How Common are Fungal Diseases?

Here are summarized the key publications and reports which either define or underlie the incidence and prevalence estimates of fungal diseases worldwide. Individual country estimates are available here and in some of the global burden papers: www.gaffi.org/media/academic-papers/

Oral, oesophageal and vulvovaginal candidiasis (thrush)

- Oral thrush occurs in ~1.9 million people worldwide based on ~90% of HIV/AIDS patients[1] not receiving anti-retroviral therapy (14.6 million), estimated by UNAIDS in 2018[2]. The number affected is probably falling as anti-retroviral therapy usage grows.
- Oral thrush also occurs in normal babies, people taking inhaled steroids for asthma, following radiotherapy to the head and neck for cancer, in denture wearers and in some leukaemia and transplant patients.
- Candida infection of the oesophagus (gullet) affects an estimated ~537,000 people as ~20% of HIV/AIDS patients[3] not on anti-retroviral therapy (420,000), and ~0.5% if on antiretroviral therapy (117,000)[4] develop it.
- Repeated attacks of vulvovaginal candidiasis affect at least 138 million women annually as 5–10% have at least 4 attacks annually[5,6]. The 25–34 year age group has the highest prevalence (9%). An estimated 372 million women are affected by recurrent vulvovaginal candidiasis over their lifetime[6]. These estimates exclude post-menopausal women on hormone replacement therapy or diabetes. The impact of on quality of life is substantial[7]. About 70% of all premenopausal women develop thrush at some point in their lives[8].

Invasive and life-threatening fungal infection

Candida infection

- Candidaemia occurs at a population rate of 2-26/100,000[9,10,11], so using 5.9 cases/100,000, ~400,000 cases are predicted worldwide, with a mortality of 30-55%[12]. The numbers rose in the US by 52% between 2000 and 2005[13]. Blood culture is only about 40% sensitive for detecting invasive candidiasis (including intra-abdominal candidiasis/Candida peritonitis)[14,15] so it is likely that nearly a 1 million people have invasive candidiasis each year. Rates in India and Brazil are much higher[16], so the overall estimate could be greater.
- *Candida* peritonitis (intra-abdominal candidiasis) affects both those undergoing long term peritoneal dialysis for renal failure (CAPD) and post-surgical patients, usually in intensive care. In a large multicentre study in 101 French intensive care units (ICU), hospital-acquired *Candida* peritonitis was documented in 73 patients over 8 months, compared with 123 patients with candidaemia without Candida peritonitis; 26 patients had both[17]. Assuming this is generalisable to other populations, this suggests a ratio of 1 patient with hospital-acquired (almost all post-operative) Candida peritonitis for every 2

patients with candidaemia, in ICU. As between 30 and 50% of candidaemia cases occur in ICU, and there are about 400,000 episodes of candidaemia globally, this suggests about 60,000 - 100,000 cases of *Candida* peritonitis each year. The mortality of Candida peritonitis was 38%. In those with end stage renal disease worldwide (~1.7M) CAPD is used in about 50%. Patients get 1 infection per 18 months on average[18] and ~0.05 episodes per patient year are attributable to *Candida* spp., equivalent to ~42,500 cases annually. The mortality is 15-20%[19,20] although survivors almost all have to transfer to haemodialysis.

- Around 150,000 of the 7.5 million patients admitted to intensive care (ICU) in Europe, USA and Japan each year grow *Candida* in their urine (a rate of 2.7% of ICU admissions[21]) and is a common finding in hospitalised patients[22] and those with catheters (~16%)[23] especially those in ICU.

Invasive aspergillosis

- Over 10 million patients in Europe, USA and Japan are at risk of invasive aspergillosis (IA) each year because of leukemia, lymphoma, transplantation, severe illness, COPD and corticosteroid or other therapies, and often a combination of these factors. Over 50% of patients with IA die, even with treatment.
- Over 350,000 patients develop IA annually. Key groups include 3-13% risk in leukaemia (437,000 new cases annually)[24] (~30,000 IA cases) and 10% rate in stem cell and other transplants (>75,000 annually in the USA, Europe and Japan) (7,500 IA cases) and 1.3-3.9% of COPD patients admitted to hospital[25,26] (10-13% of the global number of moderate and severe COPD >200 million)[27] (260,000-780,000 confirmed IA cases). There are 11.9M COPD admissions in China each year and a mean rate in OECD countries of 198/100,000 (range 364 (Ireland) to 71 (Portugal)[28]. IA also complicates lung cancer, at a rate of 2.63%[29]. Worldwide there are 2 million lung cancer cases annually[24], consistent with an additional 52,600 IA cases. A recent large survey of IA in liver failure in China documented a 5% rate, with a 95% mortality[30]. IA complicated 19% of patients with severe influenza with an overall mortality of 45%, and an attributable mortality of 25%, even diagnosed and treated rapidly[31]. All these patient groups above probably account for 90% of IA patients, with those admitted to intense care (ICU), with lymphoma or chronic leukaemia and various immunological disorders and treatments accounting for the remainder. Under diagnosis is a major problem in this disease.

