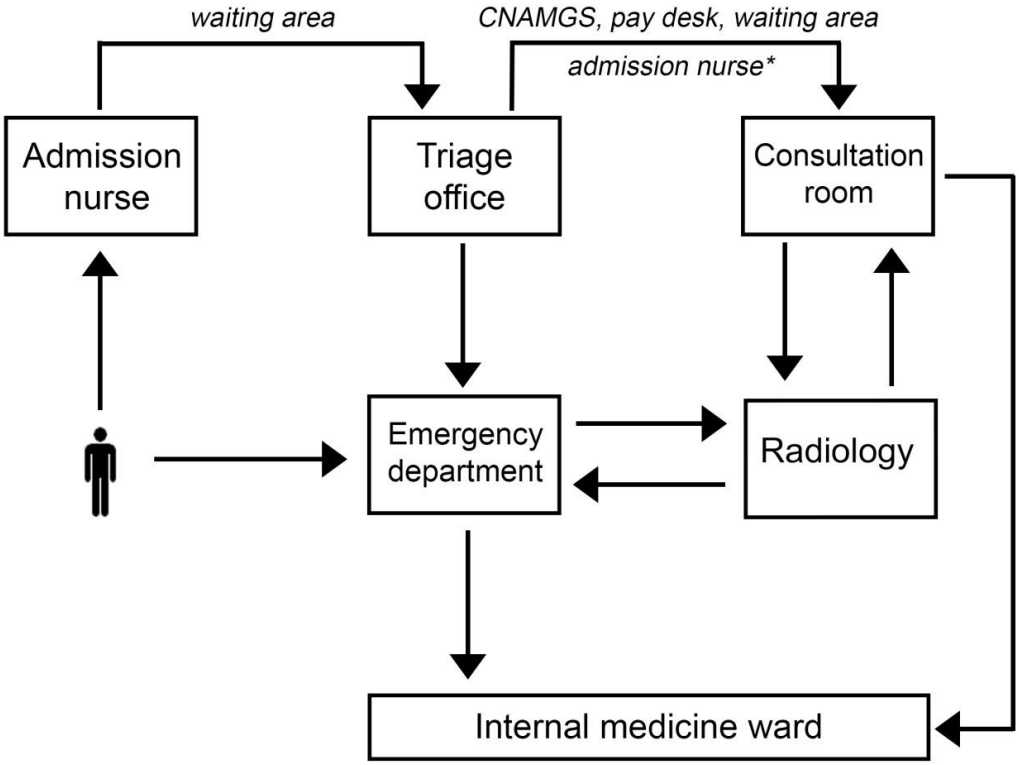
As patient management in OPDs were found to be similar, in the following the patient flow at HAS is described exemplary. The flow of a presumed TB case through the facility is presented in Graph 2.

At HAS, patients can either seek consultations at the OPD from Monday to Friday or present directly to the ED. Patients coming for outpatient consultation usually arrive from 7 a.m. onwards. After entering the facility, they register their name at the admission nurse in the waiting area. If they do not have an appointment, patients are sent to the triage office, where a nurse allocates them to a physician. If the patient is in a bad general health condition, he or she is referred to the ED.

If the patient is insured by the Caisse Nationale d'Assurance Maladie et de Garantie Sociale (CNAMGS), the Gabonese public health insurance, he or she passes by the CNAMGS office, followed by the pay desk. When his documents and payments are processed, the cashier leaves the new patient file with the admission nurse, who then takes the patient's vital parameters and gives him a number for consultation. Consultations begin approximately at 10 a.m., which means that there is a minimum of three hours waiting time for every patient.

If the consulting physician suspects TB, the patient is sent for a chest X-ray, which is later evaluated by the same physician, either the same or the following day. If the radiology suggests a TB infection, the patient is hospitalized and sputum samples are earliest given the next day. After a positive result, treatment is initiated and the patient remains hospitalized for at least the first 10 days of treatment.

During the time of assessment, the number of patients seeking consultation exceeded the capacity of the physicians available.



Graph 2: Patient flow of a presumed TB case through the facility at the Albert Schweitzer Hospital

*admission nurse takes vital parameters, CNAMGS: Caisse Nationale d'Assurance Maladie et de Garantie Sociale

3.1.6 Other findings

3.1.5.1 TB cases amongst staff

In both hospitals cases of active TB among HCW were reported during interviews with the heads of department. The cases were not notified in an occupational health register and could consequently not be confirmed. One HCW developed active TB during the study period.

In HAS two laboratory personnel were reported to have had developed TB in the past two years. One nurse of the ED developed active TB during the time of the study.

The medical director of CHRGR reported two cases of active TB amongst two nurses from the maternity ward and the IM in the past 3 years.

In the CTA there were no known TB cases amongst staff.

3.1.5.2 Documentation and archiving

The review of documents such as patient files and TB registers revealed major deficiencies in documentation. Numbers were found to be inconsistent and registers were incomplete.

All three facilities had a TB register. HAS reported to have a separate register for pediatric TB. However, the register was not found and thus not available for review.

The IM of CHRGR used the official PNLT register, but data was incomplete. The TB register of HAS was handwritten and contained the following information:

- patient file's number
- if the case was a new or known TB case
- sputum smear microscopy result
- HIV status

The total number of TB cases in the year 2015 counted from both TB registers was inconsistent with numbers reported to the PNLT. None of the registers contained treatment outcomes.

Patient files of TB cases from the last three months prior to assessment and at least the last five cases were reviewed. In all three facilities some of the files were not found. CHRGR was the only facility that kept laboratory results in all TB patient files.

3.1.6 Dispensaries

In Table 5, all visited dispensaries in Lambaréné's rural surroundings are listed. The total patient count for the past three months and the number and proportion of coughing patients amongst them as well as the number of staff working in each dispensary are also presented in Table 5. The number of patients visiting the facility in the past three months ranged from 206 to 1 253 for the dispensaries in Lambaréné and from 15 to 309 for the rural dispensaries. The proportion of coughing patients ranged from 6.8 % in the dispensary of Siat Zilé to 44.6 % in Paris-Bifoun with a median of 29 %.

Eleven dispensaries were run by only one HCW, nine by assistant nurses and the dispensaries of the villages Adanhe and Tchad by an auxiliary nurse only, who are less trained than assistant nurses. In three dispensaries (Atsie, Isaac and Magnang) there was each one nurse qualified by a state's diploma. The remaining personnel included further assistant and auxiliary nurses, cleaning staff, one intern, one vaccination agent and one technician.

Table 5: Baseline characteristics of the dispensaries

		Total patients (N)	Coughing patients (N)	Proportion (%)	Number of staff (N)
Dispensary		.	.	.	.
Urban	Atsie	346	101	29,2	4
	Isaac	1253	238	19,0	5
	Magnang	210	44	21,0	6
	Moussamoukougou	206	61	29,6	1
Rural	Tchad	309	98	31,7	1
	Kery Paga	288	47	16,3	1
	Nombakélé	74	7	9,5	2
	Zilé St Martin	22	6	27,3	1
	Siat Zilé	236	16	6,8	2
	Nzoghe Bang	31	9	29,0	2
	Kongoulé	44	13	29,5	1
	Adanhe	15	3	20,0	1
	Medang Nkoghe	15	6	40,0	1
	Nkoghe Mboum	28	10	35,7	1
	Benguie 2	30	3	10,0	1
	Benguie 4	65	24	36,9	1
	Paris-Bifoun	121	54	44,6	2

Infection control measures found in the dispensaries are presented in Table 6. There was no initial TBIC training provided for HCW. No dispensary had posters on cough hygiene, educational material or symptom checklists. In only one dispensary surgical masks were available and two dispensaries had enclosed waste baskets. Consultation rooms were adequately ventilated in six structures and windows were kept open during working hours in 13 dispensaries. Two urban dispensaries used fans in their consultation rooms. None of the facilities supervised TB treatment, i.e. there were no DOTs available.

Table 6: Implementation of infection control measures in 17 dispensaries in the Moyen-Ogooué province

INFECTION CONTROL MEASURES	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
1. Initial TBIC training for staff																	
2. Posters on cough hygiene																	
3. Educational material																	
4. Symptom checklist																	
5. Surgical masks																	
6. Enclosed waste basket																	
7. Cross ventilation																	
8. Windows are kept open																	
9. Mechanical ventilation (fans)																	
10. DOT																	

Dispensaries: 1. Atsie, 2. Isaac, 3. Magnang, 4. Moussamoukougou, 5. Tchad, 6. Kery Paga, 7. Nombakélé, 8. Zilé St. Martin, 9. Siat Zilé, 10. Nzoghe Bang, 11. Kongoulé, 12. Adanhe, 13. Medang Nkoghe, 14. Nkoghe Mboum, 15. Benguie 2, 16. Benguie 4, 17. Paris-Bifoun

3.2 KAP survey

3.2.1 Demographics and TB history

A total of 103 questionnaires were completed; 68 (66.0%) of the respondents were recruited at the two hospitals, 25 (24.3%) at dispensaries and 10 (9.7%) at the CTA. The interviews were conducted with eight auxiliary nurses, 58 assistant nurses, 11 nurses with a state diploma, 10 doctors and 16 other personnel with frequent patient contact, such as cleaning staff, radiology technicians and psychologists. The mean work experience was 11.5 years, ranging from one month to 38 years.

More than half of the respondents (59.2%) were female. The most frequent age categories were “31 - 40 years” and “41 - 50 years” with each 40 participants (38.8%), respectively, followed by the range “21-30 years” to which 13 participants (12.6%) belonged to. Nine (8.7%) respondents were over 50 years old and only one younger than 20 years.

