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Updated estimated incidence and prevalence of serious fungal infections in Trinidad and Tobago

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ABSTRACT

Objective: : To estimate the incidence and prevalence of serious fungal infections in Trinidad and Tobago (T&T), with a population of 1 394 973 million.
Methods: : The medical literature was searched to obtain published data on the incidence and prevalence of fungal infections in the Caribbean. If data were unavailable, estimations were performed using the frequencies of fungal infection in populations at risk. Asthma and pulmonary tuberculosis rates were used to derive the prevalence of allergic bronchopulmonary aspergillosis (ABPA), severe asthma with fungal sensitization (SAFS), and chronic pulmonary aspergillosis (CPA).
Results: : The estimated annual burden of fungal infections was 46 156 persons (3.3% of the population), including 21 455 women with recurrent vulvovaginal candidiasis, 118 persons with invasive aspergillosis, 3637 adults with ABPA, 4800 with SAFS, and 178 with CPA. Annually, we estimated 70 cases of candidemia and 14 647 cases of tinea capitis in children. Of the 11 000 persons living with HIV/AIDS, it was estimated that there were 40 cases of cryptococcal meningitis, 88 cases of disseminated histoplasmosis, and 124 cases of *Pneumocystis* pneumonia.
Conclusion: : There seems to be an extensive burden of fungal infections in T&T. Hence, targeted interventions are required to improve clinical and laboratory diagnosis and a national surveillance system should be implemented.

Introduction

Fungal infections are emerging as an important cause of disease, and range from superficial mycoses to systemic mycoses that may involve the lungs, abdominal organs, central nervous system, and bones, some of which may be opportunistic mycoses. As the prevalence of immunosuppressive conditions such as HIV/AIDS and cancer increases, more patients are at risk for developing these life-threatening, opportunistic fungal infections. In the Caribbean region, there are very limited data on fungal infections due to a lack of capacity for laboratory diagnosis and a shortage of healthcare workers with the expertise to appropriately diagnose and adequately treat these mycoses (Denning and Gugnani, 2015).

Trinidad and Tobago (T&T), separated by a 32-kilometer strait, form the southernmost islands of the Caribbean chain, and comprise a single nation with a population of approximately 1 394 973 (2019 mid-year estimate). The ethnic composition of the population comprises 35.4% of East Indian origin, 34.2% of African descent, 23.0% of mixed races, and 8.4% of other ethnic groups (European, Asian, Middle Eastern). In 1983, the first cases of AIDS were reported among gay/bisexual men (Bartholomew et al., 1983); from 1985, there was a shift to predominantly heterosexual transmission of HIV (Cleghorn et al., 1995). In 2002, antiretroviral therapy (ART) became available, and was subsidized by the government (Edwards et al., 2019). It is now estimated that there are 11 000 persons living with HIV (PLHIV) in T&T, of whom 27% are not on ART (UNAIDS, 2019).

Tinea capitis has been found to be more common in children of African origin, with *Trichophyton tonsurans* being the most common dermatophyte organism isolated (Moore and Suite, 1993). In patients with AIDS, opportunistic infection due to *Candida albicans, Cryptococcus neoformans, Pneumocystis jirovecii* (Bartholomew et al., 1985), and *Histoplasma capsulatum* (Bartholomew et al., 1985; Barton et al., 1988) have been described. In 2015, the burden of fungal diseases was estimated for this region (Denning and Gugnani, 2015); however, with more data now available, our study aimed to re-estimate the burden of serious fungal infections in T&T.