Cryptococcal meningitis

- The incidence of cryptococcal meningitis in AIDS estimates 223,100 cases in AIDS[32]. Deaths are high, because of a lack of diagnostic capability and optimal treatment and thought to be about 181,100, 15% of all AIDS deaths[32]. In addition, cases occur in other immunocompromised groups and in normal people. In Thailand the

records are good, and an estimated 108 'normal' and 251 immunocompromised people develop cryptococcal meningitis each year[33].

Pneumocystis pneumonia

- About 2 million HIV/AIDS infected patients[2] who should be receiving anti-retroviral therapy are at risk of *Pneumocystis* pneumonia (PCP), as well as many other immunocompromised patients, unless taking oral antifungal prophylaxis with cotrimoxazole.
- The rate of PCP as an AIDS indicator disease is very variable. In African children, using reasonably sensitive diagnostic methods prevalence rates were 10% (South Africa, 2000), 49% (South Africa, 2002), 31% (Botswana, 2003) and 5% (Malawi, 2011). In adults from Africa, rates were 9% (Malawi, 2001), 33% (Tunisia, 2002), 37% (Kenya, 2003), 11% (Malawi, 2007), 30% (Ethiopia, 2008), 4% (Uganda, 2010), 5% (Namibia, 2012). 10% (Tanzania, 2012) and 11% (Uganda, 2012)[34]. Patient inclusion varied in these studies. *Pneumocystis* pneumonia has a 10-30% mortality in the USA and UK[35,36].
- Precise estimates of annual incidence are difficult because of diagnostic deficiencies but case numbers certainly exceed 400,000 globally per year[37].
- Given the number of other patients at risk for *Pneumocystis* pneumonia and rising rates in the UK[38] and elsewhere in non-AIDS patients, a rough estimate of 100,000 additional cases per year is estimated[37].

Histoplasmosis

- In AIDS, disseminated histoplasmosis is a devastating infection and difficult to diagnose rapidly enough to save the patients, even with either rapid antigen or PCR testing. As the rates are highly variable from one locality to another, a global burden estimate is missing. An approximation of ~100,000 is likely[39], with Central and parts of South America most affected, and some cases in Africa and SE Asia. A recent paper estimated 6,710 to 15,657 cases of AIDS-associated disseminated histoplasmosis in 2012 in Latin America[40].
- Up to 50 million people are thought to have been infected with histoplasmosis, with ~500,000 new infections each year, most asymptomatic and based on skin testing[41]. About 25,000 cases of symptomatic histoplasmosis are estimated in the USA annually[14].
- Chronic pulmonary and subacute disseminated histoplasmosis are grossly under diagnosed and there are no prevalence figures published.
- Histoplasmosis caused by *Histoplasma capsulatum* var. *dubosii* (so called African Histoplasmosis) appears to be rare and there are no estimates of its prevalence[42].

How Common are Fungal Diseases?

Mucormycosis

- Population estimates of mucormycosis in most countries vary from 0.6-3 per million[43,44,45]. The high rate of diabetes in India is probably partly accountable for a much higher rate of mucormycosis there, as well as unique presentations such as renal mucormycosis; the projected annual incidence is as high as 14 per 100,000[46]. No global estimate is available.

Coccidioidomycosis

- About 150,000 cases of coccidioidomycosis occur in the US each year[47]. In Mexico, about 8,552 symptomatic cases are thought to occur (7.6/100,000), but exposure based on skin testing is about 6 times higher than this at 43/100,000)[48]. Many more cases occur in other countries in Central and South America, but there are no good estimates.

Talaromycosis (infection with *Talaromyces marneffei*)

- *Talaromyces marneffei* (previously *Penicillium marneffei*) is a potentially life threatening endemic opportunistic fungal infection, primarily reported in HIV patients living in north eastern states of India, Thailand, southern provinces of China, Taiwan, Philippines, Malaysia, New Guinea, Indonesia, Cambodia, Laos, Myanmar and Vietnam. It is likely that there at least 10,000 cases annually in AIDS, but data are scanty[12].