While none of the participants reported to have had TB themselves, 44 (42.7%) said that they had already been tested for TB at least once. Almost all of the participants (99; 96.1%) reported having been vaccinated with the Bacille Calmette-Guérin (BCG) vaccine, and 36 (35.0%) said that one of their family members had suffered from TB.

3.2.2 Knowledge

3.2.2.1 Knowledge levels

Knowledge levels according to profession are presented in Table 7. With a total of 42 respondents (40.8%), the largest part fell into the knowledge category “rather poor”, followed by “good” with 29 (28.2%) and “poor” with 22 (21.4%). Only 10 HCW (9.7%) had “Excellent” knowledge about TB.

The majority of the auxiliary nurses (5/8, 62.5%) had poor knowledge, while a bit more than half of the assistant nurses (30/58, 51.7%) had “rather poor” knowledge. Five out of 11 nurses with a state diploma (45.5%) had good

knowledge, followed by “rather poor” (3/11, 27.3%). Two nurses had excellent knowledge. All of the ten doctors interviewed had good or excellent knowledge, three (30.0%) and seven (70.0%), respectively.

Table 7: Knowledge levels by profession (n = 103)

			Knowledge Levels				**Total**
			Poor	Rather poor	Good	Excellent	
Profession	Auxiliary nurse	N	5	2	1	0	8
		%	62.5	25.0	12.5	0.0	100.0
	Assistant nurse	N	11	30	16	1	58
		%	19.0	51.7	27.6	1.7	100.0
	Nurse	N	1	3	5	2	11
		%	9.1	27.3	45.5	18.2	100.0
	Doctor	N	0	0	3	7	10
		%	0.0	0.0	30.0	70.0	100.0
	Other	N	5	7	4	0	16
		%	31.2	43.8	25.0	0.0	100.0
Total		N	22	42	29	10	103
		%	21.4	40.8	28.2	9.7	100.0

The mean knowledge score out of the maximum score of 27 was 10 [95%CI: 6.3;13.7] for auxiliary nurses, 14.2 [95%CI: 13.3;15.2] for assistant nurses, 17.7 [95%CI: 15;20.5] for nurses, 22.4 [95%CI: 21.2;23.6] for doctors and 12.5 [95%CI: 9.8;15.2] for other HCW.

3.2.2.2 Specific knowledge

The number and relative frequency of correct answers given to single-answer questions are presented in Table 8. Seventy HCW (68.0%) named the correct medical cause of TB and all respondents knew that TB is curable. The majority (83; 80.6%) knew the way of TB transmission, 75 (72.8%) knew the standard treatment and 74 (71.8%) the correct treatment duration. Only 57 participants (55.3%) thought that they could get TB despite being vaccinated with BCG. Almost all respondents (95; 92.2%) identified a connection between HIV and TB. However, only 66 HCW (64.1%) could explain the relationship between the

two diseases correctly. A minority (23, 22.3%) knew that sputum smear microscopy was the most frequently used diagnostic test for TB in Gabon. A bit more than half of the respondents (57; 55.3%) knew what MDR-TB is and 64 (62.1%) thought that it is principally curable.

Table 8: Number of correct answers to single answer questions (n = 103)

	Correct N (%)
What causes TB?	70 (68.0)
Can TB be completely cured?	103 (100.0)
How is TB transmitted?	83 (80.6)
What is the standard treatment for TB?	75 (72.8)
How long does the standard treatment for drug-sensitive pulmonary TB usually take?	74 (71.8)
Can you get TB when you are vaccinated with BCG?	57 (55.3)
Is there a relationship between HIV and TB?	95 (92.2)
If yes, what is it?	66 (64.1)
What is the most frequently used diagnostic laboratory test to diagnose TB in Gabon?	23 (22.3)
What is MDR-TB?	57 (55.3)
Is MDR-TB curable?	64 (62.1)

Table 9 shows the number and relative frequency of correct answers given to multiple answer questions other than about TB symptoms and risk factors.

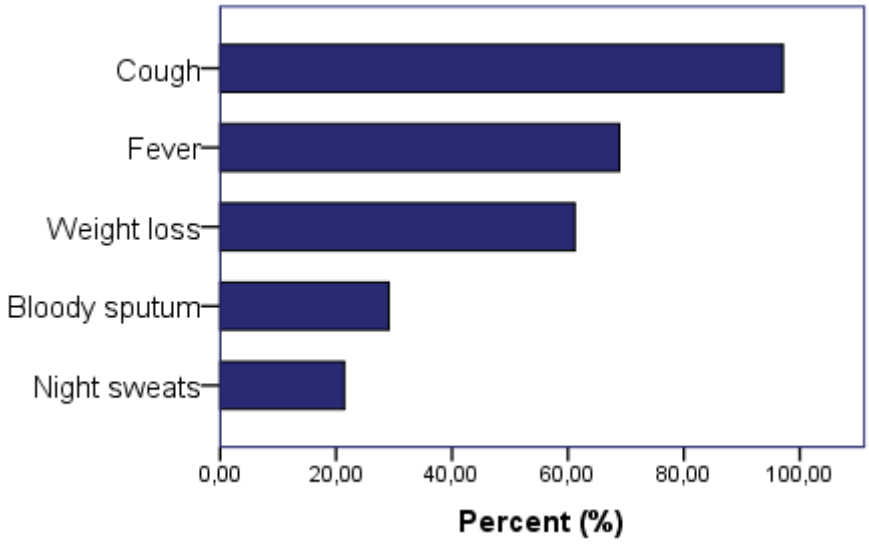
Almost half of the respondents (50; 48.5%) named the development of resistances as a consequence of incorrect TB treatment and 64 (62.1%) thought that the patient would relapse. Regarding the differences between LTBI and active TB, 27 HCW (26.2%) knew that in contrast to active TB disease, a latent infection is asymptomatic. Only one respondent stated in this context that LTBI is not contagious.

As possible infection control measures when being in the same room with a TB patient, HCW named measures aiming to increase the airflow and measures of cough hygiene with 29 (28.2%) each. Almost all respondents (98; 95.1%) knew that wearing a respirator would protect them from being infected.

Table 9: Number of correct answers given to multiple answer questions (n = 103)

	Correct N (%)
What can happen if you take your TB drugs incorrectly/ disrupt TB treatment?	
Development of resistances	50 (48.5)
Relapse	64 (62.1)
What is the difference between latent TB infection and TB disease?	
TB infection is asymptomatic	27 (26.2)
TB infection is not contagious	1 (1.0)
When you are in the same room with a TB-infected patient, how can you minimize the risk of getting TB from that patient?	
Increase airflow	29 (28.2)
Let patient perform cough hygiene	29 (28.2)
Wear respirator	98 (95.1)
How can you get MDR-TB?	
Through infection from another person with MDR-TB	32 (31.1)
Through incorrect treatment	54 (52.4)

Graph 3 shows the proportion of interviewed HCW who named the 5 major symptoms of active TB. “Cough” was named by 100 respondents (97.1%), followed by “fever” with 68.9% (71) and “weight loss” with 61.2% (63). “Bloody sputum” was named by 30 HCW (29.1%) and 22 (21.4%) named night sweats as a symptom of TB.



Graph 3: Relative frequency of TB symptoms named by the respondents (multiple answers were possible, percentages do not add up to 100)

The most frequently named risk factors and risk groups for TB are presented in Graph 4. Seven HCW (6.8%) did not know any risk factor for developing active TB. The most frequently named risk group was “young children“, which was mentioned by 44 respondents (42.7%), followed by “close contacts of a confirmed case“ and “healthcare workers“ with 40 (38.8%) each. HIV/AIDS was named as a risk factor by 26 interviewees (25.2%). Thirteen HCW (12.6%) mentioned “people smoking” as a risk factor. Less than 10% of the respondents named “people drinking alcohol” (7), “people with medical conditions that weaken the immune system” other than HIV (4), “drug users” (3) and “people under immunosuppressive therapy” (1).

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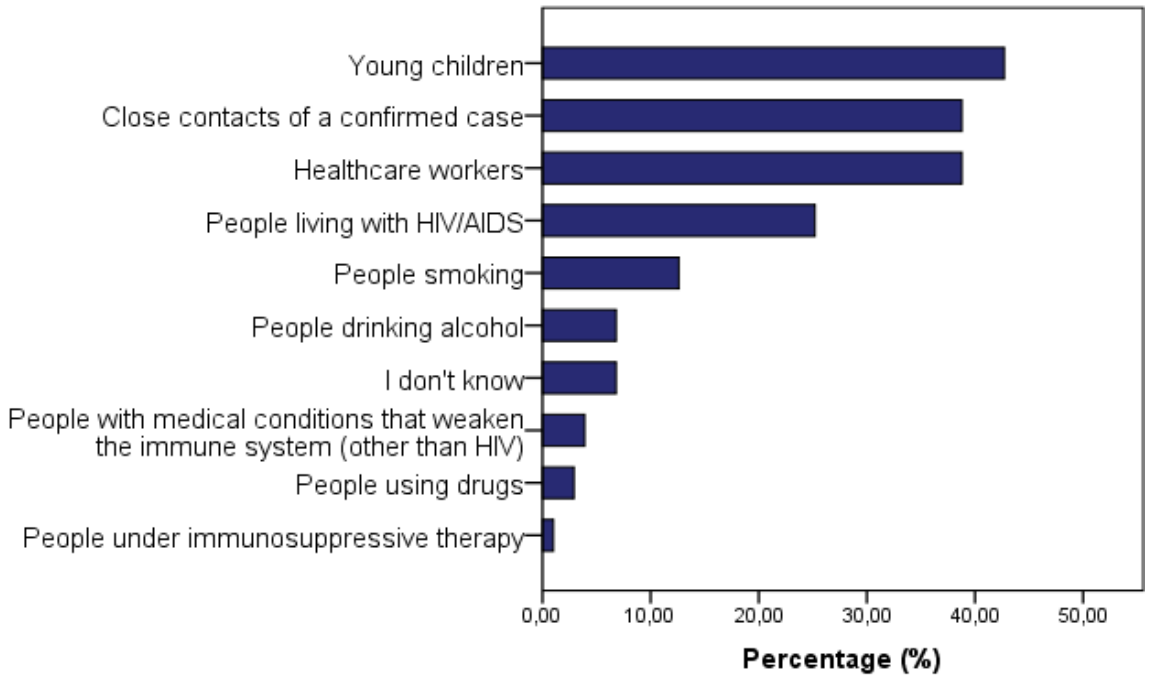

Graph 4: Relative frequency of risk factors for TB named by the respondents (multiple answers were possible, percentages do not add up to 100)

3.2.2.3 Determinants of knowledge levels

Since all doctors had good or excellent knowledge and given that they were unequally distributed in other subgroups, they were excluded from the following analyses. Fisher's exact test was conducted to identify factors that influence the knowledge level of the remaining 93 HCW.

