

HIV infection, tuberculosis and workload in a general paediatric ward

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Aim. To describe the impact of HIV infection and tuberculosis on the workload of a general paediatric ward at Red Cross War Memorial Children's Hospital in 2007.

Methods. Prospective descriptive surveillance of the patient composition of a general paediatric ward over a 1-year period.

Results. Median bed occupancy was 96.4%, and 66.7% of all patients hospitalised to the ward were less than 12 months old. Of all the admitted children, 27.6% had HIV infection, and 16.7% had tuberculosis (TB). Dual HIV and TB infection was present in 10.3% of all patients. Of all the children requiring high care, 23.1% were HIV infected. Approximately 50% of all children with HIV infection were on antiretroviral therapy. The annualised nurse-to-patient ratios were 1 registered nurse per 2.7 patients, and 1 professional nurse per 5.0 high-care patients. Fifty-six children died while in hospital, of whom 34 (60.7%) were HIV infected. Pneumonia was the main cause of death in both HIV-infected and uninfected children.

Conclusion. Despite prevention of mother-to-child-transmission intervention and paediatric antiretroviral treatment programmes, HIV infection and TB contribute substantially to the general paediatric workload at the hospital. Work associated with specific nursing functions should be quantified so that patient/nurse ratios may be optimised.

Analysis of HIV DNA polymerase chain reaction (PCR) results obtained from children <6 months old at primary health care clinics in the Western Cape has suggested that the HIV vertical transmission rate in the province declined to 4.8% during 2007 (95% confidence interval 4.4 - 5.3%).¹ Consequently, there should have been an appreciable decline in the number of HIV-infected children who access care at hospitals in the province. The general impression at Red Cross War Memorial Children's Hospital (RCH) is that there has not been a substantial drop in the HIV-related workload - a view supported by results of HIV DNA PCR tests performed at hospitals in the province. Of 1 722 tests performed in 2007 on children aged <6 months, 24.7% were positive.¹ Young children (<6 months old) constitute a sizeable proportion of the inpatient HIV workload at RCH. The majority of these children presented with advanced HIV disease, and their associated inpatient mortality approached 30%.²

Several publications have described HIV-related workload in paediatric wards at public sector hospitals in South Africa.³⁻⁹ Five of the 7 studies described in Table I were conducted prospectively. Six of the 7 studies were completed before antiretroviral therapy (ART) became widely available within the public sector, from the beginning of 2004 onwards, the exception being a cross-sectional study by Schneider *et al.*, completed in early 2005.⁶ The 3 Gauteng studies were all completed at Chris Hani Baragwanath Hospital and, although different study designs were used, the results documented the change in HIV prevalence at a single hospital over an extended period.⁴⁻⁶ Because few reports have assessed

HIV prevalence rates among hospitalised children in the antiretroviral era, the present study was completed. The specific objectives were to document the HIV, tuberculosis (TB) and HIV-TB co-infection prevalence rates in hospitalised children; to determine the proportion of hospitalised HIV-infected children who required high care; to describe the proportion of deaths associated with HIV and/or TB; and to relate workload to the level of nursing cover in a general paediatric ward over a 1-year period in a setting with an established prevention of mother-to-child transmission (PMTCT) intervention programme and relatively high ART coverage.

Methods

Study setting

This prospective study was conducted throughout 2007 in ward B1, a general paediatric ward at RCH. The Research Ethics Committee of the University of Cape Town approved the study (Reference: 124/2008). The hospital has two general 28-bed paediatric wards in which the majority of children with HIV infection and/or TB who require inpatient care at the hospital are currently admitted. Both general wards manage a similar patient mix, experience similar patient volumes, and have comparable staff complements. Therefore, the study focused on evaluating HIV and TB workload in one of the two general wards.

TABLE I. PUBLISHED HIV PREVALENCE RATES AMONG CHILDREN HOSPITALISED IN SOUTH AFRICAN INSTITUTIONS

Reference	Study and year of completion	Institution type	HIV prevalence
Roux ³	Paediatric inpatients sampled at one time point (1999)	18 facilities, Cape Town	8.3% (106/1 264)
Zwi ⁴	Hospitalised children during a 5-year period (1992 - 1996)	Tertiary hospital, Gauteng	1992: 7.5% (120/1 592) 1993: 14.5% (228/1 574) 1994: 23.3% (304/1 307) 1995: 30.9% (449/1 455) 1996: 42.3% (870/2 057)
Meyers ⁵	Hospitalised children during a 6-month period (2000)	Tertiary hospital, Gauteng	29.2% (144/493)
Schneider ⁶	Hospitalised children during a 28-day period (2005)	Tertiary hospital, Gauteng	31.5% (of 554)
Yeung ⁷	Hospitalised children over a 4-month period (1996 - 1997)	District hospital, KwaZulu-Natal	26% (72/281)
Pillay ⁸	Hospitalised children over a 4-week period (1998)	Tertiary hospital, KwaZulu-Natal	62.5% (100/160)
van Deventer ⁹	Hospitalised children during a 1-year period (2001)	Secondary hospital, Free State	16.8% (of 1 836)

