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Costs of admission for paediatric pneumonia in a setting of human immunodeficiency virus infection

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SUMMARY

BACKGROUND: Pneumonia in South African children remains a major public health concern. The costs of hospital admission for pneumonia should be determined, especially where human immunodeficiency virus (HIV) infection is common.

OBJECTIVE: To determine the hospital costs of children (HIV-infected vs. non-HIV-infected) admitted for the management of pneumonia and compare them in the public and fee-for-service sectors.

METHODS: A retrospective review of paediatric admissions in 2007 was performed. Costs were determined for the public and fee-for-service sectors. Outcome measures included hospital mortality and comparative costs of admission.

RESULTS: There were 132 admissions in a public sector facility (67% HIV-infected), and 7882 in the fee-for-service sector (1.2% HIV-infected). Total mortality was respectively 25% in the public and 0.04% in the fee-for-service sectors. The mean cost for HIV-infected patients was respectively US$639.06 and US$10 540.04 in the public and fee-for-service sectors. For non-HIV-infected patients, the cost was respectively US$399.45 and US$3936.87. Length of stay for HIV-infected patients was longer by respectively 1.8 days and 5.7 days in the public sector among admissions to the ward and to the paediatric intensive care unit.

CONCLUSION: Admission for HIV-infected children with pneumonia costs significantly more in both sectors. Preventive strategies are needed.

KEY WORDS: HIV; pneumonia; cost

PNEUMONIA IN SOUTH AFRICA remains a major public health concern, with a number of children admitted to hospital each month with severe pneumonia. The cost of admission of a patient with community-acquired pneumonia (CAP) is seldom considered, although it is an important factor in calculating the cost-efficacy of preventive strategies such as vaccines.

CAP prevalence is unknown, but it is estimated that 2.1 million children aged <5 years die worldwide from pneumonia annually.[1] The prevalence of this condition is estimated to be 2–10 times greater in Africa and Asia than in the United States.[2] Together with diarrhoea and malnutrition, pneumonia ranks among the top three causes of death in developing countries.[3] Pneumonia accounts for nearly one fifth of childhood deaths worldwide, with the majority of the approximately 2 million deaths occurring in Africa and South-East Asia.[1,4]

The human immunodeficiency virus (HIV) and acquired immune-deficiency syndrome have had a significant impact on both the prevalence and severity of pneumonia.[5] In South Africa, there are approximately 80 000 new infections annually, with 30–40% of hospital admissions being HIV-related.[6] This results in a case-fatality rate of 15–28%.[7] The natural consequence of the HIV epidemic and the increase in the prevalence and severity of childhood pneumonia is therefore a rise in hospitalisation and a consequent increase in disease-related costs. Costs are dictated by, among others, increased number of admissions and utilisation of diagnostic and therapeutic services for more severe disease.

One prevention strategy that has been shown to be highly successful in the United States is routine childhood vaccination with pneumococcal conjugate vaccine. This vaccine did not form part of the South African government immunisation schedule at the time of the study, but vaccination against polio, hepatitis B, *Bordatella pertussis*, tetanus, diphtheria, *Haemophilus influenzae* B and measles had routinely been given to our patients. Local studies have shown the benefits of pneumococcal vaccine, with a reduction of invasive pneumococcal disease by between 65% and 85% in HIV-infected and non-HIV-infected children, respectively.[8] However, a cost-efficacy analysis of the benefits of such vaccines will dictate the real world impact on pneumonia.

The actual cost of a child admitted to hospital

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with pneumonia has never been determined in South Africa, and is an important pharmaco-economic factor in resource-poor settings. This expense is an important quantum when the cost of preventive strategies is calculated. This may impact cost-benefit calculations of routine pneumococcal 7-valent, 10-valent or 13-valent vaccines for children in South Africa.

The aim of the present study was to determine the total and individual costs of children admitted to hospital for the management of pneumonia. The study also set out to determine the cost differentials for HIV-infected and non-infected children and for children admitted to a general paediatric ward or a paediatric intensive care unit (PICU) in a public sector setting. A comparative analysis of the fee-for-service sector was performed. Mortality or discharge from the hospital was determined as the end point.