Allergic fungal disease

Allergic bronchopulmonary aspergillosis (ABPA)

- Approximately 4.8 million people develop ABPA among the 193 million adults with active asthma worldwide[49]. This assumes that ~2.5% (0.7-3.5%) of adults referred to a specialist over 1-4 years have ABPA (6 studies from Ireland, New Zealand, China, Saudi Arabia and South Africa) and this represents the whole community of asthmatics. It could both under- and over-estimate prevalence. It is likely an under-estimate for India where this disease is more common[50] and distinctive for the frequency of hyper-attenuated mucus on CT scan[51].
- Individual country estimates of asthma prevalence in adults for 70 countries from 2012 are published[52], and many other countries have more recent or different statistics.
- ABPA also occurs in children with individual cases described and several series from India[53,54]. In children in India with 'perennial' asthma or 'poorly controlled' asthma, prevalences of 15% and 26% were reported[55,56], with an estimate for all children with asthma of 6.5%[55].
- ~ 15% of adults with cystic fibrosis develop ABPA with ~6,675 affected, although many teenagers and some younger children are also affected[57].

How Common are Fungal Diseases?

Severe Asthma with Fungal Sensitisation (SAFS)

- Fungal sensitization (allergy) is common in asthma and increasingly common in severe and poorly controlled asthma. Severe Asthma with Fungal Sensitisation (SAFS) is predicted to affect ~6.5 million (range 3.25-13 million) adults worldwide depending on the frequency of severe asthma (5-20% of all asthmatics) [12,58]. There is some duplication between ABPA and SAFS (collectively termed 'fungal asthma') because all ABPA patients are sensitized to fungi, and some have severe asthma.
- SAFS probably occurs in children but is poorly documented. In India 17% of 100 children with persistent asthma were sensitised to fungi and 60% of those with severe asthma[59]. One cross-sectional study from Russia found 30% of 120 children with poorly controlled asthma to be sensitized to *A. fumigatus*[60].

Allergic fungal rhinosinusitis

- A rough estimate of the point prevalence of fungal rhinosinusitis (FRS) is derived from a study in north India – 1.4% adults suffer from chronic rhinosinusitis (which translates globally into 73 million), of whom 8.1% of them have fungal rhinosinusitis or ~6 million adults[61]. The disease distribution in this study was: allergic FRS in 41 (56.1%), chronic granulomatous FRS in 13 (17.8%), eosinophilic FRS in 11 (15.0%), fungal ball in 7 (9.5%) and chronic invasive FRS in one (1.3%). In Israel, nearly 0.5% of the population (40,000) is thought to be affected by FRS[62]. Amongst patients who undergo endoscopic sinus surgery for all reasons, 6.8% (in Brazil) have allergic FRS[63].

Chronic fungal disease of the lower and upper respiratory tract

- Prevalence of chronic pulmonary aspergillosis following tuberculosis is estimated at about 1.2 million cases[64]. A prospective cross-sectional study in northern Uganda found the annual rate of new CPA development between surveys 2 years apart was 6.5% in those with chest radiography cavitation and 0.2% in those without[65]. Chest radiographs after tuberculosis treatment reveal cavitation in 20–30%. Each year, ~7.7 million patients are cured of pulmonary TB and so using the rates from Uganda with and without residual cavitation, then 112,000–160,000 people will develop CPA worldwide every year, a lower rate than previously suggested. Rates are particularly high in smear and/or GeneXpert negative (ie clinically diagnosed) non-HIV patients (22%), but HIV positive patients may also be affected[66].
- Chronic pulmonary aspergillosis complicates many respiratory disorders including tuberculosis, ABPA, sarcoidosis and COPD[16,67,68], and so the total burden of this debilitating disorder is ~3 million[37].
- *Aspergillus* bronchitis affects primarily those with bronchiectasis and cystic fibrosis. One cross-sectional study found ~30% of adults with cystic fibrosis to have *Aspergillus* bronchitis[69], which translates into 11,300 affected, not including India and some other countries[57].

How Common are Fungal Diseases?

- Chronic and granulomatous FRS are uncommon subacute entities, only found in adults. In the community survey in India, chronic granulomatous FRS was found in 13 (17.8%) and chronic invasive FRS in one (1.3%), which translates to a point prevalence in India of 1.5% of the 1.4% with any form of FRS, so ~0.02% of the adult population – 182,000 affected. These diseases are more common in the Indian sub-continent and middle east, but other estimates are lacking.

Neglected Fungal Tropical Diseases of the skin

- There are no global estimates for the Neglected Fungal Disease mycetoma[70]. A 2013 survey reported a total of 8,763 cases of mycetoma[71]. A WHO survey expanded the number of countries ever reporting mycetoma cases and in Africa, Eastern Mediterranean Region and the Americas, in 2016 840 new mycetoma cases were reported. Most cases were reported from Sudan, Senegal and El Salvador. This total is certainly a substantial underestimate the annual incidence.
- The prevalence of chromoblastomycosis[69] varies from 14/100,000 in Madagascar (3,500) to 3/100,000 (6,200) in Brazil and fewer elsewhere[72]. From other countries, Mexico, Dominican Republic, Venezuela, India, Taiwan and Southern China have the majority of reported cases.
- Sporotrichosis[69] is probably more common but very variable in frequency with hyper-endemic areas in Mexico and Peru with rates as high as 25/1,000[73]. There are fewer data on other similar conditions such as cutaneous phaeohyphomycosis.