Factors and their association with knowledge levels are presented in Table 10. Three factors were identified as significant determinants of knowledge levels: Level of education ($p = 0.007$), facility ($p = 0.047$) and former training on TB ($p = <0.001$). Age, sex, work experience and TB cases in the family were not shown to have a statistically significant influence on knowledge about TB.

Table 10: Determinants of knowledge levels of HCW other than doctors (n = 93)

		Knowledge Levels				
		Poor (n = 22)	Rather poor (n = 32)	Good (n = 26)	Excellent (n = 3)	p-value
Age						0.273
	<20 years	0 (0.0%)	1 (2.4%)	0 (0.0%)	0 (0.0%)	
	21-30 years	3(13.6%)	8 (19.0%)	1 (3.8%)	0 (0.0%)	
	31-40 years	7 (31.8%)	12 (28.6%)	14 (53.8%)	2 (66.7%)	
	41-50 years	12(54.5%)	16(38.1%)	8 (30.8%)	1 (33.3%)	
	>50 years	0 (0.0%)	5 (11.9%)	3 (11.5%)	0 (0.0%)	
Sex						0.535
	F	17(77.3%)	25 (59.5%)	16 (61.5%)	2 (66.7%)	
	M	5 (22.7)	17 (40.5%)	10 (38.5%)	1 (33.3%)	
Level of education						0.007
	CEP	5 (22.7%)	9 (21.4%)	0 (0.0%)	0 (0.0%)	
	BEPC	11 (50.0%)	28 (66.7%)	15 (57.7%)	2 (66.7%)	
	BAC	2 (9.1%)	3 (7.1%)	7 (26.9%)	1 (33.3%)	
	University	0 (0.0%)	2 (4.8%)	2 (7.7%)	0 (0.0%)	
	Other	4 (18.2%)	0 (0.0%)	2 (7.7%)	0 (0.0%)	
Facility						0.047
	Hospital	12 (54.5%)	20 (71.4%)	23 (88.5%)	3 (100.0%)	
	Dispensary	10 (45.5%)	12 (28.6%)	3 (11.5%)	0 (0.0%)	
Work experience						0.148
	≤ 5 years	7 (31.8%)	12 (28.6%)	2 (7.7%)	1 (33.3%)	
	6-10 years	8 (36.4%)	8 (19.0%)	10 (38.5%)	1 (33.3%)	
	11-20 years	6 (27.3%)	16 (38.1%)	9 (34.6%)	0 (0.0%)	
	> 20 years	1 (4.5%)	6 (14.3%)	5 (19.2%)	1 (33.3%)	
Family TB						0.767
	No	16 (72.7%)	25 (59.5%)	18 (69.2%)	2 (66.7%)	
	Yes	6 (27.3%)	17 (40.5%)	8 (30.8%)	1 (33.3%)	
TB training						<0.001
	No	21 (95.5%)	25 (59.5%)	15 (57.7%)	0 (0.0%)	
	Yes	1 (4.5%)	17 (40.5%)	11 (42.3%)	3 (100.0%)	

3.2.3 Attitudes

As presented in Table 11, 84 HCW (81.6%) thought they could get TB themselves and 75 (72.8%) said that they were scared of getting TB. For the 15 respondents (14.6%) who thought that they could not get TB, the most frequently named reasons for this were vaccination (7/15, 46.7%) and the belief of not being exposed due to adequate precautions (4/15, 26.7%). Out of the 75 respondents who were scared of getting TB, 35 (46.7%) named the severity of the disease as a reason, 21 (28.0%) the possibility of infecting a family member and 20 (26.7%) the treatment duration and/or side effects. Further named reasons were the potential fatality of the disease, the fear of social isolation and irreversible respiratory alterations.

Most of the respondents (97, 94.3%) would continue to socialize with a friend, if he was infected with TB. However, with 91 respondents (88.3%), the majority would not share the same cutlery, plates and glasses with a family member suffering from TB. A total of 65 HCW (63.1%) considered TB as a stigmatized disease.

Almost all respondents (101, 98.1%) reported that they would like to learn more about TB and 100 HCW (97.1%) said that they would be willing to get tested for TB regularly. TB was considered as a major threat to Gabon's public health by 98 HCW (95.1%) and 101 (98.1%) thought that TB control in their region should be improved. The most frequently made suggestion on how to improve the regional TB control was "conducting awareness raising campaigns", which was named by 70 HCW, followed by "intensified case finding" (16) and "vaccination programs" (10).

Table 11: Attitudes (n = 103)

	Yes	No	Not sure
	N (%)	N (%)	N (%)
1. Do you think you could get TB?	84 (81.6)	15 (14.6)	4 (3.9)
2. Are you scared of getting TB?	75 (72.8)	25 (24.3)	3 (2.9)
3. Would you continue to socialize with your friend, if he was diagnosed with TB?	97 (94.2)	3 (2.9)	3 (2.9)
4. Would you share the same cutlery, plates and glasses with a family member, if he was infected with TB?	11 (10.7)	91 (88.3)	1 (1.0)
5. Would you say that TB is a stigmatized disease?	65 (63.1)	33 (32.0)	5 (4.9)
6. Would you like to learn more about TB?	101 (98.1)	1 (1.0)	1 (1.0)
7. Would you be willing to get tested for TB regularly?	100 (97.1)	2 (1.9)	1 (1.0)
8. Do you feel TB is major threat to public health in Gabon?	98 (95.1)	3 (2.9)	2 (1.9)
9. Do you think there is a need of improvement in TB control in your region?	101 (98.1)	1 (1.0)	1 (1.0)

3.2.4 Practices

TB infection control practices that were reported to be practiced by the interviewed HCW are presented in Table 12. If no statement could be made about the practice because the applicable situation had not yet occurred to the HCW, it was marked as not applicable (NA). This was mostly the case in dispensaries with a very small patient count.

Most HCW (82, 79.6%) reported to suspect TB if the patient has been coughing for month. Less than half of the respondents (50, 48.5%) said that they separate coughing patients from other patients. While 56 (54.4%) of the respondents wear a surgical mask when dealing with a coughing patient, 73 (70.9%) reported to wear a mask when dealing with a confirmed TB patient. About half of the respondents (53.4%) said that they provide coughing patients with a surgical mask.

Environmental controls in terms of increasing the natural ventilation by opening windows and doors were reported to be practiced by 69 HCW (67%), while only 16 (15.5%) would turn on a fan. Thirty-two (31.1%) respondents said that they prioritize coughing patients in comparison to other patients. Sixty-three (61.2%) HCW stated to give newly diagnosed TB patients information about their disease and 77 (74.8%) said that they instruct coughing patients on cough hygiene.

Table 12: TB infection control practices reported by HCW (n = 103)

	practiced	not practiced	NA
	N (%)	N (%)	N (%)
1. When a patient says he has been coughing for a month, I suspect TB	82 (79.6)	21 (20.4)	0 (0.0)
2. I seperate coughing patients from other patients	50 (48.5)	46 (44.7)	7 (6.8)
3. When I deal with a coughing patient I wear a mask	56 (54.4)	47 (45.6)	0 (0.0)
4. When I deal with a confirmed active TB patient, I wear a mask	73 (70.9)	29 (28.2)	1 (1.0)
5. I give patients who arrive with a cough a mask	55 (53.4)	48 (46.6)	0 (0.0)
6. When a TB patient is in the room, I open windows and doors to increase natural ventilation	69 (67.0)	30 (29.1)	4 (3.9)
7. When dealing with a TB patient, I turn on the fan to increase ventilation	16 (15.5)	86 (83.5)	1 (1.0)
8. When a patient arrives at my facility with a cough, I prioritize him/her in comparison to patients without cough	32 (31.1)	59 (57.3)	12 (11.7)
9. If a patient is newly diagnosed with TB, I give him/her information about his/her disease	63 (61.2)	35 (34.0)	5 (4.9)
10. I explain coughing patients how they can practice cough hygiene, in order to avoid infecting other people around them	77 (74.8)	25 (24.3)	1 (1.0)

Table 13 shows practice categories by knowledge levels. According to the predefined cut-off at 60% of practiced items, a total of 46 HCW (44.7%) had “poor” practices whereas 57 (55.3%) had “good” practices. Fisher’s exact test showed no significant association between knowledge levels and practice (p = 0.263). Consequently, good knowledge about TB was not statistically associated with good infection control practice.