Data collection

Information describing the patient composition and nursing cover in ward B1 was collected prospectively between 08h00 and 09h00 on 347 days throughout 2007 by one of two professional nurses. General indicators of the patient profile included total patient number, number <4 months old, number <12 months old, and number requiring high-care monitoring or intervention. Indicators of HIV and TB workload included total number of patients with HIV infection, number of HIV-infected children requiring high care, number of patients on ART, number with TB, and number with HIV-TB co-infection. Nursing cover in the ward was determined by the total number of registered nurses and the total number of professional nurses on duty.

Case definitions

At each data collection point, each patient in the ward was classified using the following definitions for HIV infection, TB, HIV-TB co-infection and high care.

HIV infection

A child <18 months old with a positive HIV DNA PCR result, or a child >18 months old with 2 positive serological test results (HIV enzyme-linked immunosorbent assay (ELISA) and/or HIV rapid test) or a positive HIV DNA PCR result.

Tuberculosis

Any child who had been started on anti-TB medication was regarded as having TB. Children on isoniazid prophylaxis were not included.

HIV-TB co-infection

All children who fulfilled the case definition of HIV infection and in addition were receiving anti-TB medication.

High-care monitoring or intervention

'High care' is a level of clinical care between standard paediatric care and intensive (or critical) care. The following patient categories were considered in need of high care: all neonates, all children requiring respiratory support with supplemental

oxygen (saturation monitoring), children requiring monitoring of one or more organ systems (including level of consciousness, seizure frequency, and vital signs monitoring at a frequency <2-hourly), monitoring the administration of total parenteral nutrition, and the care of children with tracheostomies, haemofiltration and/or continuous peritoneal dialysis.

Information on children who died was extracted from the hospital case records using a standardised data collection sheet.

Statistical analysis

Weight-for-age z-scores (WAZ) were calculated using EpiInfo 2008, version 3.5.1 (Division of Surveillance and Epidemiology, Centers for Disease Control, Atlanta, Georgia). Moderate and severe underweight were defined as a WAZ of >-3.0 to <-2.0, and <-3.0, respectively. The data were analysed using STATA, release 9, College Station, Texas, USA. The 95% confidence interval for binomial proportions was used to estimate the frequency of positive HIV DNA PCR results. Conventional descriptive statistical methods were used. The Shapiro-Wilk test of normality was employed to assess the distribution of continuous variables. The two-sample Wilcoxon rank sum test was used to compare continuous variables. A *p*-value <0.05 was regarded as significant.

Results

Inpatient workload

During 2007, 907 children were hospitalised in ward B1, a mean \pm standard deviation (SD) of 75.5 \pm 10.7 children per month; 810 children were either discharged or transferred out of the ward, i.e. a mean \pm SD of 67.5 \pm 10.2 per month. During the year, 59 children who had been inpatients in the ward died - 56 while in hospital and 3 after hospital discharge. The median bed occupancy rate of this 28-bed ward throughout 2007 was 27 patients or 96.4%, interquartile range (IQR) 93 - 100%. Of all the children admitted to ward B1, 66.7% (IQR 59 - 76%) were <12 months old and 21.8% (IQR 18 - 27%) were <4 months old. Median monthly variations are shown in Fig. 1.

Furthermore, 57.1% (IQR 54 - 62%) of all hospitalised children required high-care monitoring or interventions.

A median of 27.6% (IQR 24.6 - 29.9) of all children in ward B1 had confirmed HIV infection. The median percentage of all children with TB was 16.7% (IQR 14.2 - 20.6%). Furthermore, 10.3% (IQR 6.9 - 13.8%) of all children had dual HIV and TB infection (Fig. 2). Of all children requiring high care, 23.1% (IQR 17 - 29%) were HIV-infected (Fig. 3). A median of 4 children (50%) of all HIV-infected children hospitalised to the ward were on highly active antiretroviral therapy (HAART) at any one time point. This percentage remained fairly constant throughout the study period (data not shown).

