Causes of hospital admission among people living with HIV worldwide: a systematic review and meta-analysis

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Summary

Background Morbidity associated with HIV infection is poorly characterised, so we aimed to investigate the contribution of different comorbidities to hospital admission and in-hospital mortality in adults and children living with HIV worldwide.

Methods Using a broad search strategy combining terms for hospital admission and HIV infection, we searched MEDLINE via PubMed, Embase, Web of Science, LILACS, AIM, IMEMR and WPIMR from inception to Jan 31, 2015, to identify studies reporting cause of hospital admission in people living with HIV. We focused on data reported after 2007, the period in which access to antiretroviral therapy started to become widespread. We estimated pooled proportions of hospital admissions and deaths per disease category by use of random-effects models. We stratified data by geographical region and age.

Findings We obtained data from 106 cohorts, with reported causes of hospital admission for 313 006 adults and 6182 children living with HIV. For adults, AIDS-related illnesses (25 119 patients, 46%, 95% CI 40–53) and bacterial infections (14 034 patients, 31%, 20–42) were the leading causes of hospital admission. These two categories were the most common causes of hospital admission for adults in all geographical regions and the most common causes of mortality. Common region-specific causes of hospital admission included malnutrition and wasting, parasitic infections, and haematological disorders in the Africa region; respiratory disease, psychiatric disorders, renal disorders, cardiovascular disorders, and liver disease in Europe; haematological disorders in North America; and respiratory, neurological, digestive and liver-related conditions, viral infections, and drug toxicity in South and Central America. For children, AIDS-related illnesses (783 patients, 27%, 95% CI 19–34) and bacterial infections (1190 patients, 41%, 26–56) were the leading causes of hospital admission, followed by malnutrition and wasting, haematological disorders, and, in the African region, malaria. Mortality in individuals admitted to hospital was 20% (95% CI 18–23, 12 902 deaths) for adults and 14% (10–19, 643 deaths) for children.

Interpretation This review shows the importance of prompt HIV diagnosis and treatment, and the need to reinforce existing recommendations to provide chemoprophylaxis and vaccination against major preventable infectious diseases to people living with HIV to reduce serious AIDS and non-AIDS morbidity.

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Introduction

The global expansion of access to antiretroviral therapy (ART) over the past decade has led to substantial declines in HIV-related morbidity and mortality, especially in low-income and middle-income countries in which HIV prevalence is highest. Increased access to ART is estimated to have averted more than 4 million deaths in low-income and middle-income countries between 2002 and 2012.[1] Nevertheless, an estimated 1·3 million (1·3–1·5) deaths caused by HIV occurred in 2013, and HIV was ranked the sixth most common cause of life lost worldwide.[2] In all regions, late diagnosis and late presentation to care result in high morbidity and mortality.[3–6]

Morbidity associated with HIV infection is poorly understood, especially in resource-limited settings where laboratory or diagnostic capabilities are scarce. Findings from studies in high-income settings have suggested that the contribution of non-AIDS-related diseases to mortality is increasing in people living with HIV.[7,8] In sub-Saharan Africa, infectious diseases, especially tuberculosis and bacterial infections, are the main causes of morbidity and mortality for people living with HIV.[9,10] High prevalence of non-AIDS events has also been reported[11] and is anticipated to play an increasingly important part as ART coverage increases. However, the specific contribution of infectious and non-infectious causes of disease to HIV-related morbidity and mortality remains poorly characterised.

We did this systematic review and meta-analysis to establish the contribution of different comorbidities to hospital admission and in-hospital mortality in adults and children living with HIV worldwide.

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See Comment page e406

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Research in context

Evidence before this study

Although mortality caused by HIV has decreased over the past decade, in many countries, HIV continues to be a leading cause of illness and death, with an estimated 1·3 million deaths due to HIV in 2013. Recent studies suggest that the burden of infectious diseases in people living with HIV has decreased with time, with an increase in non-communicable diseases. However, the contribution of infectious and non-infectious causes to severe morbidity and mortality in HIV-positive people is not well characterised. Improved understanding is needed to inform stakeholder priorities, such as WHO and other policy makers, donors, and national programme managers. Data about causes of hospital admission have been reported across a range of settings and time periods, and provide a reasonably unbiased way to understand causes of severe comorbidity in people living with HIV.