Table 13: Practice by knowledge levels

		Practice		**Total**
		Poor N (%)	Good N (%)	N (%)
Knowledge Levels	Poor	13 (28,3)	9 (15,8)	22 (21,4)
	Rather poor	20 (43,5)	22 (38,6)	42 (40,8)
	Good	10 (21,7)	19 (33,3)	29 (28,2)
	Excellent	3 (6,5)	7 (12,3)	10 (9,7)
Total		46 (100)	57 (100)	103 (100)

4. Discussion

4.1 Assessment findings and recommendations

4.1.1 Managerial controls

The study revealed that there is a complete absence of managerial TBIC measures in healthcare facilities in the Moyen-Ogooué province. This was an expected outcome, as there are yet no efforts for TBIC in Gabon on a national level. As stated by the WHO [37] and highlighted by Verkuijl and Middelkoop in their article about occupational tuberculosis prevention [49], managerial controls are the framework for all TBIC activities and are therefore an indispensable requirement for the successful implementation of TBIC measures in healthcare settings. The study results pose evidence for the urgent need of national and facility-specific guidelines as well as appropriate funding and human resources for their implementation.

4.1.2 Administrative controls

There were only a few administrative controls that could be observed to be consistently practiced in several departments, e.g. the provision of surgical masks for presumed TB cases and the separation of coughing patients from others. However, most measures were not systematically implemented.

Particularly the triage of coughing patients, which is one of the key aspects of administrative TBIC, could not be observed at all. As active cough screening can increase the detection rate of active TB, it should be systematically done at hospital admission. In addition, the early identification of a presumed TB case allows the provision with a surgical mask and can help to decrease the spread of potentially infectious aerosols in the facility (see section 4.2.5).

Except for informational leaflets on TB in the IM isolation rooms at HAS, there was no educational material provided for patients in any of the facilities. Educational materials such as posters on cough hygiene are easily available online and pose a non-costly measure to raise awareness about TB and address stigma.

Although all staff had access to free HIV testing and counseling, only the MT of CHRGR screened their personnel for TB regularly. Regarding the higher incidence of TB amongst HCW, frequent screening should be offered by the facility in order to detect potential TB infections in an early stage.

4.1.3 Environmental controls

Certain environmental TBIC measures, such as ceiling height or number of windows, depend on the facility's architecture and can thus not be easily influenced. However, keeping windows open and using fans to create airflow away from HCW are additional measures that are non-costly but nevertheless effective [39]. Although these measures are feasible in almost every setting, they could not be observed frequently. Especially in consultation rooms windows were kept closed and no fans were used because of the use of AC, which leaves the consulting physician at high risk when receiving a potentially infectious TB patient.

Environmental controls in the CTA were particularly inadequate due to the building structure. This is critical, given that most patients attending the facility are HIV positive and thus highly susceptible to TB infection as well as likely to be infectious themselves.

The MT was the only department where it was ensured that doors and windows were kept open in isolation rooms and fans were strategically positioned to direct the air out of the window. These measures should be systematically implemented throughout the facility. Window stickers can help to raise awareness regarding these environmental controls. However, triage at the beginning of a patient's way through the facility is vital to ensure that HCW know when they are receiving a presumed TB case and can react accordingly.

4.1.4 PPE

None of the facilities provided adequate PPE for their staff. It was observed that HCW wore surgical masks when dealing with presumed TB cases or TB patients, which is not protecting them sufficiently from TB transmission. There

are only very few systematic studies providing evidence for this assumption. One of them was conducted by Lindsley et al. using an aerosol exposure simulation model to systematically assess filtration efficiency of different types of PPE. They found that surgical masks showed a significantly higher aerosol particle penetration than respirators and are thus not suitable to protect an exposed HCW from cough-generated aerosols [50]. This is not only applicable to TB, but to many other airborne diseases such as influenza or measles. Particularly in radiology rooms, where all presumed TB cases enter and sufficient ventilation is often not achievable due to the enclosed environment, staff depends on adequate respirators as a protective measure.

Not only a budget for PPE must be put in place, but also awareness needs to be raised to ensure the appropriate use of respirators. The misconception of surgical masks being protective was also found in a KAP survey in South Africa, where only 24.6% of the participating HCW knew that surgical masks do not protect them from TB [51]. This can possibly increase risky behavior and needs thus be addressed in training sessions.

4.1.5 Optimizing the patient management regarding TBIC

Triaging, i.e. integrating early TB screening and following TBIC measures into the regular patient flow can help to systematically apply TBIC in the daily routine work. Verkuijl and Middlekoop suggest a patient flow chart that focuses on the identification of presumed TB cases by screening for chronic cough, separating patients accordingly and prioritizing them for fast consultation and sputum collection in order to minimize their time spent in the facility [49]. This is in line with the WHO recommendations as well as with the FAST strategy.

Most aspects of this triaging system could also be applied in facilities like HAS. The admission nurse could screen for chronic cough and already provide the patient with a surgical mask. The triage office should then ensure the prioritization of the patient, e.g. by labeling the patient file with a priority marker. As suggested by Verkuijl and Middlekoop, the first sputum sample should be collected directly after the consultation. This should also be implemented at

HAS, where the first sample is usually collected the following day, leading to delays in treatment initiation. However, there are a few aspects that might not be feasible in this particular setting. According to the triaging system mentioned above, TB patients should leave the facility on the same day pursuing ambulatory treatment. In Gabon, TB drugs are not easily available and transport to CDTs is often long and costly. Henceforth, the practice of hospitalizing TB patients for the first 10 days of anti-tuberculous treatment, as it is done in HAS, might be more suitable for this setting, as it ensures treatment surveillance for the first days. As DOTS is not yet available in Gabon, this might be a suitable alternative. Furthermore, most patients are no longer infectious after these 10 days so that TB transmission within the community becomes less likely.

Another strategy that was developed to improve the management of presumed TB cases and is closely linked to triaging procedures is the FAST strategy. Although it was specifically developed for limited-resource settings, its implementation is not fully feasible in Gabon, as it relies on the constant availability of Xpert® MTB/RIF assays. During the time of the study, this diagnostic tool was only available at the CERMEL for the Moyen-Ogooué province. In order to implement the FAST strategy effectively, funding is necessary to provide all CDTs with Xpert® machines.

4.1.6 Other findings

There were several TB cases amongst staff reported in in-depth interviews with the heads of the department. However, they could not be verified as they were not documented. In addition, the true incidence of TB amongst HCW in Gabon remains unknown and requires further investigation.

Documentation of TB cases, TB patient files and registers were highly incomplete and inconsistent with the officially reported data. For better treatment surveillance and regarding the increasing drug-resistances, it is of paramount importance to fully document TB cases, diagnostic results and treatment outcomes. These findings indicate that TB reporting systems need to

be strengthened in to gain systematic data about the true burden of TB in Gabon.

4.1.7 Dispensaries

Although dispensaries are not authorized to treat TB in Gabon, they must be able to recognize presumed cases and refer them to a diagnostic center. In most dispensaries nearly a third of the patients presented with cough as one their main symptoms (see table 3). Thus, it can be assumed that there is a considerable number of TB infected patients seeking consultation in dispensaries. More than half of the dispensaries were run by a single assistant or auxiliary nurse, who is usually not adequately trained to identify presumed TB cases.

Due to their proximity to the communities dispensaries also play a central role in patient education. Considering this, dispensaries were found to be extremely insufficiently equipped. None of them had informational material on TB or posters on cough hygiene and only two facilities had enclosed waste baskets. Only one dispensary had surgical masks available. They should be able to provide coughing presumed TB cases with surgical masks in order to protect themselves as well as others during the transport to the next diagnostic center in Lambaréné.

Regarding TBIC, however, the dispensaries had one advantage: In contrast to the larger facilities, environmental controls in terms of natural ventilation were found to be adequate in many of the dispensaries. There was cross-ventilation in 6 facilities and 13 facilities constantly kept their windows open during working hours. Mechanical ventilation was only found in two urban dispensaries in Lambaréné, as there was no electricity in rural areas.

Ideally, dispensaries should be integrated in TB treatment surveillance, which would be in line with the DOTS strategy. As the Panepi study in Lambaréné showed, high transport costs to the urban hospitals were one of the main reasons why patients abandoned their TB treatment [22]. This implies that primary health services must not be neglected in general TB control.

4.2 KAP survey findings

4.2.1 Knowledge levels

The survey allowed deep insight into regional HCWs' knowledge and awareness levels towards different aspects of TB. It serves as an orientation for future training programs and provides background information on general TB management.

Two-fifth of the participants fell into the knowledge category "rather poor", which suggests that HCW in the Moyen-Ogooué province are not adequately trained regarding TB and TBIC. While nurses with a state diploma and doctors had overall high knowledge levels, the majority of assistant and auxiliary nurses fell into the categories "rather poor" and "poor". Considering that assistant nurses represent the largest part of HCW in the Moyen-Ogooué province and well-trained personnel such as nurses and doctors are rather rare, the survey findings suggest that training programs should focus on HCW with a lower professional degree.