Fungal eye infections

- Estimates of the annual incidence of fungal keratitis vary from 1 million to 6 million in SE Asia annually. Rates vary from as low as 6.3/100,000 in Hong Kong[74] to as high as 799/100,000 in Kathmandu[75]. Rates in Nepal have fallen in recent years to 73/100,000 (20,000 affected)[76]. The incidence of fungal keratitis in S. America was found to be 5/100,000 in Colombia[77]. The annual incidence in Africa is not known. Among causes of avoidable blindness, corneal opacities (caused by fungi or bacteria) accounts for 10% of the 284 million people visually impaired worldwide[78].

Cutaneous fungal infections

- Fungal infection of the skin, hair or nails affects ~1 billion people[79] and in the US alone accounted for 4M outpatient medical visits[80].
- Fungal nail infection (onychomycosis) is common in the general adult population, probably 5-25% rate with an increasing incidence in elderly people[81,82].
- Athlete's foot (tinea pedis) is more common than onychomycosis and is more common in younger people and sportsmen.

How Common are Fungal Diseases?

- Hair infection (tinea capitis) is most common among children, often resulting in bald patches with psychosocial consequences. In a recent US survey, tinea capitis was found in 6.6% with ranges from 0% to 19.4%[83], is more common in deprived areas and black children (with rates up to 41%)[84,85,86,87], suggesting a global prevalence of 200 million cases.

Summary table:

Infection	Global burden estimates in main underlying disease groups				
	None	HIV/AIDS	Respiratory	Immune deficit	Critical care
Life-threatening infections					
Invasive aspergillosis			>260,000	>90,000	>100,000
Candida bloodstream infection	50,000			600,000	300,000
Candida peritonitis (intra-abdominal)				42,500	>60,000
Cryptococcal meningitis	10,000's	223,000		10,000's	
Pneumocystis pneumonia		~400,000		>100,000	
Histoplasmosis	>25,000	>25,000	?10,000	>10,000	
Coccidioidomycosis	~150,000	>500		5,000	
Mucormycosis	>5,000			>150,000	>5,000
Talaromycosis (*T. marneffei* infection)		>10,000			
Superficial fungal infections					
Oral thrush		1,900,000	100,000's	millions	
Oesophageal candidasis		537,000		>100,000	
Recurrent Candida vaginitis	~138,000,000				
Candiduria				>200,000	>150,000
Fungal hair infection	200,000,000				
Onychomycosis, ringworm, tinea pedis and other skin fungal infections	>700 million	10,000,000			
Chronic fungal infections					
Chronic pulmonary aspergillosis			3,000,000		
Aspergillus bronchitis			>20,000		
Chronic invasive/granulomotous fungal rhinosinusitis	>200,000				
Paracoccidioidomycosis	~2500				
Allergic fungal infections					
ABPA in asthma and cystic fibrosis			4,800,000		
Severe asthma with fungal sensitisation			>6,500,000		
Fungal rhinosinusitis	~6,000,000				
Fungal NTDs					
Fungal keratitis	>1,000,000				
Sporotrichosis	>40,000				
Mycetoma	>20,000				
Chromoblastomycosis	>25,000				
Totals	>1,044,002,500	~13,095,500	>14,690,000	>2,195,000	>615,000

The Fungal Infection Trust
July 2019

Citing this document: "The Fungal Infection Trust. How common are fungal diseases? Fungal Research Trust 20th Anniversary meeting. London June 18th 2011, updated July 2019."

References

[1] Matee MI, Scheutz F, Moshy J. Occurrence of oral lesions in relation to clinical and immunological status among HIV-infected adult Tanzanians. Oral Dis 2000; 6:106-11.

[2] www.unaids.org/en/resources/fact-sheet (assumes that 1 in 7 of those not on antiretroviral therapy has a low CD4 counts and is susceptible to opportunistic infection)

[3] Smith E, Orholm M. Trends and patterns of opportunistic diseases in Danish AIDS patients 1980-1990. Scand J Infect Dis 1990;22:665-72.