Added value of this study

This is the first review to systematically assess causes of hospital admission among adults and children living with HIV worldwide. We estimated the main causes of hospital admission and in-hospital mortality by age and geographical region with a focus on data published post 2007 after the scale-up of antiretroviral therapy in most low-income and middle-income countries. We noted that, across all regions, infectious causes, particularly tuberculosis and severe bacterial infections, are the most common causes of hospital admission and mortality in HIV-positive people who were admitted to hospital. Although some evidence suggests that the proportion of hospital admissions due to infectious causes is decreasing with time, AIDS-related disorders and bacterial infections remain leading causes. This finding is partly because people continue to be diagnosed late in their HIV infection, with about a third of patients diagnosed at admission in this study. In some regions, non-infectious causes, including liver disease, renal disease, and psychiatric disorders account for an important proportion of hospital admissions.

Implications of all the available evidence

Our findings emphasise the need for continued efforts to diagnose and treat HIV early to avoid immune depletion. Furthermore, our results reinforce existing recommendations that prioritise the provision of essential preventive prophylaxis and vaccination against major preventable infectious diseases to people living with HIV, including co-trimoxazole prophylaxis, isoniazid preventive therapy, and vaccinations against pneumococcal and meningococcal infection.

Methods

Search strategy and selection criteria

This study has been designed and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement.[12] The protocol for this study, is available from the corresponding author on request.

To be included, studies had to report the cause of hospital admission for at least 20 HIV-positive patients. We were specifically interested in studies that reported causes of hospital admission since 2007, after the scale-up of ART in developing settings. Studies reporting causes of hospital admission before 2007 were eligible for inclusion if most (>50%) hospital admissions occurred after 2007 or if data could be disaggregated for the post-2007 period. We used no language, geographical, or age restrictions. We excluded verbal autopsy studies.

By use of a broad, iteratively developed search strategy that combined terms for hospital admission and HIV infection (for a full list of search terms used, see appendix p 1), two investigators (NF, ZS), working independently and in duplicate, searched MEDLINE via PubMed, Embase, Web of Science, LILACS, AIM, IMEMR, and WPIMR databases from inception to Jan 31, 2015. We also screened abstracts from all International AIDS Society conferences up to Melbourne, 2014. We supplemented database searches by screening bibliographies of review articles and all included full-text articles. The same investigators scanned all abstracts and full-text articles and achieved consensus on final study inclusions.

Data extraction

Three reviewers, working independently in pairs (OA, NF, ZS), extracted data in accordance with a predefined protocol. Data were recorded with a standardised and piloted extraction form. Our main aim was to establish the most common causes of hospital admission and in-hospital mortality in people living with HIV. We classified morbidity with the tenth edition of the International Classification of Diseases (ICD10),[13] divided into 17 categories, which were the most commonly reported in the scientific literature: AIDS-related, malnutrition/wasting, parasitic infections, bacterial infections, malignancies, drug toxicities, neurological, cardiovascular, renal, endocrine/metabolic, haematological, respiratory, digestive, liver, viral, skin/soft tissue, and psychiatric disorders.[14] We only recorded the primary cause of admission. We also extracted data about study setting, age of patients, period and midpoint of data reporting for each study, prior knowledge of HIV status, ART status at admission, and co-trimoxazole and isoniazid preventive therapy use among patients admitted to hospital. We did subgroup analyses to explore potential effects of these variables on the proportion of patients admitted to hospital for an AIDS-related illness, the most consistently reported category of cause of hospital admission across all geographical regions.