METHODS

Study design

This was a retrospective observational cross-sectional study. The study protocol was approved by the University of Pretoria ethics committee.

Each admission of children diagnosed with pneumonia to the Steve Biko Academic Hospital's paediatric pulmonology ward and PICU during the period 1 January 2007 to 31 December 2007 was reviewed. Pneumonia was defined, based on the World Health Organization definition of clinical severity, as severe pneumonia (cough, tachypnoea, rib and sternal recession) and very severe pneumonia (cough, tachypnoea, chest wall retraction, inability to drink, cyanosis). All children had pneumonic consolidation on chest radiograph. Admission to the PICU was based on the development of type 2 respiratory failure, assessed by arterial blood gas analysis. Patients with a diagnosis of bronchiolitis, tuberculosis or comorbid cardiac disease were excluded.

The direct costs of each admission, obtained from the hospital billing file, were calculated[9] based on hospital category code H2, for hospitalised patients partially subsidised by the state, as set out on the Uniform Patient Fee Schedule (UPFS). All aspects of public sector health care are subsidised, including facility fees, which reflects the overhead costs of providing the environment in which health care service is rendered (Level 3 tertiary hospital), and professional fees, which cover the costs of services provided by health care, laboratory and radiology professionals and antibiotics. Costs were calculated per patient per admission, and a median monthly cost per diagnosis per ward was calculated. All laboratory blood culture results and sputum results were also included. The present study was conducted before a routine policy of sampling for *Pneumocystis jirovecii* and cytomegalovirus was introduced. The outcome of these admissions was assessed as death in hospital or discharge home. Data were also obtained from the fee-for-service sector.[10] Data were compared for mortality and the average length and cost of hospitalisation in the ward and the PICU for the two health care sectors for both HIV-infected and non-infected children. To complete the analysis of the cost of severe pneumonia in children, all costs of strategies that may be deemed 'pneumonia preventive' were added. These costs may highlight what cost in savings (if any) could be achieved through preventing pneumonia in children.

Statistical analysis

An analysis of actual costs was compared for the different groups using the two-sample Wilcoxon rank-sum (Mann-Whitney) test. A 5% level of significance was considered statistically significant.

RESULTS

A total of 200 patients were admitted to the public sector facility for pneumonia during the study period; 68 were excluded as the diagnosis proved to be bronchiolitis ($n = 11$) or because HIV testing was not performed ($n = 57$). A total of 132 patients therefore qualified for data analysis: 86 were admitted to the paediatric pulmonary ward and 46 to the PICU. The male-to-female ratio was 1.45:1 (51:35) in the ward and 1:1.42 (19:27) in the PICU. Of these, 33 (25%) died: 12 in the ward and 21 in the PICU (Table 1). In the fee-for-service sector, 7882 patients were admitted: 7786 to the ward and 93 to the PICU. The male-to-female ratio was 1:0.8 (4423:3406) in the ward and 1:1.1 (24:26) in the PICU. Three patients (0.04%) died, all three in the PICU.

Table 2 (A and B) reflects the comparison of median costs for HIV-infected and non-HIV-infected children in both the ward and the PICU in the public sector. The costs of HIV testing were higher for HIV-infected than non-infected patients in the ward and the PICU ($P = 0.02$ and $P = 0.002$, respectively). This is because an HIV-DNA (polymerase chain reaction [PCR]) has to be performed on HIV-enzyme-linked immunosorbent assay (ELISA) positive children

Table 1 Overview of the patient profile and outcome of children admitted with pneumonia to a public service in South Africa, $N = 132$

	Ward *n/N* (%)	PICU *n/N* (%)
HIV-infected	58/86 (67)	31/46 (67)
Total deaths	12/86 (14)	21/46 (46)
HIV-infected deaths	12/58 (20.7)	17/31 (54.8)
Non-HIV-infected deaths	0/28 (0)	4/15 (26.7)
Length of stay, days, median [IQR]	7 [5–12]	6.5 [3–14]
HIV-infected length of stay	8 [4–12]	9 [5–18]
Non-HIV-infected length of stay	6.5 [5–8]	3 [2–7]

PICU = paediatric intensive care unit; HIV = human immunodeficiency virus; IQR = interquartile range.