[4] Buchacz K, Baker RK, Palella FJ Jr, Chmiel JS, Lichtenstein KA, Novak RM, Wood KC, Brooks JT; HOPS Investigators. AIDS-defining opportunistic illnesses in US patients, 1994-2007: a cohort study. AIDS 2010; 24:1549-59.
[5] Foxman B, Muraglia R, Dietz, JP, Sobel JD, Wagner J. Prevalence of recurrent vulvovaginal candidiasis in 5 european countries and the United States: Results from an internet panel survey. J Low Genit Tract Dis 2013; 17:340-5.
[6] Denning DW, Kneale M, Sobel JD, Rautemaa-Richardson R. Global burden of recurrent vulvovaginal candidiasis. Lancet Infect Dis 2018;18:e339-e347.
[7] Aballea S, Guelfucci F, Wagner J, Khemiri A, Dietz JP, Sobel JD, Toumi M. Subjective health status and health-related quality of life among women with recurrent vulvovaginal candidosis (RVVC) in Europe and the USA. Health Qual Life Outcomes 2013; 11:169.
[8] Ferre J. Vaginal candidosis: epidemiological and etiological factors. Int J Gynaecol Obstet 2000; 71 Suppl 1:S21-7.
[9] Arendrup MC. Epidemiology of invasive candidiasis. Curr Opin Crit Care. 2010;16:445-52.
[10] Cleveland AA, Farley MM, Harrison LH, Stein B, Hollick R, Lockhart SR, Magill SS, Derado G, Park BJ, Chiller TM. Changes in incidence and antifungal drug resistance in candidemia: results from population-based laboratory surveillance in Atlanta and Baltimore, 2008-2011. Clin Infect Dis 2012; 55:1352-61.
[11] Puig-Asensio M, Padilla B, Garnacho-Montero J, Zaragoza O, Aguado JM, Zaragoza R, Montejo M, Muñoz P, Ruiz-Camps I, Cuenca-Estrella M, Almirante B; CANDIPOP Project; GEIH-GEMICOMED (SEIMC); REIPI. Epidemiology and predictive factors for early and late mortality in *Candida* bloodstream infections: a population-based surveillance in Spain. Clin Microbiol Infect 2014; 20:O245-54.
[12] Brown GD, Denning DW, Gow NAR, Levitz S, Netea M, White T. Human fungal infections: the hidden killers. Sci Transl Med 2012:4: 165rv13.
[13] Zilberberg MD, Shorr AF, Kollef MH. Secular trends in candidemia-related hospitalization in the United States, 2000-2005. Infect Control Hosp Epidemiol. 2008;29:978-80.
[14] Avni T, Leibovici L, Paul M. PCR diagnosis of invasive candidiasis: systematic review and meta-analysis. J Clin Microbiol 2011;49:665-70.
[15] Nguyen MH, Wissel MC, Shields RK, Salomoni MA, Hao B, Press EG, Shields RM, Cheng S, Mitsani D, Vadnerkar A, Silveira FP, Kleiboeker SB, Clancy CJ. Performance of *Candida* real-time polymerase chain reaction, b-D-glucan assay, and blood cultures in the diagnosis of invasive candidiasis. Clin Infect Dis 2012; 54:1240e8.
[16] Bongomin F, Gago S, Oladele RO, Denning DW. Global and national prevalence of fungal diseases – Estimate precision. J Fungi 2017; 3:E57.
[17] Montravers P, Mira JP, Gangneux JP, Leroy O, Lortholary O; AmarCand study group. A multicentre study of antifungal strategies and outcome of *Candida* spp. peritonitis in intensive-care units. Clin Microbiol Infect. 2011; 17:1061-7.
[18] Li PK, Szeto CC, Piraino B, de Arteaga J, Fan S, Figueiredo AE, Fish DN, Goffin E, Kim YL, Salzer W, Struijk DG, Teitelbaum I, Johnson DW. ISPD Peritonitis Recommendations: 2016 Update on prevention and treatment. Perit Dial Int 2016;36:481-508.
[19] Indhumathi E, Chandrasekaran V, Jagadeswaran D, Varadarajan M, Abraham G, Soundararajan P. The risk factors and outcome of fungal peritonitis in continuous ambulatory peritoneal dialysis patients. Indian J Med Microbiol 2009;27:59-61.
[20] Kazancioglu R, Kirikci G, Albaz M, Dolgun R, Ekiz S. Fungal peritonitis among the peritoneal dialysis patients of four Turkish centres. J Ren Care 2010;36:186-90.
[21] Bougnoux ME. Candidemia and candiduria in critically ill patients admitted to intensive care units in France: incidence, molecular diversity, management, and outcome. Intensive Care Med 2008;34:292-9.
[22] Sobel JD, Fisher JF, Kauffman CA, Newman CA. Candida urinary tract infections--epidemiology. Clin Infect Dis. 2011 May;52 Suppl 6:S433-6.
[23] Bouza E, San Juan R, Munoz P, Voss A, Kluytmans J. A European perspective on nosocomial urinary tract infections II. Report on incidence, clinical characteristics, and outcome (ESGNI–004 study). European Study Group on nosocomial infection. Clin Microbiol Infect 2001; 7:532-42.
[24] https://gco.iarc.fr/today/data/factsheets/populations/900-world-fact-sheets.pdf
[25] Guinea J, Torres-Narbona M, Gijón P, Muñoz P, Pozo F, Peláez T, de Miguel J, Bouza E. Pulmonary aspergillosis in patients with chronic obstructive pulmonary disease: incidence, risk factors, and outcome. Clin Microbiol Infect. 2010; 16:870-7.