Statistical analysis

We calculated proportions and corresponding 95% CIs for all reported causes of hospital admission and in-hospital mortality, and pooled data after transformation,[15,16] by use

of random effects meta-analysis.[17] Where studies reported that patients were admitted to hospital more than once, we based our estimates of the cause of hospital admission on the number of hospital admissions. We disaggregated all estimates by age and geographical region in accordance with WHO regional groupings. Because statistical tests for heterogeneity do not work well with pooled proportions,[18] we did metaregression to examine heterogeneity by study design, cause of admission and ART status, date of hospital admission, and length of stay. To explore changes over time, we did a sensitivity analysis of cause of hospital admissions, restricted to studies reporting data from 2009 onwards; this analysis was limited to adults because of insufficient data for children. We analysed all data with Stata version 12.0.

Role of the funding source

There was no funding source for this study. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

From an initial screen of 9049 abstracts, we included 99 studies, which reported data for 106 cohorts (319 188 patients; figure 1). Hospital admission data were reported from 50 countries across all WHO regions. Most studies were either retrospective cohorts (52 studies) or prospective cohorts (33 studies). The remaining studies were cross-sectional, web-based, randomised controlled trials, administrative databases, and discharge records. Three autopsy studies contributed to mortality estimates. Nine studies reported cause of hospital admission through review of discharge records. The median year of hospital admission was 2007 (IQR 2006–2010), and the number of patients per study ranged from 24 to 249 743. 81 studies reported only one hospital admission event per patient. Median length of stay was 9 days (IQR 6–13). 66% (95% CI 62–69) of adults admitted to hospital were male, whereas for children, no difference by sex existed. 30% (95% CI 24–36) were diagnosed as HIV positive at the time of hospital admission, with no significant difference by age or year of hospital admission. CD4 count at hospital admission was reported for 73 studies and the median was 168 cells per µL (IQR 91–263) for adults and 538 cells per µL (IQR 271–649) for children. ART status was reported by 73 studies, with 43% (IQR 27–72) of patients on treatment at time of hospital admission; median time on ART before admission was 11 months for adults (IQR 7–25 months) and 7 months for children (IQR 4–25 months). Co-trimoxazole prophylaxis coverage, reported in 16 studies, was 50% (IQR 27–84). Hepatitis C virus co-infection status was reported by 21 studies (all adults) and the pooled prevalence ranged from 7% (0–14) in the western Pacific region to 47% (30–63) in North America. Hepatitis B virus co-infection status was reported by 18 studies (all adults) and pooled prevalence was lowest in the Africa region (2%, 1–3) and highest in the eastern Mediterranean region (13%, 11–16). The appendix contains details of all included studies.

85 studies reported cause of hospital admission in 313 006 adult patients from 42 countries across all geographical regions (figure 2). Overall, AIDS-related illnesses (25 119 patients) and bacterial infections (14 034 patients) were the most common causes of hospital admission. These two categories were the most common causes of hospital admission in all geographical regions. Within the category of AIDS-related illnesses, the main causes of hospital admission were tuberculosis (18% of all hospital admissions, 95% CI 16–21), of which pulmonary tuberculosis represented most cases of tuberculosis-related hospital admissions (67%); oral candidiasis (18%, 16–20); *Pneumocystis jirovecii* pneumonia (8%, 7–8); and toxoplasmic encephalitis (6%, 5–7). The remaining AIDS-related illnesses accounted for less than 5% of all hospital admissions, but with notable regional differences. Of the bacterial infections, bacterial pneumonia (15% of all hospital admissions, 13–18), isolated bacteraemia (11%, 10–13), and severe diarrhoea (9%, 7–10) were the most common causes of hospital admission in HIV-positive adults.