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Methods

The medical literature was searched to obtain published data on the incidence and prevalence of fungal infections in the Caribbean, and data were extracted from the United Nations (UN) Country Population Data 2019 (https://population.un.org/wpp/) to obtain demographic information on the population of T&T. Data on people living with HIV (PLHIV) were obtained from 2019 T&T UNAIDS data (www.unaids.org/en/regionscountries/countries/trinidadandtobago) and data on pulmonary tuberculosis were taken from the 2020 World Health Organization Global Tuberculosis Report for T&T (https://worldhealthorg.shinyapps.io/tb_profiles/?_inputs_&entity_type=%22country%22&lan=%22EN%22&iso2=%22TT%22). Data on serious fungal infections in T&T were very limited; therefore, specific populations at risk for fungal diseases, including patients with asthma, chronic obstructive pulmonary disease (COPD), tuberculosis (TB), HIV, and cancer, as well as postsurgical patients and those admitted to intensive care units (ICUs) were used to estimate the burden of serious fungal infections in T&T. If no published data on fungal infections in patients with HIV/AIDS were found in Latin America or the Caribbean, unpublished local data on fungal infections in HIV/AIDS patients were obtained from the Medical Research Foundation of Trinidad and Tobago (MRFTT), the largest HIV clinic in T&T, representing approximately 70% of PLHIV in the country, to estimate the incidence/prevalence of these fungal infections.

The denominators included the overall population in T&T, the female population, persons < 15 years of age, the number of PLHIV, and those with various respiratory diseases.

Our study did not involve data collection through interaction/intervention with patients or identifiable private information. Informed consent was not required from patients because overall data (rather than individual data) were collected and analyzed.

Data on persons affected by allergic bronchopulmonary aspergillosis (ABPA) and severe asthma with fungal sensitization (SAFS) were obtained from the published adolescent rates (11–19 year olds) for T&T, which were used as a proxy for adult rates (Monteil et al., 2005). The prevalence of ABPA was assumed to be 2.5% of the rate of asthma in adults who presented to secondary care, based on a study from South Africa (Denning et al., 2013) while SAFS was estimated by assuming that 10% of asthmatic patients have severe asthma, with SAFS occurring in approximately 33% of severe asthmatics (Denning et al., 2013). The prevalence of invasive aspergillosis (IA) was estimated by assuming its presence in: 13% of cases of acute myeloid leukemia (AML) per year and an equivalent number among all other hematologic malignancies (Lortholary et al., 2011); 2.6% of cases of lung cancer (Yan et al., 2009); 4% of deaths due to AIDS (Denning, 2016); and 1.3% of hospitalized chronic obstructive pulmonary disease (COPD) patients (Guinea et al., 2010). Chronic pulmonary aspergillosis (CPA) often occurs following tuberculosis treatment, and may be a long-term outcome of many respiratory disorders. Estimates of its prevalence were based on an assumed 22% of pulmonary TB cases with cavitation and 2% of those without, and an estimate of the relative ratios of other underlying respiratory conditions associated with CPA and pulmonary TB (Denning et al., 2011). Pulmonary TB was assumed to underlie 25% of cases (Smith and Denning, 2011).

Women with four or more episodes of vaginal candidiasis annually are defined as having recurrent vulvovaginal candidiasis; this was calculated based on a 6% incidence in women > 15 years, according to multiple studies (Foxman et al., 1998; Foxman et al., 2010; Denning et al., 2018). The incidences of candidemia and *Candida* peritonitis were estimated in patients with cancer and those undergoing postsurgical procedures or critical care, as well as other immunocompromised patients at high risk for developing candidemia. The annual incidence of Candida peritonitis was calculated using the assumption that if candidemia occurs at a population rate of five cases per 100 000 (Arendrup, 2010; Cleveland et al., 2012), then one-third are in critical care wards, and that for every two patients with candidemia, there will be one patient with Candida peritonitis (Montravers et al., 2011).

To estimate the incidence of histoplasmosis, cryptococcal disease, *Pneumocystis* pneumonia (PCP),and esophageal candidiasis in HIV/AIDS patients, data were obtained from literature relating to Latin America and the Caribbean. If no data were available, unpublished data were collated from the electronic medical records system of the MRFTT for the period 2011–2020, for patients who initially presented to the General Hospital in Port of Spain, Trinidad (one of five major hospitals in T&T and with approximately 70% of PLHIV in the country).

Patients at risk for cryptococcal disease are those with a CD4 < 100 cells/mm^3 not on ART, those on ART with a CD4 < 100 cells/mm^3 and virologic failure, or those lost to follow-up. An annual incidence rate of 4.9% for cryptococcal meningitis has been estimated for the Caribbean (Rajasingham et al., 2017), and this rate was used in our study. In Guatemala, histoplasmosis was found in 10.6% of those patients with CD4 < 200 cells/mm^3 (Samayoa et al., 2019), so this estimate was used. The prevalence of PCP in a number of Caribbean islands was previously found to be 14–45% (De Armas Rodriquez et al., 2011), so a conservative estimate of 15% was used.