[26] Xu H, Li L, Huang WJ, Wang LX, Li WF, Yuan WF. Invasive pulmonary aspergillosis in patients with chronic obstructive pulmonary disease: a case control study from China. Clin Microbiol Infect. 2012; 18:403-8.
[27] Vestbo J, Mathioudakis AG. The emerging Chinese COPD epidemic. Lancet. 2018;391:1642-1643.
[28] www.oecdilibrary.org/docserver/download/8111101ec040.pdf?expires=1355694700&id=id&accname=guest&checksum=A5D8D12C997E1ABA9EE66C3C4410F4DF
[29] Yan X, Li M, Jiang M, Zou LQ, Luo F, Jiang Y. Clinical characteristics of 45 patients with invasive pulmonary aspergillosis: retrospective analysis of 1711 lung cancer cases. Cancer. 2009;115:5018-25.
[30] Chen J, Yang Q, Huang J, Li L. Risk factors for invasive pulmonary aspergillosis and hospital mortality in acute-on-chronic liver failure patients: A retrospective cohort study. Int J Med Sci 2013; 10:1625-31.
[31] Schauwvlieghe AFAD, Rijnders BJA, Philips N, Verwijs R, Vanderbeke L, Van Tienen C, Lagrou K, Verweij PE, Van de Veerdonk FL, Gommers D, Spronk P, Bergmans DCJJ, Hoedemaekers A, Andrinopoulou ER, van den Berg CHSB, Juffermans NP, Hodiamont CJ, Vonk AG, Depuydt P, Boelens J, Wauters J; Dutch-Belgian Mycosis study group. Invasive aspergillosis in patients admitted to the intensive care unit with severe influenza: a retrospective cohort study. Lancet Respir Med 2018;6:782-792.
[32] Rajasingham R, Smith RM, Park BJ, Jarvis JN, Denning DW, Govender NP, Loyse A, Boulware DR. Estimation of the global burden of disease of HIV-Associated cryptococcal meningitis. Lancet Infect Dis 2017; 17:873-81.
[33] Chayakulkeeree M, Denning DW. Estimating the burden of serious fungal diseases in Thailand. Eur J Clin Microbiol Infect Dis 2017; 36:931-5.
[34] http://www.gaffi.org/media/fact-sheets/
[35] Teshale EH, Hanson DL, Wolfe MI, Brooks JT, Kaplan JE, Bort Z, Sullivan PS; Adult and Adolescent Spectrum of HIV Disease Study Group. Reasons for lack of appropriate receipt of primary *Pneumocystis jirovecii* pneumonia prophylaxis among HIV-infected persons receiving treatment in the United States: 1994-2003. Clin Infect Dis. 2007; 44:879-83.
[36] Walzer PD, Evans HE, Copas AJ, Edwards SG, Grant AD, Miller RF. Early predictors of mortality from *Pneumocystis jirovecii* pneumonia in HIV-infected patients: 1985-2006. Clin Infect Dis. 2008;46:625-33.
[37] Global Action Fund for Fungal Infections. 95-95 by 2025. Improving outcomes for patients with fungal infections across the world; A roadmap for the next decade. May 2015 www.gaffi.org/roadmap/
[38] Maini R, Henderson KL, Sheridan EA, Lamagni T, Nichols G, Delpech V, et al. Increasing pneumonia, England, UK, 2000-2010. Emerg Infect Dis 2013;19:386-92.
[39] Denning DW. Minimizing fungal disease deaths will allow the UNAIDS target of reducing annual AIDS deaths below 500 000 by 2020 to be realized. Phil Trans Roy Soc B 2016; 371: 20150468.
[40] Adenis AA, Valdes A, Cropet C, McCotter OZ, Derado G, Couppie P, Chiller T, Nacher M. Burden of HIV-associated histoplasmosis compared with tuberculosis in Latin America: a modelling study. Lancet Infect Dis 2018;18:1150-1159.
[41] Hammerman KJ, Powell KE, Tosh FE. The incidence of hospitalized cases of systemic mycotic infections. Sabouraudia. 1974; 12:33-45.
[42] Oladele R, Ayanlowo OO, Richardson MD, Denning DW. Histoplasmosis in Africa: An emerging or a neglected disease? PLoS Negl Trop Dis 2018;12: e0006046.
[43] Rees J R, Pinner RW, Hajjeh RA, Brandt ME, Reingold AL. The epidemiological features of invasive mycotic infections in the San Francisco Bay area, 1992-1993: results of population-based laboratory active surveillance. Clin Infect Dis 1998; 27:1138-1147.
[44] Bitar D, Morizot G, Van Cauteren D, Dannaoui E, Lanternier F, Lortholary O, Dromer F. Estimating the burden of mucormycosis infections in France (2005-2007) through a capture-recapture method on laboratory and administrative data. Rev Epidemiol Sante Publique 2012; 60:383-7.
[45] Prakash H, Chakrabarti A. Global Epidemiology of Mucormycosis. J Fungi 2019;5(1).
[46] Chakrabarti A, Sood P, Denning DW. Estimating fungal infection burden in India using computational models: Mucromycosis burden as a case study. 23rd European Congress of Clinical Microbiology and Infectious Diseases (ECCMID, 23rd) Berlin 2013. P1044.
[47] Twarog M, Thompson GR, 3rd. Coccidioidomycosis: recent updates. Semin Respir Crit Care Med 2015;36:746–755.
[48] Corzo-León DE, Armstrong-James D, Denning DW. Burden of serious fungal infections in Mexico. Mycoses, 2015: 58 (Suppl. S5):34–44.