Regional differences existed among the causes of hospital admission that accounted for 10% or more of

For the **WHO regional groupings** see http://www.who.int/about/regions/en/

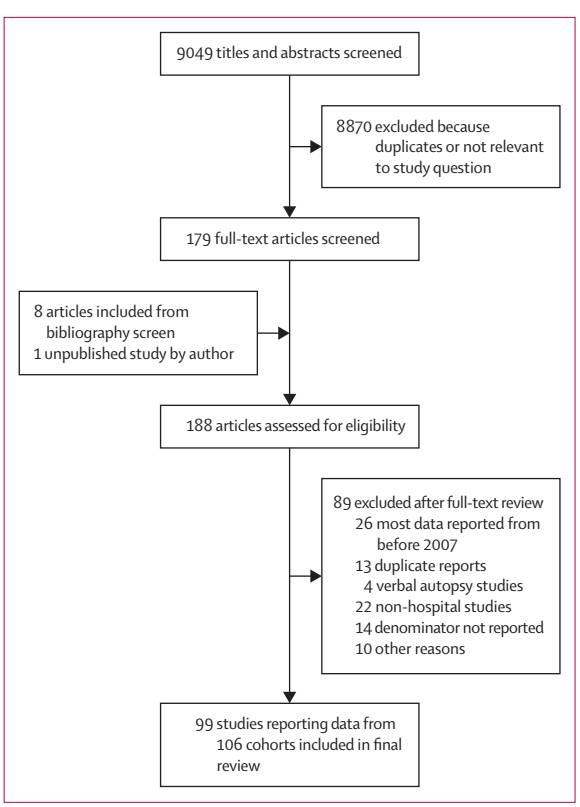
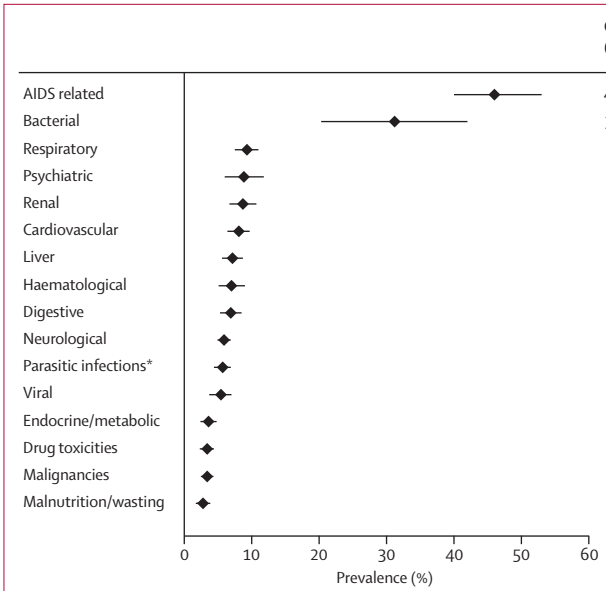
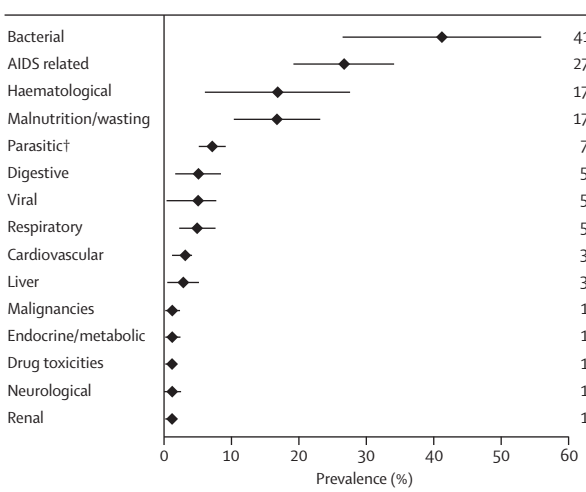