Oral candidiasis has been estimated to occur in 90% of untreated HIV patients with CD4 < 200 cells/mm^3 (Matee et al., 2000), while esophageal candidiasis was assumed to be similar to the prevalence in HIV/AIDS patients in Denmark, affecting 20% of patients not on ARVs, and 5% of those on ARVs (Smith et al., 1990).

Tinea capitis is a dermatophytosis that occurs in school-age children in T&T (Moore and Suite, 1993). A systematic review of studies on tinea capitis in Africa conducted between 1990 and 2020 showed a pooled prevalence of 23% (Bongomin et al., 2020). A study in India showed a prevalence of tinea capitis of 10% (Kundu et al., 2012). After consultation with our local dermatology colleagues, a conservative estimate of 5% was used for our study.

The prevalence of fungal keratitis was estimated to be 5/100 000, based mostly on data from Paraguay (Brown et al., 2021; Alvarez-Moreno et al., 2018), while mucormycosis was calculated at 2 per million (Prakash and Chakrabarti, 2019).

Results

The T&T population has been estimated at 1 394 973 (UN, 2019) of whom 292 944 (21%) are children < 15 years of age. Of the adults, 795 135 (57%) are over 40 years of age (Table 1). In 2019, the gross domestic product per capita in T&T was US$17 398. An estimated 11 000 were persons living with HIV/AIDS (PLHIV) (UNAIDS, 2019), with an estimated HIV prevalence of 0.7% among adults aged 15–49 years (UNAIDS, 2019), of whom 2970 (27%) were not on ARVs. Our estimate for annual new cases of HIV/AIDS at risk for opportunistic infections was 424 (unpublished local data). Of the 8030 (73%) patients on ART, ART failure was estimated at 5% or 402 patients. Based on the above, our estimate for the annual at-risk population for opportunistic infections was 826 PLHIV (Table 1).

The prevalence of asthma (wheezing in the last 12 months) in adolescents (11–19 years old) has been calculated at 13.2% (Monteil et al., 2005). Using adolescent rates of asthma as a proxy for adult rates, suggests an estimated 145 468 asthmatics. T&T has an estimated 3637 cases of ABPA (261 per 100 000 person-years) and 4800 cases of SAFS (344 per 100 000 person-years) (Table 3). Chronic pulmonary aspergillosis (CPA) is less common, with a total of 178 CPA cases expected nationally (12.8 per 100 000 person-years) (Table 3).

An estimated 9.5% of persons older than 40 years have COPD (Seemungal et al., 2017), with approximately 13.0% of hospital admissions each year attributed to COPD (Thorington et al., 2011). Overall, our estimate for IA cases in T&T was 118, at a rate of 8.5 cases per 100 000 person-years.

Of a total of 357 586 women aged 15–50 years in T&T, 21 455 — a rate of 1538 per 100 000 — were estimated to have four or more

Table 1
Baseline demographic data for Trinidad and Tobago

Population	Details	Source
Demographic data	Total population = 1,394,973 Children (< 15 years) = 292 944 (21%) Total number of adults = 1 102 029 Adults over 40 years = 628 156 Adult women = 573 055 Women 15–50 years = 357 586	UN population data, 2019
HIV/AIDS	HIV/AIDS patients in 2019 = 11 000 Number of diagnosed cases on ARVs = 8030 (73%) Number of undiagnosed cases and those not on ARVs = 2970 (27%) Annual new AIDS cases (at risk of OIs) = 424 ART failure = 402 (5%) At risk population for OIs = 826 AIDS-related deaths 2016 = 139	Trinidad and Tobago/UNAIDS, 2019 HIV annual report, 2016 (unpublished local daa)
Tuberculosis	Pulmonary tuberculosis annual incidence, total = 250	Source: https://www.who.int/teams/global-tuberculosis-programme/data
Adults with asthma	Prevalence of asthma in adults = 13.2% Number of adults with asthma = 145 468	Source: Monteil et al., BMC Public Health 2005:5:96 (using adolescent rates as a proxy for adult rates)
COPD	COPD prevalence (all GOLD stages) = 59 674 (9.5% > 40 years) COPD admissions to hospital per year = 7757 (13%)	Source: Seemungal et al., 2017 https://pesquisa.bvsalud.org/portal/resource/pt/biblio-1006476 Thorington et al., 2011
Patients with leukemia	AML population frequency = 2.5/100 000 AML patients per year = 35	ICD-10 C92.0
Lung cancer	Estimate of lung cancer = 244	Globocan, 2020
All cancer sites	Total cancer incidence = 3919	Globocan, 2020
Number of critical care patients	Estimated number of critical care beds = 27	Harriharan et al., 2007