Table 2 Median costs per patient (in US$)

Cost centre	HIV-infected	Non-HIV-infected	*P* value*
Public sector ward			
HIV testing	45.60	10.90	0.02
Blood culture	11.30	11.30	0.54
Sputum microbiology	28.80	28.80	0.18
Haematological testing	59.80	33.10	0.01
Hospital bed	173.50	139.50	0.23
Radiology	30.90	30.90	0.25
Antibiotics	0	0	0.20
Public sector PICU			
HIV test	45.60	10.90	0.002
Blood cultures	11.30	11.30	0.42
Sputum microbiology	28.80	28.80	0.54
Haematological testing	103.50	71.30	0.17
Hospital bed	382.50	127.50	0.01
Radiology	45.70	45.70	0.04
Antibiotics	0	0	0.11

*Statistical significance for comparison of HIV-infected patients with non-HIV-infected patients.
HIV = human immunodeficiency virus; PICU = paediatric intensive care unit.

aged <18 months to define HIV infection; 81% of our cohort required this test. HIV DNA (PCR) is ideally routinely conducted at postnatal follow-up. The mean cost of admission to the public sector ward was US$435.12 (for a mean of 8.67 days) and US$795.81 (for a mean of 9.35 days) to the PICU. The fee-for-service costs were US$1375.35 (for a mean of 5.6 days) and US$13 101.55 (for a mean of 10.5 days) for the ward and PICU, respectively. The public sector costs are therefore respectively 4.9 times (ward) and 1.3 times (PICU) lower than in the fee-for-service sector. In the public sector, antibiotics are included in the hospital bed costs, in accordance with the UPFS.

In the public sector, HIV-infected patients admitted to PICU had, on average, more haematological and blood culture tests performed than non-infected children and HIV-infected patients in the ward. The mean number of haematological investigations in the PICU was 16.03 haematological specimens and 1.67 blood culture specimens for HIV-infected patients, while 7.41 haematological specimens and 0.71 blood culture specimens were drawn from non-infected patients. In patients admitted to the ward, a mean of 6.41 haematological specimens and 0.83 blood culture specimens were collected in HIV-infected patients compared to 7.21 haematological specimens and 1.03 blood culture specimens in non-HIV-infected patients. HIV-infected patients had a greater number of positive cultures for bacteria than non-infected patients. This was noted in both the ward and the PICU. The mortality rate for the public sector was 25% (14% and 46% in the ward and PICU, respectively), but it was 0.04% (0% and 6% in the ward and PICU, respectively) in the fee-for-service sector. When all items deemed 'pneumonia preventive' are totalled, these amount to US$341.33–$1389.42 for HIV-infected children and US$229.91 for non-infected children (Table 3). The best-case scenario is one in which a child is born to a mother whose CD4 count is sufficiently high as not to warrant ongoing highly active antiretroviral therapy (HAART) throughout pregnancy and where the child is HIV-exposed but not infected. The worst-case scenario is where these criteria exist.