Figure 1: **Study selection**



	Overall (95% CI)	AFRO (95% CI)	SEARO (95% CI)	WPRO (95% CI)	EMRO (95% CI)	EURO (95% CI)	AMRO N (95% CI)	AMRO S (95% CI)
AIDS related	46% (40–53)	63% (49–78)	66% (36–96)	79% (71–78)	68% (27–100)	31% (23–39)	28% (17–38)	40% (15–65)
Bacterial	31% (20–42)	36% (22–50)	35% (20–49)	17% (0–33)	7% (5–9)	27% (23–32)	27% (20–35)	57% (21–92)
Respiratory	9% (8–11)	<1% (0–1)	<1% (0–1)	1% (0–4)	NR	14% (5–22)	9% (6–12)	19% (11–28)
Psychiatric	9% (6–12)	1% (0–2)	8% (0–19)	NR	NR	13% (0–25)	6% (5–7)	9% (3–15)
Renal	9% (7–11)	7% (3–11)	NR	9% (0–27)	NR	11% (4–19)	5% (4–7)	6% (2–10)
Cardiovascular	8% (6–10)	3% (2–4)	4% (1–7)	2% (0–6)	NR	12% (7–18)	7% (4–9)	9% (4–14)
Liver	7% (6–9)	2% (1–3)	3% (1–4)	<1% (0–1)	10% (1–19)	10% (7–14)	1% (0–2)	17% (14–19)
Haematological	7% (5–9)	15% (5–24)	2% (0–5)	1% (1–2)	NR	6% (3–9)	16% (7–25)	5% (0–15)
Digestive	7% (5–9)	9% (3–14)	<1% (0–1)	8% (0–20)	NR	5% (2–8)	5% (4–7)	13% (8–18)
Neurological	6% (5–7)	5% (4–6)	5% (0–12)	9% (2–16)	NR	8% (5–10)	1% (1–2)	15% (8–21)
Parasitic infections*	6% (4–7)	15% (9–21)	1% (0–4)	3% (0–9)	2% (0–5)	<1% (0–1)	NR	3% (0–9)
Viral	5% (4–7)	3% (2–5)	5% (2–8)	2% (0–6)	NR	9% (0–24)	1% (1–1)	16% (4–19)
Endocrine/metabolic	4% (2–5)	3% (0–9)	4% (0–12)	2% (1–3)	NR	3% (1–6)	4% (4–5)	5% (5–6)
Drug toxicities	3% (2–4)	5% (2–7)	6% (1–10)	1% (0–3)	1% (0–2)	1% (0–2)	2% (1–2)	13% (12–14)
Malignancies	3% (3–4)	4% (3–6)	<1% (0–1)	5% (4–6)	4% (0–7)	4% (3–6)	3% (1–4)	2% (0–3)
Malnutrition/wasting	3% (2–4)	12% (7–18)	6% (0–18)	1% (0–1)	NR	1% (0–1)	<1% (0–1)	6% (0–15)

***Figure 2*: Causes of hospital admission in adults**
AFRO=African region. AMRO N=region of the Americas (North). AMRO S=region of the Americas (South and Central). EURO=European region. EMRO=eastern Mediterranean region. NR=not reported. SEARO=southeast Asia region. WPRO=western Pacific region. *Mainly malaria.



	Overall (95% CI)	AFRO (95% CI)	SEARO (95% CI)	EURO (95% CI)	AMRO N (95% CI)	AMRO S (95% CI)
Bacterial	41% (26–56)	56% (43–69)	27% (0–57)	1%* (0–1)	14%* (11–17)	37%* (26–48)
AIDS related	27% (19–34)	25% (15–35)	25% (12–38)	5% (0–16)	10% (7–12)	68% (38–97)
Haematological	17% (6–28)	10% (3–18)	9% (6–11)	NR	NR	41% (4–100)
Malnutrition/wasting	17% (10–23)	19% (6–32)	16% (0–49)	NR	3% (2–5)	22%* (16–28)
Parasitic†	7% (5–9)	21% (10–33)	<1%* (0–1)	NR	NR	<1%* (0–1)
Digestive	5% (2–8)	NR	5% (0–13)	NR	4% (3–6)	5% (2–9)
Viral	5% (0–8)	3%*(0–5)	1% (0–1)	4%* (4–5)	31%* (24–38)	3%*(2–5)
Respiratory	5% (2–8)	3% (1–5)	11% (6–16)	NR	3% (1–5)	<1% (0–1)
Cardiovascular	3% (1–4)	8%* (3–12)	3% (1–4)	NR	2%* (1–4)	2% (0–4)
Liver	3% (0–5)	NR	<1%* (0–1)	NR	NR	5% (1–9)
Malignancies	1% (0–2)	3% (0–6)	1% (0–2)	NR	NR	<1% (0–1)
Endocrine/metabolic	1% (0–2)	<1% (0–1)	<1% (0–2)	NR	5% (3–7)	<1% (0–1)
Drug toxicities	1% (0–1)	1% (0–2)	2%* (1–4)	NR	NR	<1% (0–1)
Neurological	1% (0–2)	2% (0–4)	2% (1–4)	NR	2%*(0–3)	<1%* (0–1)
Renal	1% (0–1)	1%(0–1)	<1% (0–1)	NR	4%* (2–5)	<1%* (0–1)