Table 2
Frequency of fungal diseases in selected patient populations

Fungal infection	Population	Annual incidence or prevalence	Reference
Cryptococcal meningitis	HIV/AIDS	4.9%	Rajasingham et al., 2017
Pneumocystis pneumonia (PCP)	HIV/AIDS	15%	De Armas et al., 2011
Histoplasmosis	HIV/AIDS	10.6%	Samayoa et al., 2019
Invasive aspergillosis (IA)	Hematologic malignancies; lung cancer; HIV/AIDS and COPD patients	13% of cases of AML per year and an equivalent number among all other hematologic malignancies; 2.6% of cases of lung cancer; 4% of patients dying of AIDS; 1.3% of hospitalised COPD patients	Lortholary et al., 2011 Yan et al., 2009 Guinea et al., 2010
Chronic pulmonary aspergillosis (CPA)	Tuberculosis and other respiratory diseases	Assumes 22% of pulmonary TB cases with cavitation and 2% of those without; pulmonary TB assumed to underlie 25% of cases	Denning et al., 2011 Smith and Denning, 2011
Allergic bronchopulmonary aspergillosis (ABPA)	Adult asthma patients	2.5%	Denning et al., 2013
Severe asthma with fungal sensitization (SAFS)	Severe asthma (adults) 10% of asthmatic patients have severe asthma	33%	Denning et al., 2013
Candidemia	5/100 000 (mean of 2–11/100 000)		Arendrup, 2010
Oral candidiasis	90% of untreated HIV patients with CD4 < 200	90%	Matee et al., 2000
Esophageal candidiasis	HIV/AIDS patients in Denmark	20% of patients not on ARVs, and 5% of those on ARVs	Smith and Orholm, 1990
Recurrent candida vaginitis	Adult women	6%	Foxman et al., 2010 Denning, 2018
Mucormycosis	0.2/100 000		Prakash, 2019
Fungal keratitis	5/100 000		Brown et al., 2021
Tinea capitis	School-age children Children	23% 10%	Bongomin et al., 2020 Kundu et al., 2012

episodes of vaginal candidiasis annually, based on an incidence of 6% in women in that age group (Denning et al., 2018).

Our study estimated that 70 cases of candidemia occur every year, with an annual incidence of 5 per 100 000 person-years, and that 11 episodes of Candida peritonitis are expected, with an incidence of 0.8 per 100 000 person-years (Table 3).

In patients with HIV/AIDS, there were estimated to be 40 cases of cryptococcal meningitis annually, with an incidence of 2.9 per 100 000 person-years, 124 cases of PCP (8.9 per 100 000 person-years), 88 cases of histoplasmosis (6.3 per 100 000 person-years), and 489 and 426 cases of oral and esophageal candidiasis, respectively (34.9 and 30.4 per 100 000 person-years, respectively) (Table 3).

Table 3
Estimate of the incidence or prevalence of serious fungal diseases in T&T