4.2.2 Knowledge gaps

Overall basic knowledge about TB transmission and treatment was good. However, the survey revealed several knowledge gaps. Almost half of the respondents erroneously thought that they could not get TB when being vaccinated with BCG, a belief that was also found amongst 41% of the nurses and 9% of the doctors in a KAP survey conducted at two university hospitals in Ethiopia [52]. Only 22.3% of the HCW knew that sputum smear microscopy is the most frequently used diagnostic test for TB in Gabon. Whereas nearly all HCW named "cough" as an indicator of TB, only 21.4% knew that "night sweats" were also a typical symptom. Basic knowledge about symptoms and diagnostics of TB are crucial to identify presumed TB cases. A lack of suspicion can lead to delays in diagnosis and treatment initiation and therefore contribute to the spread of TB in the community. This is why all HCW should be sensitized and trained to recognize possible TB cases early.

Moreover, the majority did not know what LTBI was; 26.2% knew that LTBI is asymptomatic and only one HCW mentioned in this context that LTBI is not contagious. Furthermore, there were signs that could indicate a lack of awareness towards the problem of increasing drug resistance. Merely a bit less than half of the participants named “development of resistance” as a consequence of incorrect treatment. In addition, only 55.3% of the participants knew what MDR-TB was.

Regarding TBIC measures, with 95.1% almost all HCW knew that wearing a respirator when with a TB patient would protect them from becoming infected. However, in this context it can be assumed that the respondents were referring to surgical masks and not particular respirators. Other measures as increasing the ventilation e.g. by opening windows or ensuring that the patient is provided with a surgical mask were named by less than a third of the respondents only.

For effective case finding strategies, the knowledge of groups who are particularly vulnerable to TB is of paramount importance. The majority of the survey respondents were able to name several risk factors for TB. Young children were the most frequently named risk group for TB. This might be attributed to the idea that children are generally a vulnerable group for infectious diseases. The second most named groups were HCW and contact cases, which shows that participants were well aware of the risk of exposure. However, HIV-infection, as one of the most relevant risk factors in this setting, was named by 25.2% only. This might indicate a lack of awareness amongst HCW towards the high co-infection rates in Gabon and the difficulties regarding the control of these synergistically acting diseases. In addition, the survey showed that the majority of HCW knew that there is a relationship between HIV and TB, but only 64.1% could correctly explain this association.

These findings contribute to the understanding of awareness levels regarding TB amongst HCW in Moyen-Ogooué and can help to plan specific training programs. These should focus on topics where knowledge was found to be rather poor amongst the participants, such as LTBI and MDR-TB. In addition, awareness should be raised towards the role of HIV-infection and TB.

4.2.3 Factors associated with good knowledge

Besides the profession, there were several factors identified that are significantly associated with knowledge levels. Whereas work experience was not found to have an influence on knowledge about TB (p = 0.148), former TB training was a highly statistically significant determinant of good knowledge levels (p = < 0,001). This reinforces the assumption that training of staff has a sustainable effect on their awareness towards certain diseases and should therefore be provided for all HCW. Another determinant identified was the highest level of education (p = 0.007), which can be attributed to the association with the profession. In addition, it was found that HCW in hospitals had better knowledge about TB than in dispensaries (p = 0.047). This indicates that HCW in primary healthcare services must not be forgotten and should be included in training programs.

4.2.4 Attitudes

While attitudes towards TB were generally positive and almost all (94.2%) of the HCW would continue to socialize with a TB infected friend, 88.3% of the participants would not share the same cutlery, plates and glasses with a TB infected family member. This possibly indicates misconceptions about TB transmission, which could contribute to the stigmatization of TB infected individuals. The idea of TB being transmitted through eating from the same plate was also found amongst the general population in Cameroon [53] and thus seems to be a common belief.

TB was considered as a stigmatizing disease by 63.1% of the HCW. This finding is in line with the perception of the 30 TB patients who were interviewed in Lambaréné in 2013, as 67% considered their disease as problematic with regard to stigma [54].

Almost all respondents said that they would like to learn more about TB and would also be willing to get themselves tested regularly. In addition, the majority considered TB as a major threat to Gabon’s public health and thought that TB control must be improved in their region. Furthermore, more than two-thirds of

the participants said that they are scared of getting TB. These findings show that HCW are aware of TB being a serious public health problem in Gabon and imply that they would be open for new policies and training programs.

4.2.5 Good Practice

Practices reported in the survey did not imply reasons why certain measures were done or not done. Henceforth it could not be concluded if poor TBIC practice resulted from a lack of awareness or inadequate facility structures and equipment. For example, in some departments such as the ED at HAS there were no isolation rooms available and henceforth coughing patients could not be separated from others even though HCW were aware of the risk of transmission. This might explain why less than half of the HCW separate coughing patients from others.

Only 53.4% of the respondents said that they provide coughing patients with surgical masks. This is partly attributed to the unavailability of masks in dispensaries, but could also indicate fear of encouraging the stigmatization of patients. The same reasons could possibly explain why only a bit more than half of the HCW reported to wear a mask themselves when receiving a coughing patient. However, this could not be concluded from the survey findings and needs further qualitative research.

Another rather rarely practiced TBIC measure was the prioritization of coughing patients, which was reported to be practiced by about a third of the respondents. This is in line with the observations made during the assessment and shows that TBIC is not yet implemented into the daily activities. Furthermore, it could be attributed to a lack of awareness towards the fact that minimizing the time spend in the facility can reduce the risk of nosocomial transmission.

With 15.5%, only a minority reported to turn on a fan when dealing with a TB patient. This can be explained by the absence of fans in most facilities. In addition, only about two-thirds of the respondents said that they would open windows and doors to increase natural ventilation when being with a TB patient.

These findings might indicate a lack of awareness towards environmental TBIC measures and should be included in TBIC training of HCW.

Good knowledge about TB was not found to be statistically associated with good practice ($p = 0.263$). This suggests that good TBIC practice does not only depend on good knowledge about TB, but also on the facility structure, feasibility regarding manpower and adequate equipment.

These results stand in contrast to findings in a South African study, where good knowledge was found to be a significant predictor of good practice. This might be explained by the different methodology, as only knowledge about TBIC in particular was measured [51]. However, there is another similar study, which was conducted in Ethiopia and showed that there was no association between knowledge and practice [55].

4.3 Strengths and limitations of the methods

4.3.1 Assessment method and presentation of the results

The standardized facility assessment tool was very comprehensive and therefore captured many aspects of TBIC and general TB management. However, it turned out to be not fully suitable regarding the setting. In order to be more specific, it had to be adjusted during the study, leading to a combination of quantitative and qualitative data. In addition, the observational character of the study contributed to more qualitative data. A new tool was elaborated accordingly and can be used in future studies. It includes distinct instructions on the conduction of the assessment and thus ensures comparable data.

A limitation of the study was that the duration of the assessment of two to three days per department was sometimes not long enough to observe the management of (presumed) TB cases, due to a lack of cases. Consequently, certain measures could not be determined. This needs to be taken into consideration for future assessments.

In this study, openings on opposite walls were used as an indicator for adequate ventilation. This poses only an estimate and needs to be verified with quantitative methods e.g. measuring carbon dioxide concentration and calculating the risk of transmission as proposed by Rudnick and Milton [56].

By choosing color-coded dashboards for the presentation of the results, the aim was to provide a general overview of the current state of implementation of TBIC measures. This allows easy comparison of the baseline results to future follow-up data once an implementation process is initiated, as it was done e.g. by Dokubo et al. in Nigeria [57].

4.3.2 KAP survey

The professional categories amongst the participants were unequally distributed with more than half of the study population being represented by assistant nurses. This, however, reflects the contribution of professions amongst medical staff that was observed in the study and could thus be regarded as representative for HCW in the Moyen-Ogooué province.

Although the participation rate was generally high, a few HCW refused to sign the informed consent form und could thus not be included in the survey. Oral informed consent with anonymous questionnaires might be taken into consideration for future surveys.

By asking the KAP questionnaire in personal interviews, it could be ensured that the questions were clearly understood. In addition, participants did not skip any questions, as it might have been the case in self-administered questionnaires. However, response bias could not be completely excluded.

Another strength of the study was that questions in the survey were asked openly, in order to avoid respondents guessing the correct answer. In contrast to self-administered questionnaires, this aimed to test the awareness level and not passive knowledge. On the contrary, this might have lead to inconsistencies between answers, which could not be explained and need further investigation.

Practices reported in the survey were partly inconsistent with observations made during the assessment. This discrepancy could possibly be due to a social desirability bias, which could not be completely eliminated. A limitation of the study was that reasons for these discrepancies could not be evaluated. More qualitative research is necessary to explain why theoretical knowledge was sometimes not put into practice.

4.4 Conclusions

The observed lack of well implemented infection control measures poses evidence for the urgent need of national TBIC guidelines, including an appropriate budget and human resources for their implementation. The claim that HCW are not sufficiently protected from TB transmission was highlighted by the fact that in both hospitals, there were each two cases reported amongst staff and one further case was observed during the study period. The interviews revealed that HCW were aware of this risk, as 72.8% stated to be scared of getting TB and with 98.1%, almost all survey participants thought that there was a need of improvement in TB control in their region. In addition, HCW were amongst the most frequently named risk groups for TB. Regular screening procedures should be put in place for all personnel, as it was done in only one out of a total of 10 individual departments and in none of the dispensaries. As it was shown in the KAP survey, the majority of HCW (97.1%) would approve being tested for TB regularly.

Although there was no association found between good knowledge and good TBIC practice, it can be assumed that basic knowledge about TB is the basis for understanding and performing TBIC adequately. The rather low knowledge levels found among the interviewed HCW empathizes the need of specific TB training. Assistant nurses presented the largest part of HCW in the respective facilities, but only less than a third (29.3%) had good or excellent knowledge and more than half of them (51.7%) fell into the category “rather poor”. On the contrary, 70% of the doctors participating in the survey had excellent and 30% good knowledge. These findings indicate that special attention should be paid to assistant nurses in training activities.