***Figure 3*: Causes of hospital admission in children**
AFRO=African region. AMRO N=region of the Americas (North). AMRO S=region of the Americas (South and Central). EURO=European region. EMRO=eastern Mediterranean region. NR=not reported. SEARO=southeast Asia region. WPRO=western Pacific region. *Only one study contributed to the estimate. †Mainly malaria.

hospital admissions in HIV-positive adults. Common causes by region included malnutrition and wasting, parasitic infections (mainly malaria), and haematological disorders in the Africa region; respiratory disease, psychiatric disorders, cardiovascular disease, renal disorders, and liver disease in Europe; haematological disorders in North America; and respiratory, neurological, digestive and liver-related disorders, viral infections, and drug toxic effects in South and Central America, although the proportion of hospital admissions caused by drug toxic effects declined over time. Liver disease accounted for 10% of hospital admissions in the eastern Mediterranean region. Non-AIDS malignant diseases accounted for more than 4% of hospital admissions in the African, European, and eastern Mediterranean region.

21 studies reported cause of hospital admission for 6182 HIV-positive children from 19 countries across five of the seven geographical regions (figure 3), although these causes were poorly described in some settings. Similar to adults, AIDS-related illness (783 patients) and

bacterial infections (1190 patients) were the most common causes of hospital admission overall. Other common causes of hospital admission among children included malnutrition and wasting and haematological disorders. Region-specific causes of hospital admission included parasitic diseases (mainly malaria) in the Africa region, respiratory disorders in the southeast Asia region, and viral infections in North America. The appendix contains detailed information about specific causes of hospital admission in adults and children.

In the metaregression, the proportions of patients admitted to hospital for AIDS-related illnesses, malnutrition and wasting, and viral infections were inversely associated with the proportion of adults and children receiving ART before hospital admission. The proportion of patients admitted to hospital for AIDS-related disorders did not decrease over time; similarly, we detected no significant differences in the sensitivity analysis that compared data from hospital admissions after 2009 to the overall cohort (appendix, p 17). Study design did not affect the results. Reduced CD4 cell count at hospital admission was associated with tuberculosis as a cause of hospital admission, and increased length of stay was associated with a greater proportion of patients admitted for AIDS-related disorders. Data about the use of co-trimoxazole prophylaxis or isoniazid preventive therapy were too scarce to be evaluated. The appendix contains results of the metaregression and sensitivity analysis.

In-hospital mortality among HIV-positive adults (12 902 deaths) was 20% (95% CI 18–23) overall, and was higher in Intensive Care Unit (ICU) wards (36%, 17–55) than in non-ICU wards (17%, 15–19). Mortality was highest in the Africa region (31%, 7–37). In children (643 deaths), mortality was 14% (10–19) overall, with no studies reporting information about outcomes from ICUs. Again, mortality was highest in the Africa region (19%, 13–26). AIDS-related infections and bacterial infections were the most common causes of mortality in adults and children (figure 4). Neurological, respiratory, and liver-related disorders contributed substantially to adult in-hospital mortality. For children, malnutrition and wasting and diarrhoea were common causes of in-hospital mortality in the Africa region.