Fungal infection	Predominant risk groups	Rate per 100 000	Estimated number of cases
Cryptococcal meningitis	HIV/AIDS	2.9	40
Pneumocystis pneumonia (PCP)	HIV/AIDS	8.9	124
Histoplasmosis	HIV/AIDS	6.3	88
Invasive aspergillosis (IA)	Critical care and surgical; cancer and other immunocompromised; HIV/AIDS; respiratory diseases	8.5	118
Chronic pulmonary aspergillosis (CPA)	Tuberculosis and other respiratory diseases	12.8	178
Allergic bronchopulmonary aspergillosis (ABPA)	Adult asthma patients	261	3637
Severe asthma with fungal sensitization (SAFS)	Adult asthma patients	344	4800
Candidemia	Critical care and surgical; cancer and other immunocompromised	5.0	70
Candida peritonitis	Critical care and surgical	0.8	11
Oral candidiasis	HIV/AIDS	34.9	489
Esophageal candidiasis	HIV/AIDS	30.4	426
Recurrent candida vaginitis	Adult women	1538*	21 455
Mucormycosis	Cancer and other immunocompromised	0.2	3
Fungal keratitis		5.0	70
Tinea capitis	Children < 15 years	1050	14 647
Total serious fungal infection burden			**46 156**

* Prevalence for females only

Over the 10 year period 2011–2020, at the General Hospital, Port of Spain, there were 32 cases of cryptococcal meningitis, 167 cases of histoplasmosis, 321 cases of PCP, and 206 cases of oral/esophageal candidiasis in HIV/AIDS patients. This equates to an annual burden of three cases of cryptococcal meningitis, 17 cases of histoplasmosis, 32 cases of PCP, and 20 cases of oral/esophageal candidiasis.

Finally, it was estimated that, annually, there were 14 647 cases of tinea capitis in school-aged children, with an incidence of 1050 per 100 000, three cases per 100 000 of mucormycosis in cancer and immunocompromised patients, and 70 cases per 100 000 of fungal keratitis (Table 3).

Discussion

In patients with HIV/AIDS, systemic fungal infections due to PCP, histoplasmosis, and cryptococossis are responsible for severe, life-threatening infections (Limper et al 2017; Hoving et al 2020), and mortality may exceed 50% despite the availability of antifungal medications (Brown et al., 2012). Due to the widespread availability of ART, the incidence of these systemic fungal infections has decreased in developed countries. However, in resource-limited countries, a number of patients are first diagnosed with advanced HIV infection, with low CD4 counts, while others are failing ART due in part to poor adherence to therapy and transmitted resistance to first-line regimens, thereby limiting therapeutic options (Limper et al., 2017; Hoving et al 2020).

C. neoformans is widely distributed globally, often in association with the droppings of birds, such as pigeons (Emmons, 1955). Indeed, the first case of AIDS in T&T was diagnosed in 1983 in a patient with disseminated cryptococcal infection (Bartholomew et al., 1983). In T&T, HIV patients with cryptococcal meningitis are usually diagnosed using the cryptococcal antigen lateral flow assay (CrAg LFA) with serum and CSF, or the India ink test with CSF.

Histoplasmosis and paracoccidiodomycosis are endemic in Venezuela (Cermeno et al., 2005; Martinez Mendez et al., 2013). Trinidad is approximately 11 kilometers off the northeast coast of Venezuela, so conditions for fungal pathogens may resemble those present in Venezuela; however, there are limited data on the burden of fungal infections in Venezuela (Dolande et al., 2015). Histoplasmosis is thought to be more common than reported in Trinidad because *H. capsulatum* has been isolated in soil associated with bats (Emmons and Greenhall, 1963), and 42% of the population studied in this region were shown to have a positive skin-test reactivity (Hay et al., 1981). Histoplasmosis has been reported among patients with AIDS in Trinidad (Bartholomew et al., 1985; Barton et al., 1988). A systematic review among PLHIV in Latin America showed the incidence of disseminated histoplasmosis to be comparable to that of tuberculosis, but higher in terms of deaths (Adenis et al., 2018). It has also been reported that patients with chronic pulmonary histoplasmosis may be misdiagnosed as smear-negative tuberculosis (Baker et al., 2020), resulting in delayed diagnosis, inappropriate treatment, and an increased risk of mortality.

In T&T histoplasmosis is diagnosed by skin biopsy if the patient has skin lesions, and clinically with the appropriate response to therapy. Since not all patients with histoplasmosis develop skin lesions, a number of diagnoses are probably missed by clinicians, resulting in an underestimate of histoplasmosis cases in T&T.