Nurse/patient ratios

Total registered nursing complements comprised all professional, staff and auxiliary nurses. Median monthly ratios of total patients to total number of registered nurses, and children requiring high care to total number of professional nurses, are presented in Fig. 4. The median ratios for the entire

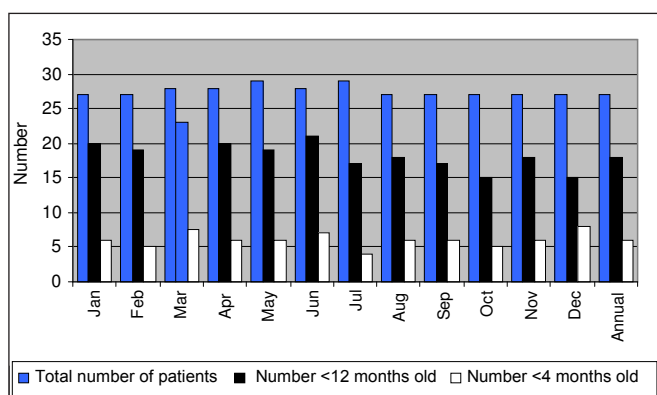


Fig. 1. Median numbers (total number, number <4 months old, and number <12 months old) of children admitted to ward B1 in 2007.

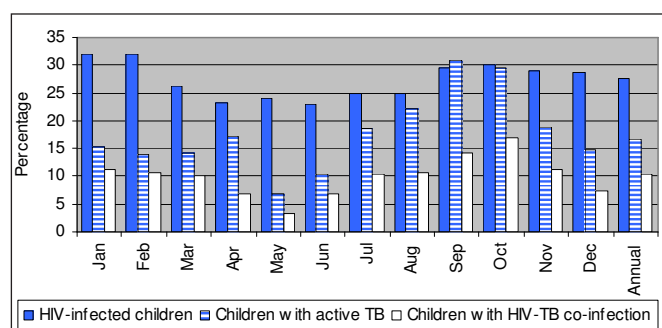


Fig. 2. Proportions of patients with HIV infection, tuberculosis and HIV-TB co-infection.

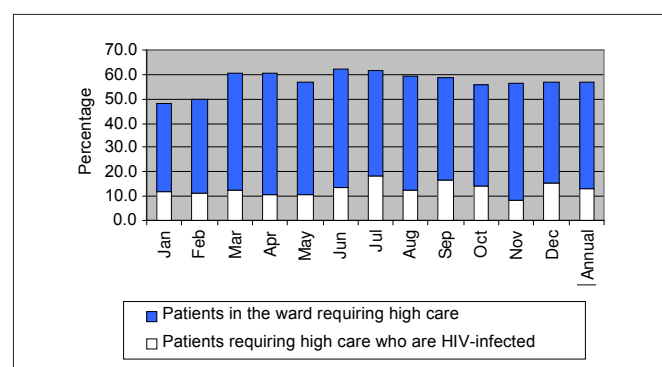


Fig. 3. The percentage of patients requiring high care, including the proportion in high care who were HIV-infected.

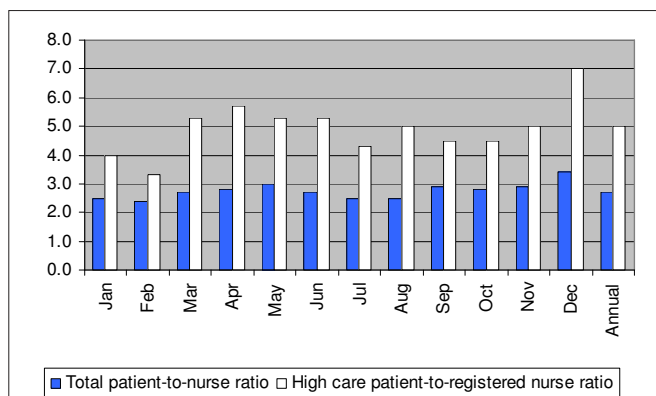


Fig. 4. Ratios of total number of patients to total number of nurses on duty and number of patients in high care to number of registered nurses on duty.

year were 1 registered nurse per 2.7 patients and 1 professional nurse per 5.0 high-care patients.