Six studies provided data about mortality rates in HIV-negative patients admitted to hospital during the same reporting period.[19–24] HIV-positive individuals were more than twice as likely to die than were HIV-negative individuals (pooled odds ratio 2·6, 95% CI 1·8–3·7, p<0·0001).

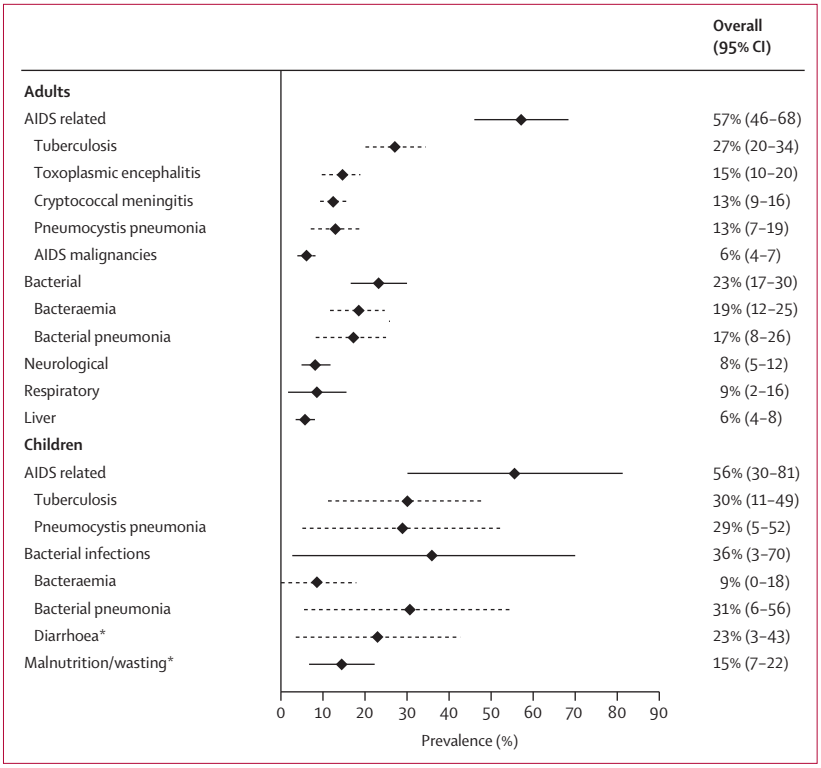


Figure 4: **Causes of mortality in HIV-positive adults and children admitted to hospital**
Dotted lines show specific conditions within categories. *Data from the Africa region only.

Discussion

We identified that AIDS-related infections (particularly tuberculosis) and bacterial infections (particularly pneumonia and bacteraemia) continue to be leading causes of hospital admission and in-hospital mortality in adults and children living with HIV worldwide. This finding is partly explained by the low average CD4 cell counts of patients who were admitted to hospital, with less than half of all patients receiving ART at admission. As with mortality, decreased rates of hospital admission have been reported to be associated with increasing CD4 count, and the highest hospital admission rates are seen in patients with CD4 counts of less than 100 cells per μL.[25] Low CD4 cell counts also predict risk of readmission,[26] whereas ART use has been associated with improved survival, increased CD4 cell counts, and reduced numbers of HIV-associated hospital admissions.[27]

The contribution of other non-AIDS infectious and non-infectious causes of hospital admission varies with age and geographical region. For adults, respiratory, psychiatric, renal, cardiovascular, hepatic, haematological, digestive, and neurological disorders and malnutrition and wasting were all common causes of hospital admission, accounting for more than 5% of patients in at least three regions. For children, haematological disorders and malnutrition and wasting were common causes of hospital admission in two or more regions, and in one study from west Africa malnutrition was more common in children who had not initiated ART or co-trimoxazole prophylaxis than in those who had.[28] Malaria was an additional important cause of hospital admission for children in the Africa region.