PCP is a life-threatening pneumonia in PLHIV, which usually occurs at CD4 < 200 cells/mm^3. In T&T, diagnostic methods are unavailable, so PCP is usually diagnosed clinically and by appropriate response to treatment. Oral and esophageal candidiasis are also diagnosed clinically and by appropriate response to treatment.

A previous study carried out to estimate the burden of serious fungal infections in T&T (Denning and Gugnani, 2015), when ART was initiated at a CD4 < 350 cells/mm^3 among PLHIV, estimated that, annually, there were 400 cases of PCP, 50 cases of cryptococcal meningitis, and 750 cases of esophageal candidiasis. However, due to a lack of data, the authors were unable to estimate the annual number of cases of histoplasmosis (Denning and Gugnani, 2015). Among PLHIV in our study, it was estimated that, annually, there were 124 cases of PCP, 40 cases of cryptococcal meningitis, 88 cases of histoplasmosis, and 426 cases of esophageal candidiasis. The estimates in our study were lower than those in the 2015 study because UNAIDS reduced its estimate of the number of PLHIV in T&T from 14 000 in 2015 to 11 000 in 2019, while

'Treat all' was started in September 2017, whereby all PLHIV were offered ART regardless of CD4 counts (Edwards et al., 2021); hence, more patients are now on ART.

The OI fungal data collected over the period 2011–2020 at the General Hospital in Port of Spain are probably an underestimate because a number of HIV patients admitted to hospital may have died before a diagnosis was made, or the diagnosis may have been missed due to a lack of diagnostic facilities for OIs in T&T. In addition, a non-negligible number of coinfections comprising two or more opportunistic pathogens (such as TB + histoplasmosis or histoplasmosis + cryptococcosis) have been recently described in a screening program performed in newly diagnosed HIV patients in Guatemala (Medina et al., 2021).

Asthma is common in T&T (Monteil et al., 2005), with one study showing that it accounted for 8.8% of admissions to an accident and emergency hospital (Mahabir et al., 1999). In 2015, it was estimated that there were 1927–3491 persons affected by ABPA and 2544–4608 with SAFS in T&T (Denning and Gugnani., 2015). Our study estimated that T&T has 3637 cases of ABPA and 4800 cases of SAFS, which are similar to the upper-range estimates in the 2015 study (Denning and Gugnani, 2015). The lower-range values in their study were estimated using an adult asthma prevalence of 7.3%, based on data from Jamaica (Denning et al 2013), whereas our study assumed an adult asthma prevalence of 13.2% (Monteil et al., 2005). Thus, ABPA and SAFS are fairly common in T&T, while studies have shown that when asthma seems to be refractory to conventional medication, these conditions should be considered among the differential diagnoses, based on appropriate investigations and responses to treatment with antifungal therapy (Denning et al., 2009; Chishimba et al., 2012; Agarwal et al., 2013). It has been estimated that, annually, 178 CPA cases and 118 cases of IA are expected nationally; though uncommon, this represents a small increase in CPA cases compared with 2015, when data for IA were lacking (Denning and Gugnani, 2015).

Our study estimated that 21 455 women aged 15–50 years have four or more episodes of vaginal candidiasis annually — slightly fewer than previously estimated (23 763) (Denning and Gugnani, 2015). This represents a slight demographic change — postmenopausal women were not included because recurrent vulvovaginal candidiasis is uncommon in those women not using hormone replacement therapy.

In line with the 2015 study (Denning and Gugnani, 2015), our study estimated that 70 cases of candidemia occur every year. Among nosocomial bloodstream infections, *Candida* species are the most common (Wisplinghoff et al., 2014) and an important cause of mortality; hence, source control and timely antifungal therapy are crucial to survival (Clancy and Nguyen, 2018). There are no data to support these conservative estimates, but rates are thought to be much higher and result in undiagnosed causes of deaths due to fungal infections. Cultures for candidemia are very rarely performed in T&T, but positive cultures may be an incidental finding, and antifungal therapy is started in these cases.

No previous attempt has been made to estimate the number of cases of mucormycosis, fungal keratitis, or superficial mycoses (including tinea capitis). For tinea capitis, our conservative estimate of 5% would indicate that, annually, there are 14 647 cases, with no data available regarding superficial fungal infections of the skin and nails.