Deaths during hospitalisation

Three children died at home. Each had an underlying potentially terminal condition: 1 had primary T-cell immune deficiency and had been discharged for palliation at home, 1 had Down syndrome with congenital cardiac defects, and 1 was HIV infected.

Characteristics of the 56 children who died during hospitalisation are presented in Table II. The majority were male (66.1%), <12 months old (82.1%) and moderately or severely underweight (60.7%). Of the 6 children with peripheral oedema, 1 had a normal WAZ, 4 were moderately underweight, and 1 was severely underweight. There were 11 HIV-uninfected children; 6 participated in the PMTCT intervention programme: 3 mothers had tested HIV negative and therefore received no further intervention, while 3 mothers tested positive and were given prophylaxis with a satisfactory outcome. Thirty-four children were HIV infected; 19 had participated in the PMTCT programme - 14 failed PMTCT

TABLE II. CHARACTERISTICS OF CHILDREN WHO DIED IN HOSPITAL (N=56)

Gender (%)	Female 19 (33.9)
Median age in months (IQR)	4.50 (2.55 - 8.45)
Number <12 months old (%)	46 (82.1)
Nutrition	
Median weight-for-age z-score (IQR)	-2.40 (-3.44 to -1.49)
Number moderately underweight (%)	12 (21.4)
Number severely underweight (%)	22 (39.3)
Number with peripheral oedema (%)	6 (10.7)
HIV status	
Infected	34 (60.7)
Exposed but uninfected	3 (5.4)
Uninfected	8 (14.3)
Unknown	11 (19.6)

IQR = interquartile range.

intervention, while 5 did not receive PMTCT intervention because their mothers had tested HIV negative by the rapid test antenatally.

There were 9 children on HAART at the time of death. Seven had been started on treatment 32.3±24.5 days prior to hospitalisation. The other 2 children were started on HAART during admission. Both were severely immunosuppressed, with baseline CD4 percentages of 9.0% and 14.3%. The 9 children on HAART were older than the remaining 25 HIV-infected children who were not yet on HAART at the time of death; median age 8.2 (IQR 7.0 - 12.6) v. 3.3 (IQR 2.7 - 5.0) months, $p=0.0235$. The median WAZ was significantly lower in the HAART group, i.e. -3.97 (IQR -3.97 to -3.06) v. -1.52 (IQR -2.7 to -0.94), $p=0.0010$.

Pneumonia was the primary presenting illness in patients who died (Table III). Of the 18 HIV infected children who died of pneumonia, 5 (27.8%) had proven *Pneumocystis jirovecii* pneumonia, only one of whom was on co-trimoxazole prophylaxis at the time of hospitalisation. TB was considered the cause of death in 4 children - 1 HIV infected and 3 uninfected. An additional 6 (17.6%) of the 34 HIV-infected children were co-infected with TB. However, TB was not considered the primary cause of their deaths. Factors possibly contributing to death in the HIV-uninfected group included congenital heart disease (2 children), cystic fibrosis (1), congenital syphilis (1) and severely underweight with oedema (1). Eleven children had unknown HIV status at death. Factors possibly contributing to their deaths included congenital rubella (1 child), congenital hydrocephalus (2, one with an associated meningomyelocele), congenital heart disease (2) and severely underweight with oedema (1).

Discussion

In this study, we documented high rates of HIV infection and TB among hospitalised children in a general paediatric ward during 2007. HIV infection was the dominant disease, diagnosed in 27.6% of hospitalised patients. The study was not designed to gauge the success of recently introduced interventions in the Western Cape, such as the implementation of the public sector ART rollout and the introduction of dual zidovudine and nevirapine prophylaxis for PMTCT since April - May 2004.^{10,11} The prevalence of HIV infection recorded in the present study is high for a single disease. Contributing factors probably include high HIV prevalence (estimated at 12.6% in

2007) among women of child-bearing age in the Western Cape, gaps in the PMTCT intervention programme, and inadequate care for HIV-infected infants.¹¹⁻¹³ Furthermore, migration of patients to the Western Cape from provinces with less-developed PMTCT intervention and treatment programmes probably contributed to the high HIV prevalence.