There was evidence of common misconceptions about TB, e.g. the fact that 44.7% thought that they could not get TB when being vaccinated with BCG vaccine. This was, however, inconsistent with the finding that 81.6% thought that they could get TB themselves, given that almost all respondents reported to be vaccinated with BCG. Nevertheless, there were still 14.6% who demonstrably stated that they did not think that they could be infected with TB, out of which 46.7% saw the BCG vaccine as the reason for this. Such misconceptions could possibly hinder HCW from adequately practicing TBIC

In addition, the KAP survey findings indicate a lack of awareness towards the vulnerability of HIV infected people to TB. This could possibly explain why only 2 out of 10 individual departments screened newly diagnosed HIV-positive patients for TB.

Some reported TBIC practices can be attributed to inadequate structural conditions. The facility assessment identified structural obstacles such as the unavailability of surgical masks and fans in dispensaries as well as the lack of isolation rooms in hospitals. This is in line with low practice rates reported in the survey. However, further investigations such as focus group discussions are necessary to understand further obstacles that might hinder HCW from successful TBIC.

4.5 Prospects

The study results indicate that HCW in the Moyen-Ogooué province are insufficiently protected from TB infection. Efforts have to be made to improve TBIC and general knowledge about TB amongst HCW.

Prior to other activities, guidelines have to be established on a national level in collaboration with the PNLT. These guidelines need to be specifically adjusted for each healthcare structure, followed by regular monitoring assessments. As Emerson et al. showed in their longitudinal study in Zambia and Botswana, a facility-specific plan and training of HCW can considerably improve the TBIC performance of a clinic within one year [58]. Another prerequisite for the

successful implementation of these guidelines are adequate manpower and financing.

Once the implementation is in progress, focus group discussions have been proven beneficial to identify obstacles in the implementation process. Frequently named obstacles that were found in other studies included inadequate structures, lack of manpower and managerial support as well as stigma [59, 60].

As the KAP survey revealed, knowledge about TB was rather poor, especially amongst auxiliary and assistant nurses who present the largest part of HCW in the Moyen-Ogooué province, particularly in rural areas. As good basic knowledge is vital for effective TB control, training sessions need to be initiated with focus on these groups in order to raise awareness, eliminate misbelieves and fight against the stigmatization of TB patients.

Due to their proximity to the communities, primary healthcare services play a crucial role in TB control and should therefore not be forgotten. In the future, the PNLT should make efforts to integrate dispensaries into TB care and educational programs as it is also part of the DOTS strategy.

The results of this study pose evidence for gaps regarding the current TBIC situation in the Moyen-Ogooué province and aim to serve as a starting point for initiating a change in local TB control. More operational research will be necessary in the future to eventually maximize the protection of HCW and other patients from nosocomial TB transmission.

5. Summary

Background: Due to their interaction with infectious TB patients, HCW are at greater risk to develop TB than the general population. TB transmission in healthcare settings does not only threaten HCW, but also other patients and visitors in the hospital. Although Gabon ranks among the top-ten high incidence countries in the world, there are currently no national guidelines available for TBIC and several TB cases have already been notified among HCW. In the Moyen-Ogooué province, where resources are limited and evidence of a high MDR-TB prevalence is accumulating, effective TB control remains a challenge. The aim of this study was to assess the current TBIC practices in different healthcare facilities in the Moyen-Ogooué province and to provide insight into the knowledge, attitude and practices of HCW regarding TB.

Methods: Twenty healthcare facilities, including two hospitals, one ambulatory HIV-clinic and 17 dispensaries, were assessed using a standardized tool. The assessments were conducted by direct observation, reviewing documents and in-depth interviews with the head of the facility or department. Current TBIC practices in the Moyen-Ogooué province were evaluated in comparison to the WHO recommendations on TBIC in healthcare facilities in limited-resource settings. In addition, the knowledge, attitude and practices of HCW were investigated by means of an interviewer-administered questionnaire which was particularly designed for this study.

Results: The study revealed a complete absence of managerial TBIC controls such as infection control guidelines or committees. The implementation of administrative and environmental control measures was generally low. The MDR-TB department of one of the assessed hospitals was the only department that provided regular TB screening for its personnel.

A total of 103 KAP survey questionnaires were completed by HCW. According to predefined categories, 40.8% of the respondents had “rather poor” knowledge about TB. However, all doctors had “good” or “excellent” knowledge. The professional category, level of education and former training on TB were

found to be significantly associated with good knowledge levels. Attitudes towards TB and TBIC were overall positive. With 72.8%, the majority of HCW was scared of getting TB and 97.1% would be willing to be screened for TB regularly. Reported TBIC practice rates were rather low, especially regarding triaging of presumed TB cases and environmental controls. Good knowledge about TB was not statistically associated with good TBIC practice.

Conclusions: The study results provided evidence for the urgent need of national TBIC guidelines, as HCW in the Moyen-Ogooué province are not sufficiently protected from occupational TB transmission. The assessment results can serve as a reference point for elaborating feasible guidelines and monitoring their implementation. The KAP survey results suggest, that effective TBIC does not only depend on good knowledge about TB, but also requires adequate facility structures, manpower and financing. However, particularly HCW with a lower professional degree, who represent the peripheral healthcare system, must receive training on TB and TBIC, as basic knowledge about TB is crucial for the early identification of TB patients.

6. Summary in German language

Hintergrund: Aufgrund ihrer Interaktion mit infektiösen Tuberkulosepatienten haben Beschäftigte des Gesundheitswesens ein höheres Risiko eine Tuberkulose zu entwickeln, als die allgemeine Bevölkerung. Die Tuberkuloseübertragung in Gesundheitseinrichtungen gefährdet nicht nur die Mitarbeiter, sondern auch andere Patienten und Besucher. Obwohl Gabun zu den zehn Ländern mit der höchsten Tuberkuloseinzidenz weltweit zählt, gibt es zurzeit keine nationalen Leitlinien für deren Infektionskontrolle und es wurde bereits über mehrere Tuberkulose-Fälle unter Beschäftigten des Gesundheitswesens berichtet. In der Moyen-Ogooué Provinz, wo Ressourcen beschränkt sind und es immer mehr Hinweise auf eine hohe MDR-TB-Prävalenz gibt, ist eine effektive Infektionsprävention der Tuberkulose weiterhin eine Herausforderung. Das Ziel dieser Studie war es, die aktuellen Infektionskontrollmaßnahmen in verschiedenen Gesundheitseinrichtungen der Moyen-Ogooué Provinz zu erfassen und einen Einblick in das Wissen und die Haltung des Personals, sowie Anwendung von Präventionsmaßnahmen bezüglich der Tuberkulose von Mitarbeitern des Gesundheitswesens zu gewinnen.

Methoden: Mithilfe eines standardisierten Fragebogen wurden insgesamt 20 Gesundheitseinrichtungen beurteilt, einschließlich zweier Krankenhäuser, einer ambulanten HIV-Klinik und 17 sogenannter „dispensaires“ (periphere Gesundheitseinrichtungen, in welchen vor allem Krankenpfleger und Krankenpflegerinnen Patienten medikamentös behandeln). Die Beurteilung der Gesundheitseinrichtungen erfolgte durch direkte Beobachtung, Überprüfung von Dokumenten und Tiefeninterviews mit den Leitern der Einrichtung bzw. der Abteilung. Die aktuell praktizierten Infektionskontrollmaßnahmen bezüglich der Tuberkulose wurden im Vergleich zu den Empfehlungen der WHO zur Tuberkulose-Infektionskontrolle in Gesundheitseinrichtungen unter ressourcenlimitierten Verhältnissen evaluiert. Außerdem wurden mithilfe eines Interviewer-gestützten Fragebogens, welcher speziell für diese Studien entwickelt wurde, das Wissen der Mitarbeiter mit Patientenkontakt über die

Tuberkulose, deren Einstellung zu der Erkrankung und deren derzeit ausgeübten Präventionsmaßnahmen erfasst.

Ergebnisse: Die Studie zeigte einen generellen Mangel an aufbauorganisatorischen Infektionskontrollmaßnahmen wie entsprechenden Leitlinien oder Ausschüsse. Die Umsetzung von administrativen Maßnahmen und adäquaten Umweltbedingungen war allgemein unzureichend. Die Station für MDR-TB war die einzige Abteilung, welche Personal regelmäßig auf Tuberkuloseinfektionen untersuchte.

Insgesamt nahmen 103 Beschäftige des Gesundheitswesens an der Umfrage teil. Gemäß den zuvor definierten Kategorien, hatten 40,8% der Teilnehmer „eher schlechte“ allgemeine Kenntnisse über die Tuberkulose. Alle teilnehmenden Ärzte dagegen hatten „gutes“ oder „exzellentes“ Wissen. Es stellte sich heraus, dass die Berufsgruppe, der Bildungsgrad sowie vorherige Fortbildungen über Tuberkulose signifikant mit gutem Wissen assoziiert waren. Einstellungen gegenüber der Tuberkulose und Infektionspräventionsmaßnahmen waren alles in allem positiv. Mit 72,8% hatte die Mehrheit der Befragen Angst sich mit Tuberkulose zu infizieren und 97,1% wären einverstanden sich regelmäßig testen zu lassen. Nach eigenen Angaben wurden eher wenige Infektionspräventionsmaßnahmen ausgeübt, vor allem bezüglich der Triage von eventuellen Tuberkulosefällen und Umweltmaßnahmen. Gutes Wissen über Tuberkulose stand statistisch in keinem Zusammenhang mit der konsequenten Ausübung jener Maßnahmen.