[49] Denning DW, Pleuvry A, Cole DC. Global burden of ABPA in adults with asthma and its complication chronic pulmonary aspergillosis. Med Mycol 2013;51:361-70.
[50] Agarwal R, Denning DW, Chakrabarti A. Estimation of the burden of chronic and allergic pulmonary aspergillosis in India. PLoS One 2014;9:e114745.
[51] Agarwal R, Khan A, Gupta D, Aggarwal AN, Saxena AK, Chakrabarti A. An alternate method of classifying allergic bronchopulmonary aspergillosis based on high- attenuation mucus. PLoS ONE 2007; 5(12): e15346.
[52] To T, Stanojevic S, Moores G, Gershon AS, Bateman ED, Cruz AA, Boulet LP. Global asthma prevalence in adults: findings from the cross-sectional world health survey. BMC Public Health 2012 19; 12:204.
[53] Shah A, Kunal S. A review of 42 asthmatic children with allergic bronchopulmonary aspergillosis. Asia Pac Allergy 2017;7:148-155.
[54] Jat KR, Vaidya PC, Mathew JL, Jondhale S, Singh M. Childhood allergic bronchopulmonary aspergillosis. Lung India 2018;35:499-507.
[55] Chetty A, Bhargava S, Jain RK. Allergic bronchopulmonary aspergillosis in Indian children with bronchial asthma. Ann Allergy 1985;54:46-9.
[56] Singh M, Das S, Chauhan A, Paul N, Sodhi KS, Mathew J, Chakrabarti A. The diagnostic criteria for allergic bronchopulmonary aspergillosis in children with poorly controlled asthma need to be re-evaluated. Acta Paediatr 2015;104:e206-9.
[57] Armstead J, Morris J, Denning DW. Multi-country estimate of different manifestations of aspergillosis in cystic fibrosis. PLoS One 2014; 9:e98502.
[58] Denning DW, Pashley C, Hartl D, Wardlaw, A, Godet C, Del Giacco, Delhaes L, Sergejeva S. Fungal allergy in asthma–state of the art and research needs. Clin Transl Allergy 2014;4:14.
[59] Gupta A, Singh M, Chakrabarti A, Mathew JL, Rawat A. Correlation between fungal sensitisation in childhood persistent asthma and disease severity. Mycoses 2018;61:195-200.
[60] www.aspergillus.org.uk/content/allergic-bronchopulmonary-aspergillosis-children-asthma-st-petersburg-russia
[61] Chakrabarti A, Rudramurthy SM, Panda N, Das A, Singh A. Epidemiology of chronic fungal rhinosinusitis in rural India. Mycoses 2015;58:294-302.
[62] Ben-Ami R, Denning DW. Estimating the burden of fungal diseases in Israel. Israel Med Assc J 2015;17:374-9.
[63] Dall'Igna C, Palombini BC, Anselmi F, Araújo E, Dall'Igna DP. Fungal rhinosinusitis in patients with chronic sinusal disease. Braz J Otorhinolaryngol. 2005; 71:712-20.
[64] Denning DW, Pleuvry A, Cole DC. Global burden of chronic pulmonary aspergillosis as a sequel to tuberculosis. Bull WHO 2011;89:864-72.
[65] Page ID, Byanyima R, Hosmane S, Onyachi N, Opira C, Opwonya J, Sawyer R, Richardson MD, Sawyer R, Sharman A, Denning DW. Chronic pulmonary aspergillosis commonly complicates treated pulmonary tuberculosis with residual cavitation. Eur Resp J 2019 53: 1801184.
[66] Oladele RO, Irurhe NK, Foden P, Akanmu AS, Gbaja-Biamila T, Nwosu A, Ekundayo HA, Ogunsola FT, Richardson MD, Denning DW. Chronic pulmonary aspergillosis as a cause of smear-negative TB and/or TB treatment failure in Nigerians. Int J Tuberc Lung Dis 2017; 21:1056-1061.
[67] Smith N, Denning DW. Underlying pulmonary disease frequency in patients with chronic pulmonary aspergillosis. Eur Resp J 2011; 37:865-72.
[68] Denning DW, Pleuvry A, Cole DC. Global burden of chronic pulmonary aspergillosis complicating sarcoidosis. Eur Resp J 2013; 41:621-6.
[69] Baxter CG, Dunn G, Jones AM, Webb K, Gore R, Richardson MD, Denning DW. Novel immunologic classification of aspergillosis in adult cystic fibrosis. J Allergy Clin Immunol 2013; 132:560-566.
[70] www.gaffi.org/media/fact-sheets
[71] Van de Sande WWJ. Global burden of human mycetoma: A systematic review and meta-analysis. PLoS Negl Trop Dis 2013; 7(11): e2550.
[72] Queiroz-Telles F, de Hoog S, Santos DW, Salgado CG, Vicente VA, Bonifaz A, Roilides E, Xi L, Azevedo CM, da Silva MB, Pana ZD, Colombo AL, Walsh TJ. Chromoblastomycosis. Clin Microbiol Rev 2017; 30:233-276.
[73] Chakrabarti A. Global epidemiology of sporotrichosis. *Medical Mycology*, 2015, 53, 3–14
[74] Lam DS, Houang E, Fan DS, Lyon D, Seal D, Wong E. Incidence and risk factors for microbial keratitis in Hong Kong: comparison with Europe and North America. Eye (Lond) 2002; 16:608-18.