The care of HIV-infected infants should be aligned with recently updated World Health Organization (WHO) treatment recommendations. In particular, all HIV-infected infants must be fast-tracked for HAART soon after diagnosis.¹⁴ This programmatic change should reduce the rate of hospitalisation of HIV-infected children, particularly the high proportion of young infants with advanced disease;² this requires urgent consideration by national and provincial policymakers, because the increasing under-5 mortality rate in South Africa is directly linked to the paediatric HIV epidemic, which can be ameliorated with effective intervention.^{13,15}

Several features of current general paediatric practice at RCH are described in the present study; these include the high proportion of children <12 months old among hospitalised patients, that approximately 25% of children who required high-care monitoring or intervention were HIV infected, and the relatively high HAART coverage among HIV-infected inpatients. A study completed in 2006 showed that young children constituted a sizeable proportion of the HIV workload at RCH. In that study, more than 40% of HIV-infected inpatients were <6 months old; and more than 90% of young children who were HIV-infected but not on HAART had advanced HIV infection.² The findings of the present study complement the previous findings. Furthermore, at the end of 2006, a policy was implemented whereby all HIV-infected infants were commenced on HAART before hospital discharge, which may account for the relatively high proportion of inpatients receiving HAART.

Overall, 16.7% of hospitalised patients had TB. Of these, more than 60% (or 10.3% of all hospitalised children) had HIV-TB co-infection. A recurring observation made by nurses in the general paediatric wards is that the administration of both antiretroviral agents and anti-TB medication to co-infected children requires considerable nursing time. The present study did not measure this aspect of the nursing workload. Instead, we confined our analysis to measuring patient/nurse ratios.

While the total patient/registered nurse ratio was acceptable, the ratio of high-care patients to professional nurses was

TABLE III. PRIMARY PRESENTING ILLNESSES OF PATIENTS WHO DIED (N=56)

Cause	HIV infected (%), N=34	HIV uninfected (%), N=11	Unknown HIV status (%), N=11
Gastroenteritis	1 (2.9)	0 (0.0)	0 (0.0)
Pneumonia	18 (52.9)	5 (45.5)	3 (27.3)
Sepsis	7 (20.6)	1 (9.1)	1 (9.1)
Gastroenteritis and sepsis	2 (5.9)	0 (0.0)	2 (18.2)
Pneumonia and sepsis	3 (8.8)	0 (0.0)	1 (9.1)
Meningitis related	1 (2.9)	1 (9.1)	1 (9.1)
TB	1 (2.9)	3 (27.3)	1 (9.1)
Other	1 (2.9)*	1 (9.1)†	2 (18.2)‡

*Dilated cardiomyopathy.

†Acute renal failure.

‡Fulminant hepatitis A (1), ventriculitis (1).

relatively high. The nurse/patient ratio and the proportion of care provided by professional nurses are known to influence quality of care, nosocomial infection rates and patient outcome.¹⁶⁻¹⁹ In contrast, inadequate staffing is associated with job dissatisfaction, burnout, and increased staff turnover.^{19,20} In a study conducted in Massachusetts hospitals, the mean (\pm SD) patient-to-registered nurse ratios for paediatric and paediatric critical care settings were 2.99 (\pm 0.6) and 1.39 (\pm 0.21) respectively.²¹ Although optimal patient/nurse ratios remain unclear, these published ratios suggest that general paediatric wards in South Africa, with a large proportion of patients requiring high-care monitoring or interventions, should be staffed by a higher proportion of professional nurses. Further research is required to optimise patient/nurse ratios. In particular, the workload associated with common HIV-related activities, such as the provision of optimal palliative care and the administration of HAART to infants, should be quantified. These inpatient functions will assume greater importance as the response to the paediatric HIV epidemic in South Africa improves.^{22,14}

Pneumonia was the common diagnosis among children who died. Although confirmed HIV infection was present in 60.7% of children who died during hospitalisation, several children had other risk factors, including congenital heart disease and malnutrition. These findings are similar to a recent analysis of 6 839 child deaths at South African institutions using the Child Healthcare Problem Identification Programme. In that analysis, 48% of all children who died had WHO clinical stage 3 or 4 HIV infection, and 35% of deaths were associated with pneumonia.²³ The extent to which palliative care interventions were administered to dying patients was not evaluated in the present study. Effective palliative care, including adequate pain control, requires significant nursing and medical time.²²

The data for the present study were primarily collected by two professional nurses during working hours, which limited the number of information fields that were collected. Despite this constraint, data were collected on 347 days of 2007, provided a detailed description of HIV- and TB-related workload in a general paediatric ward, and generated further questions about specific aspects of nursing functions.

In conclusion, HIV and TB remain dominant paediatric diseases managed at RCH. The findings of this study may serve as a basis for evaluating the impact of future interventions on paediatric practice, including the anticipated introduction of HAART for all HIV-infected infants immediately following confirmation of their status.

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