Schlussfolgerungen: Die Studie lieferte den Beweis für eine dringende Notwendigkeit für nationale Tuberkulose-Infektionskontrollleitlinien, da die Beschäftigten des Gesundheitsweisens in der Moyen-Ogooué Provinz nicht ausreichend vor berufsbedingter Tuberkuloseübertragung geschützt sind. Die Ergebnisse der Beurteilungen der Gesundheitseinrichtungen können dabei als Orientierung für die Entwicklung solcher Leitlinien dienen, Aufschluss über deren Umsetzbarkeit geben und helfen, den Implementierungsprozess zu überwachen. Die Umfrageergebnisse deuten darauf hin, dass erfolgreiche Tuberkulose-Infektionsprävention nicht nur von guten Kenntnissen über die

Erkrankung abhängt, sondern außerdem adäquate Gebäudestrukturen, Personal und Finanzierung braucht. Trotzdem müssen insbesondere Mitarbeiter mit einem niedrigeren Ausbildungsgrad in Fortbildungen über Tuberkulose und die entsprechenden Präventionsmaßnahmen eingebunden werden, da allgemeines Wissen über Tuberkulose entscheidend für die rechtzeitige Identifizierung von Tuberkulosepatienten ist.

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8. Declaration of own contribution

The study for this thesis was conducted at the Institute for Tropical Medicine, Travel Medicine and Human Parasitology at the University Department of medicine of the Eberhard Karls Universität in Tübingen under the supervision of Prof. M.P. Grobusch and Prof. A.A. Adegnika.

The study was designed by me under the supervision of Prof. M.P. Grobusch, Prof. A.A. Adegnika and Dr. M. Massinga Loembe.

The facility assessment tool was created by me under the supervision of Dr. M. Massinga Loembe. The KAP survey questionnaire was designed by me in collaboration with A. L. Cremers.

All research data presented in this thesis were entirely collected by myself. The facility assessments as well as the KAP survey interviews were conducted by me. In three exceptional cases the KAP questionnaires were read out to the respondent by Dr. J. R. Edoa in my presence.

Data analysis was entirely done by myself.

The manuscript of this thesis was written by myself under the supervision of Prof. M. P. Grobusch, Prof. A.A. Adegnika and A.L. Cremers. No other references than noted were used.

_____

Date and signature

9. Acknowledgements

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Annex 1: Facility assessment tool

TB-ICE – Facility Assessment

Assessed by: _____ **Date:** _____

Facility: _____

Person in charge of infection control or equivalent:

_____

1. Managerial controls: Supporting structures and activities to ensure implementation of TB infection control interventions

	0	1	2	NA
1.1. Does your facility have an Infection prevention and Control Committee?	No		Yes	NA
1.2. Did this committee meet within the last 4 weeks?	No		Yes	NA
1.3. Is there a written TB Infection Control Plan for the facility?	No	Yes (not kept on site)	Yes (kept on site)	NA
1.4. Is the TB infection control plan displayed in (a) public place?	No		Yes	NA
1.5. Were TB infection control measures assessed internally within the last 5 weeks?	No		Yes	NA
1.6. Were staff trained in TB infection control this month?	No	Some staff	Yes	NA
1.7. Is initial training provided for new staff members about TB infection control practices?	No	Some staff	Yes	NA
1.8. Were all newly diagnosed HIV+ clients screened for TB symptoms (cough, loss of weight, night sweat)?	Some (no proof)	Some (proof available)	Yes (proof availabl e)	NA
1.9. Were any maintenance activities undertaken during the last 4 weeks on structures, which improve TB infection control (e.g. air conditioning, fans, ultraviolet germicidal irradiation (UVGI))?	No		Yes	NA
			Max. total score = 18	

If initial training about TB is provided for new staff members, what groups of employees are included in this training?

_____

_____

Is ongoing training provided for health care workers about TB infection control practices? □ Yes □ No

If YES, what groups of employees are included in the training?

How often is training done?

Is it mandatory? □ Yes □ No

Are records kept of training sessions? □ Yes □ No

If YES, review documentation of when trainings were held and who attended the trainings and summarize below.

2. Patient Education and Awareness

	0	1	2	NA
2.1. Are posters displaying cough hygiene prominently displayed?	No		Yes	NA
2.2. Are TB suspects/patients taught about cough etiquette and respiratory hygiene?	No	Occasionally	Yes	NA
2.3. Are patients given educational materials on TB?	No	Occasionally	Yes	NA
2.4. Are patients taught about signs and symptoms of TB?	No	Occasionally	Yes	NA
			Max. total score = 8	

If patients are given educational materials on TB, describe the materials and keep a copy for review.

If patients are educated about signs and symptoms of TB, where, how often, and by whom?

If patients are taught about cough etiquette and respiratory hygiene, where, how often, and by whom?

3. Administrative controls: Strategies to reduce generation of infectious aerosols:

	0	1	2	NA
3.1. Are patients screened for cough as they enter your facility?	No	Occasionally	Yes	NA
3.2. Is there a symptom checklist in place to screen patients for TB?	No		Yes	NA
3.3. Are patients educated in cough hygiene as they enter your facility?	No	Occasionally	Yes	NA
3.4. If patients cough, are they provided with masks/tissues to reduce infectious aerosols?	No	Occasionally	Yes	NA
3.5. Is there an enclosed waste basket where tissues and face masks can be discarded?	No		Yes	NA
3.6. Are TB suspects/patients separated from those who are not?	No	Occasionally	Yes	NA
3.7. Are TB suspects given priority to ensure shorter waiting times in outpatient facilities?	No	Occasionally	Yes	NA
3.8. Were staff reminded of the need for 'early TB diagnosis' during this month?	No		Yes	NA
3.9. Are there separate and ventilated facilities for sputum collection from suspects?	No	Yes, but not ventilated	Yes	NA
3.10. Is there a 'fast queue' for collection of sputum smear results?	No		Yes	NA
3.11. What is the laboratory turn-around time for sputum AFB/microscopy for the last sputum AFB result received?	> 72 hours	48-72 hours	< 48 hours	NA
			Max. total score = 22	

If a TB suspect register is available, record the following numbers for the previous calendar year (2015):

How many presumed TB cases were identified?	
How many TB suspects had sputum smear/Xpert sent?	
How many TB suspects had sputum culture sent?	
For how many TB suspects were smear/Xpert results available?	
For how many TB suspects were culture results available?	
How many TB suspects had a positive smear /Xpert?	
How many TB suspects had a positive culture?	
How many suspects with positive smears were started on TB treatment?	
How many suspects with positive cultures were started on TB treatment?	

What was the total adult headcount (patient-visits) for the clinic? ☐

How are TB suspects evaluated? Observe consultations and describe in as much detail as possible (include details on route and time between entry to evaluation, including sputum collection, to departure):

_____

_____

_____

Where are sputum specimens kept?

_____

_____

Is there a specimen tracking system? □ Yes □ No

Review the charts for 5 TB patients seen in the last 3 months to determine the # days between sputum collection and initiating TB treatment.

	Date sputum collected	Date result received	Date treatment started
Patient # 1 ……			
Patient # 2 ……			
Patient # 3 ……			
Patient # 4 ……			
Patient # 5 ……			

Where do patients from this facility receive TB treatment (tick all that apply)?

□ on-site

□ off-site

□ BOTH on-site AND off-site

If BOTH on-site and off-site, what are the criteria to refer them off-site?

_____

_____

If ON-SITE, is directly observed therapy (DOT) available? □ Yes □ No

If YES, for what duration?

□ First 2 months of therapy

□ Entire course of therapy

□ Other - specify: _____

What is the frequency of DOT?

□ 7 days/week

□ 5 days/week

□ 3 days/week

□ Other –
specify;_____

What systems are in place to ensure adherence/follow-up of TB patients?

_____

_____

_____

If OFF-SITE, describe the process by which referral information and information on treatment progress are transferred between the facility and the referral site.

_____

_____

_____

Does the HIV care and treatment unit have a TB register? □ Yes □ No

If NO, where are TB patients registered? Tick the appropriate boxes.

□ In the TB unit of the same facility

□ In the clinic the patient is referred to (local clinic)

□ TB patients treated in the HIV care and treatment unit are not registered

□ Elsewhere – specify _____

If a TB register is available, record the following numbers for the most recent calendar year:

How many TB patients (all types of TB) were registered?	
How many Pulmonary TB patients (PTB) were registered?	
How many PTB patients had a sputum smear/Xpert or culture result at diagnosis?	
How many PTB patients had a positive sputum smear/Xpert result at diagnosis?	
How many PTB patients had a positive sputum culture result at diagnosis?	
How many smear positive PTB patients became smear negative after 3 months of treatment?	
How many smear positive PTB patients were moved out to another facility?	
How many bacteriologically confirmed PTB patients were cured[1]?	
How many bacteriologically confirmed PTB patients completed treatment without proof of cure?	
How many bacteriologically confirmed PTB patients died?	
How many bacteriologically confirmed PTB patients were lost to follow up (no follow-up for more than 2 months)?	
How bacteriologically confirmed PTB patients were smear positive at the end of treatment (treatment failures)?	
How many bacteriologically confirmed PTB patients were identified as MDR/RR TB patients?	
How bacteriologically confirmed PTB patients were identified as XDR-TB patients?	

1 *Definition TB cure: A pulmonary TB patient with bacteriologically confirmed TB at the beginning of treatment who was smear- or culture-negative in the last month of treatment and on at least one previous occasion*.