[75] Upadhyay MP Karmacharya PC, Koirala S, Tuladhar NR, Bryan LE, Smolin G, Whitcher JP. Epidemiological characteristics, predisposing factors, and etiologic diagnosis of corneal ulceration in Nepal. Am J Ophthalmol 1991; 111: 92–99.
[76] Khwakhali US, Denning DW. Burden of serious fungal infections in Nepal. Mycoses 2015: 58 (Suppl. S5):45-50.
[77] Galvis V, Tello A, Guerra A, Acuna MF, Villarreal D. Antibiotic susceptibility patterns of bacteria isolated from keratitis and intraocular infections at Fundacion Oftalmologica de Santander (FOSCAL), Floridablanca, Colombia. Biomedica 2014, 34, 23–33.
[78] www.who.int/mediacentre/factsheets/fs282/en/index.html
[79] Vos, T, Flaxman AD, NaghaviM et al, Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990—2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012; 380:2163–96.
[80] Panackal AA, Halpern EF, Watson AJ. Cutaneous fungal infections in the United States: Analysis of the National Ambulatory Medical Care Survey (NAMCS) and National Hospital Ambulatory Medical Care Survey (NHAMCS), 1995-2004. Int J Dermatol 2009;48:704-12.
[81] Pierard G. Onychomycosis and other superficial fungal infections of the foot in the elderly: a pan-European survey. Dermatology 2001; 202:220-4.
[82] Thomas J, Jacobson GA, Narkowicz CK, Peterson GM, Burnet H, Sharpe C. Toenail onychomycosis: an important global disease burden. J Clin Pharm Ther 2010;35:497-519.
[83] Abdel-Rahman SM, Farrand N, Schuenemann E, Stering TK, Preuett B, Magie R, Campbell A. The prevalence of infections with *Trichophyton tonsurans* in schoolchildren: the CAPITIS study. Pediatrics 2010; 125:966-73.
[84] Ali J, Yifru S, Woldeamanuel Y. Prevalence of tinea capitis and the causative agent among school children in Gondar, North West Ethiopia. Ethiop Med J 2009; 47:261-9.
[85] Chepchirchir A, Bii C, Ndinya-Achola JO. Dermatophyte infections in primary school children in Kibera slums of Nairobi. East Afr Med J 2009; 86:59-68.
[86] Nweze EI. Dermatophytosis among children of Fulani/Hausa herdsmen living in southeastern Nigeria. Rev Iberoam Micol 2010; 27:191-4.
[87] Adefemi SA, Odeigah LO, Alabi KM. Prevalence of dermatophytosis among primary school children in Oke-Oyi community of Kwara state. Niger J Clin Pract 2011; 14:23-8.