Several longitudinal studies included in this review reported a reduction in AIDS-related causes of hospital admission and an increase in non-AIDS causes over the

past 15 years as access to ART has improved. In France, a fall in AIDS-related illnesses was reported between 1999 and 2010, with a temporal increase in non-AIDS cancers and cardiac, pulmonary, hepatic, and renal co-morbidities.[29] In the USA, AIDS-related illnesses fell between 2001 and 2008.[30] Reductions in AIDS-related infections were reported during a similar period in patients in Brazil and France,[31] and in children in the USA.[32] Despite these trends, all of these studies reported that either AIDS-related illnesses, bacterial infections, or both, remained the leading causes of hospital admission.

The major contribution of bacterial infections to hospital admission and subsequent mortality in both adults and children is an important finding of this review, and emphasises the importance of co-trimoxazole prophylaxis and essential vaccinations against pneumococcal and meningococcal infection for people living with HIV. A randomised trial in Côte d'Ivoire noted that immediate ART initiation and 6 month isoniazid preventive therapy independently led to reduced rates of severe clinical events, an effect that was partly driven by a reduction in bacterial infections.[33] Few studies in our systematic review provided details about microbiology and antimicrobial resistance patterns, although high prevalence of antimicrobial resistance has been noted in other studies, and this is an important topic for future research.[34,35] Similarly, the high prevalence of tuberculosis as the cause of hospital admission and mortality in both adults and children could be reduced through early HIV diagnosis and prompt initiation of ART and isoniazid preventive therapy.[33,36]

The fact that almost a third of patients were newly diagnosed as HIV positive at the time of hospital admission shows the need to increase efforts to diagnose HIV early and offer ART to those who are eligible to reduce the risk of severe morbidity, which might require hospital admission. Community-based testing approaches, including home-based testing and self-testing can identify people who are HIV positive early in the course of infection[37] and are recommended by WHO as ways to expand access to HIV diagnosis.[38] The high prevalence of hepatitis C virus and HIV co-infection reported in some regions suggests that screening for hepatitis C virus needs to be a priority for HIV-positive adults who are admitted to hospital.[39]

Our ability to investigate the potential effect of immune status and use of ART was limited because about a third of the studies did not report this information. Furthermore, very few studies reported the use of other key preventive interventions, notably co-trimoxazole prophylaxis,[40] isoniazid preventive therapy,[41] and pneumococcal vaccination status,[42] which might explain some of the differences seen in the contribution of infectious causes of hospital admission between regions. Similarly, few studies reported information about underlying risk factors for diseases such as hypertension and concomitant alcohol and recreational drug use. Another important limitation of our study is the shortage of information provided about diagnostic and data-recording approaches. Consequently, some comorbidities might have been misclassified (eg, undiagnosed tuberculosis classified as bacterial pneumonia), and some recorded causes of admission might be disorders that are straightforward to diagnose (eg, oral candidiasis) instead of underlying causes of illness that might be more difficult to diagnose. Improved reporting of diagnostic approaches will be needed to increase the quality of future studies. Another limitation was that findings about the causes of hospital admission could not be assessed with respect to ART coverage in the surrounding population. Finally, causes of hospital admission and mortality probably differ between younger and older children,[32] but insufficient data were reported to allow for further age disaggregation. In future, investigators should be encouraged to report such information.

In conclusion, our findings emphasise the need for continued efforts to diagnose and treat HIV early, to avoid immune depletion. Additionally, our results reinforce existing recommendations that prioritise the provision of essential preventive prophylaxis and vaccination against major preventable infectious diseases to people living with HIV, in addition to basic improvements in water, sanitation, and food security in regions where these factors are a concern. Our analysis provides a basis for national governments and funding agencies in different regions to prioritise resources to tackle the most common infectious and non-infectious causes of serious morbidity and mortality among adults and children living with HIV.

Contributors

NF, MD, GM, BG, ZS, AC, and MV conceived and designed the study. NF, ZS, and OA acquired the data. NF did the statistical analysis. NF and ZS drafted the manuscript. All authors participated in the critical revision of the manuscript.

Declaration of interests

We declare no competing interests.

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