4. Environmental controls: Strategies to remove infectious aerosols after generation

	0	1	2	NA
4.1. Are there windows on opposite walls leading to unrestricted airflow?	No	Only on one wall	Yes	NA
4.2. Are the windows in your facility kept open during working hours?	No	Occasionally	Yes	NA
4.3. Are there high ceilings (> 3m) in your facility?	No	Some	Yes	NA
4.4. Are fans used to increase circulation of air in your area of work?	No	Occasionally	Yes	NA
4.5. Do you know the direction of airflow in each consultation room in your facility?	For none	Only for some	Yes	NA
4.6.Do staff in consultation rooms sit with their back towards the direction of airflow?	uncert ain	Occasionally	Yes	NA
4.7. Is there mechanical ventilation?	No		Yes	NA
Max. total score = 14				

If mechanical ventilation is used, please specify:

_____

What air-cleaning methods are used?

□ none

□ ultraviolet germicidal irradiation (UVGI)

□ HEPA filtration

5. Personal risk reduction strategies to reduce inhalation of infectious aerosols:

	0	1	2	NA
5.1. Were staff screened for TB infection symptoms this month?	No	Some staff	Yes	NA
5.2. Are staff offered confidential voluntary HIV counseling and testing?	No		Yes	NA
5.3. Were staff reminded of the risks of TB for people who are living with HIV this month?	No	Some staff	Yes	NA
5.4. Is isoniazid preventive treatment available for HIV-infected staff members?	No		Yes	NA
5.5 Were staff trained to recognize and diagnose TB this month?	No	Some staff	Yes	NA
5.6. Are N 95 respirator/masks available this month?	No	Sometimes	Yes	NA
5.7. Were N95 respirator/masks used by staff in high risk services this month (e.g. TB, coughing queue)?	No	Sometimes	Yes	NA
Max. total score = 14				

Are staff involved in sputum induction procedures? □ Yes □No

If NO, skip next question

Do staff use any personal respiratory protection when doing sputum induction?

□ No

□ Yes: surgical mask

□ Yes: N95 or FFP2 mask (personal respirator)

□ Yes: other – please specify:_____

If N95 or FFP2 masks are available, describe the situations in which N95 or FFP2 masks are used in the facility (confirm through observation):

_____

_____

If staff is screened for TB, describe procedures used and frequency of screening.

_____

_____

Do you know of any staff member who developed active TB in the past 2 years? □ Yes □No

If YES, please provide more details (category of staff, workplace, type of TB etc.):

_____

_____

_____

_____

What is the recommended action for HIV-infected workers?

What are the policies for reassignment if an HIV-infected worker requests it?

What HIV-related care and treatment is available on-site for infected staff members?

6. Facility Layout

Draw a diagram with measurements of the facility, indicating waiting areas, consultation rooms, procedure rooms, dispensary, laboratory and offices. Include windows, doors, environmental control measures (fans, UV light, etc) and airflow. Indicate where patients are screened for TB and how 1) a TB suspect and 2) a patient not suspected of TB flows through the facility during a typical visit. Include photographs if possible.

Annex 2: KAP survey questionnaire

Demographics

Age:

- ☐ < 20 years
- ☐ 21-30 years
- ☐ 31-40 years
- ☐ 41-50 years
- ☐ > 50 years

Gender: ☐ M ☐ F

Role in the facility (professional category of current position):

☐ Doctor

☐ Nurse

☐ Assistant nurse

☐ Midwife

☐ Other:_____

☐ in training

Level of education:

☐ CEP

☐ BEPC

☐ BAC

☐ University degree (e.g. Master, Doctorate)

☐ Other: _____

Duration of work in health care: _____ years

Current department (if applicable): _____

Have you ever had TB?

☐ Yes☐ No

Have you ever been tested for TB?

☐ Yes☐ No

Has one of your family members had TB?

☐ Yes☐ No

Are you vaccinated against TB? (BCG vaccine)

☐ Yes☐ No ☐ Not sure

Have you ever received training on TB during your work in the hospital?

☐ Yes☐ No ☐ Not sure

If yes, what kind of training?

_____

<u>Knowledge:</u>

1. What causes TB?

- ☐ A bacterium
- ☐ I don't know
- ☐ Other

2. What are the typical symptoms that are used as an indicator for active pulmonary TB?

- ☐ Cough
- ☐ Bloody sputum
- ☐ Fever
- ☐ Weight loss
- ☐ Night sweats
- ☐ I don't know
- ☐ Other

3. Can TB be completely cured?

☐ Yes☐ No ☐ Not sure

4. How is TB transmitted?

- ☐ Through coughed-up droplets via the air
- ☐ I don't know
- ☐ Other

5. What is the standard treatment for TB?

- ☐ Specific antibiotics/ anti-TB regimen/RHZE
- ☐ I don't know
- ☐ Other

6. How long does the standard treatment for drug-sensitive (TB responding well to therapy) TB of the lungs (pulmonary TB) usually take?

- ☐ 6 months
- ☐ I don't know
- ☐ Other

7. What can happen if you take your TB drugs incorrectly/disrupt TB treatment? (more than one answer possible)

- ☐ Development of resistances
- ☐ Relapse
- ☐ I don't know
- ☐ Other

8. Who has a higher risk to get TB than average population? (Name 3 risk groups/ risk factors)

- ☐ People living with HIV/AIDS
- ☐ Young children
- ☐ Close contacts of a confirmed case
- ☐ Health care workers
- ☐ Laboratory staff
- ☐ People with medical conditions that weaken the immune system (e.g. Cancer, Diabetes)
- ☐ People under immunosuppressive therapy
- ☐ Undernourished people
- ☐ People drinking alcohol
- ☐ People smoking
- ☐ People using drugs
- ☐ Prisoners
- ☐ I don't know
- ☐ Other

9. Can you get TB when you are vaccinated with BCG?

☐ Yes☐ No ☐ Not sure

10. Is there a relationship between HIV and TB?

☐ Yes (go to 10.1) ☐ No ☐ Not sure

10.1. What is it?

- ☐ Person with HIV is more likely to develop TB
- ☐ I don't know
- ☐ Other

11. What is the most frequently used diagnostic laboratory test to diagnose TB in Gabon?

- ☐ Sputum smear microscopy
- ☐ I don't know
- ☐ Other

12. What is the difference between latent TB infection and TB disease? (More than one answer possible)

- ☐ TB infection is asymptomatic
- ☐ TB infection is not contagious
- ☐ I don't know
- ☐ Other

13. When you are in the same room with a TB-infected patient, how can you minimize the risk of getting TB from that patient? (more than one answer possible)

- ☐ Increase airflow (e.g. open windows and doors, fan)
- ☐ Let patient perform cough hygiene (mask, tissue, arm, etc.)
- ☐ Wear respirator
- ☐ I don't know
- ☐ Other

14. What is MDR-TB?

- ☐ TB that is resistant to the most important anti-TB drugs/ TB that doesn't respond to the usual treatment
- ☐ I don't know
- ☐ Other

15. How can you get MDR-TB? (more than one answer possible)

- ☐ Through infection from another person with MDR-TB
- ☐ Through incorrect treatment
- ☐ I don't know
- ☐ Other

16. Is MDR-TB curable?

☐ Yes☐ No ☐ Not sure

<u>Attitude</u>

1. Do you think you could get TB?

☐ Yes☐ No ☐ Not sure

If not, why?_____

_____

2. Are you scared of getting TB?

☐ Yes☐ No ☐ Not sure

If yes, why?_____

_____

3. Would you continue to socialize with your friend, if he was diagnosed with TB?

☐ Yes☐ No ☐ Not sure

4. Would you share the same cutlery, plates and glasses with a family member, if he was infected with TB?

☐ Yes☐ No ☐ Not sure

5. Would you say that TB is a stigmatized disease?

☐ Yes☐ No ☐ Not sure

6. Would you like to learn more about TB?

☐ Yes☐ No ☐ Not sure

7. Would you be willing to get tested for TB regularly?

☐ Yes☐ No ☐ Not sure

If not, why?_____

_____

8. Do you feel TB is a major threat to public health in Gabon?

☐ Yes☐ No ☐ Not sure

9. Do you think there is a need of improvement in TB control in your region?

☐ Yes☐ No ☐ Not sure

If yes, how?_____

_____

Practice

1. When a patient says he has been coughing for a month, I suspect TB

☐ Never ☐Sometimes ☐ Most of the times ☐ Always

2. I separate coughing patients from other patients

☐ Never ☐Sometimes ☐ Most of the times ☐ Always

3. When I deal with a coughing patient I wear a mask

☐ Never ☐Sometimes ☐ Most of the times ☐ Always

4. When I deal with a confirmed active TB patient, I wear a mask

☐ Never ☐Sometimes ☐ Most of the times ☐ Always

5. I give patients who arrive with a cough a mask

☐ Never ☐Sometimes ☐ Most of the times ☐ Always

6. When a TB patient is in the room, I open windows and doors to increase natural ventilation

☐ Never ☐Sometimes ☐ Most of the times ☐ Always

7. When dealing with a TB patient, I turn on the fan to increase ventilation

☐ Never ☐Sometimes ☐ Most of the times ☐ Always

8. When a patient arrives at my facility with a cough, I prioritize him/her in comparison to patients without cough

☐ Never ☐Sometimes ☐ Most of the times ☐ Always

9. If a patient is newly diagnosed with TB, I give him/her information about his/her disease

☐ Never ☐Sometimes ☐ Most of the times ☐ Always

10. I explain coughing patients how they can practice cough hygiene, in order to avoid infecting other people around them

☐ Never ☐Sometimes ☐ Most of the times ☐ Always