Fungal keratitis is a severe, sight-threatening corneal infection of the eye which, may result in permanent blindness and eye loss (Brown et al., 2021). It has been estimated that 70 cases of fungal keratitis occur in T&T every year, with most going undiagnosed.

Mucormycosis is an angio-invasive fungal infection most commonly associated with patients diagnosed with diabetes mellitus and other immunosuppressive conditions, and tends to have a high mortality (Prakash and Chakrabarti, 2019). The outbreak of mucormycosis with COVID-19 in India has not been mirrored in T&T.

There are no published data on mycetoma, chromoblastomycosis, or sporotrichosis in T&T, with mycetoma caused by fungi seemingly uncommon in the Caribbean (Fletcher et al., 2001). Chromoblastomycosis has been shown to be the most frequently diagnosed subcutaneous fungal infection in Venezuela (Martínez Méndez et al., 2013), and cases have been reported in Jamaica (Bansal and Prabhakar., 1989) and Cuba (Díaz-Almeida et al., 1978). Many cases of sporotrichosis have been reported in Venezuela (Martínez Méndez et al., 2013). In Brazil, there are cases of sporotrichosis associated with contact with feral cats (Pereira et al., 2014; Silva et al., 2012), and there is an increased incidence of severe disseminated sporotrichosis in PLHIV (Freitas et al., 2014). Paracoccidiodomycosis and coccidioidomycosis are public health problems in Venezuela (Novoa-Montero and Serrano., 2001), and may lead to endemic infections (in addition to imported infections) in Trinidad, but our study was not able to accurately estimate incidence.

There is a critical need for training programmes and improved diagnostic tests, including affordable point-of-care tests, for clinicians and laboratory technicians in the management of fungal infections. In addition, the implementation of an epidemiological surveillance programme (Hoving et al., 2020) to track fungal diseases — especially cryptococcal meningitis, histoplasmosis, and candidemia — is important in T&T. The antifungal drugs used to treat cryptococcal meningitis and disseminated histoplasmosis in T&T include amphotericin B deoxycholate, fluconazole, and itraconazole. Liposomal amphotericin B, flucytosine, and the newer antifungal drugs are unavailable, and it is these medications that are required for the optimal treatment of these life-threatening, invasive fungal infections.

Limitations

Our study had a number of limitations. First, local data on the incidence of fungal infections were sparse; therefore, data from Latin America and neighboring Caribbean countries, unpublished local data, and data from Africa and India were used to support the estimates. Second, data were limited on the numbers of patients who were on immunosuppressive therapy due to autoimmune diseases, cancer chemotherapy, and organ transplantation. A cancer registry exists in T&T, where the numbers and types of cancer cases are recorded, but data on those patients treated with chemotherapy or radiotherapy may be limited because some patients are treated in both the public and private sectors. Finally, data on deaths due to invasive fungal infections are scant because diagnostic capacity and appropriately skilled personnel for the diagnosis of these conditions are not widely available in T&T.

Conclusion

The burden of fungal infection is high in T&T, with an estimated 46 156 persons (3.3% of the population) with a serious fungal infection annually. Targeted interventions, including training programmes, improved diagnostic tests, and appropriate drugs for the diagnosis and optimal treatment for these life-threatening, invasive fungal infections are urgently required. In addition, the establishment of a national surveillance system for fungal diseases should be implemented to document infections such as cryptococcal meningitis, disseminated histoplasmosis, and candidemia. This should be linked to the national register of deaths to more accurately estimate the burden and help develop strategies to reduce mortality from these diseases.

Conflicts of interest statement

All authors declare no conflicts of interest.

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Ethical statement

The study did not involve data collection through interaction/intervention with patients or identifiable private information. In-

formed consent by patients was not required because overall data (rather than individual data) were collected and analyzed.

CRediT authorship contribution statement

Robert Jeffrey Edwards: Conceptualization, Formal analysis, Resources, Writing – review & editing. **Gregory Boyce:** Conceptualization, Formal analysis, Writing – original draft, Writing – review & editing. **Ana Alastruey-Izquierdo:** Conceptualization, Writing – review & editing. **David W. Denning:** Conceptualization, Formal analysis, Resources, Writing – review & editing.

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