DISCUSSION

HIV-infected and non-infected children are still admitted to hospital and the PICU for management of severe pneumonia, and they cost the state a significant amount of money each year. During the study period, 132/1477 (8.9%) admissions to the public sector ward and 46/460 (10%) PICU admissions were diagnosed with pneumonia. The total number of non-HIV-infected children with severe and very severe pneumonia (28 in the ward and 15 in the PICU, respectively) during the study year (2007) suggests that, even in the absence of HIV infection, pneumonia is still a common condition among children. This is supported by figures from the fee-for-service sector, where even higher numbers (n = 7786) of non-HIV-infected children are admitted with a diagnosis of pneumonia. Pneumonia appears to cost less in the public sector than the fee-for-service sector in South Africa, but

Table 3 Costs (in US$) of pneumonia preventive strategies in children in South Africa

	HIV-infected		
Cost centre	Worst-case scenario	Best-case scenario	Non-HIV-infected
Antenatal ELISA	10.90	10.90	—
Maternal PMTCT best-case scenario (ARV at delivery)	—	1.11	—
Maternal PMTCT worst-case scenario (HAART/triple ARV × 9 months)	507.15	—	—
ELISA child	10.90	10.90	10.90
PMTCT child × 1 month	—	8.86	—
PCR at 6 weeks + 6 months	91.25	91.25	—
Worst-case scenario HAART/triple ARV × 1 year	550.21	—	—
PCV 7 × 3 doses	76.95	76.95	76.95
Infanrix Hexa (DTaP-HBV-IPV/HIB) × 4 doses	142.06	142.06	142.06
Total costs of preventive strategies	1389.42	341.33	229.91

ELISA = enzyme-linked immunosorbent assay; PMTCT = prevention of mother-to-child transmission; ARV = antiretroviral; HAART = highly active antiretroviral therapy; PCR = polymerase chain reaction; PCV = pneumococcal conjugate vaccine; DTaP = diphtheria, tetanus acellular pertussis vaccines; HBV = hepatitis B virus; IPV = inactivated poliovirus vaccine; HIB = *Haemophilus influenzae* type B.

this fact may be misleading, as all public health costs are heavily subsidised by the state. Fee-for-service costs may represent a truer quantum for this condition. Pneumonia mortality occurs irrespective of HIV status, and this has been well described.[11,12] However, what has emerged from this study is that once very severe pneumonia occurs and the patient requires admission to the PICU, the protective effect of not having HIV infection is mitigated and patients continue to die in the PICU. In the fee-for-service sector, deaths occurred only in non-HIV-infected patients admitted to the PICU. Reasons for this increasing mortality phenomenon are poorly understood, but immune compromise has been cited as a reason for hospital-acquired pneumonia.[13] The low mortality due to pneumonia in the fee-for-service sector probably reflects a less severely ill group of patients.

Not surprisingly, HIV-infected children admitted to hospital with pneumonia cost more, but this is seldom considered. The comparative costs of 'pneumonia preventive' strategies were US$1389.42 in HIV-infected (worst-case scenario) and US$341.33 (best-case scenario) and US$229.91 for non-HIV-infected patients (Table 3). This is important when calculating the true cost-benefit ratio of preventive strategies and in achieving the Millennium Developmental Goals for childhood mortality.[14] When the costs of pneumonia prevention strategies are weighed against the costs of admission and treatment of pneumonia, this calculation suggests that for every 1 dollar spent on prevention a cost saving of $1.70 and $17.10 may be realised for non-HIV-infected children in the public and fee-for-service sectors, respectively. For HIV-infected children, $1.90 and $30.90 would be saved for children classified as the best case scenario (maternal HIV but with high CD4 count) in the public and fee-for-service sectors, respectively. However, when the costs of prevention are balanced against treatment for HIV-infected children whose mothers also require HAART during pregnancy (worst case scenario), then savings would occur only for those children subject to preventive interventions in the fee-for-service sector ($7.60). In the public sector this balance would translate into a 50 cent loss for every dollar spent on prevention. In this setting, for pneumonia strategies to be cost-effective, one barrier is significant maternal AIDS. Prevention of pneumonia in children from this perspective would require an additional element of disease recognition and treatment in mothers for paediatric outcomes to be 'cost-effective'. This then becomes an ethical as well as a medical issue.

Blood culture and microbiology costs were not statistically significantly different between HIV-infected and non-infected children in the public sector, as all children undergo initial microbiological screening. Patients admitted to the PICU had significantly more haematological investigations performed, irrespective of HIV status, confirming that this population group had more severe disease. HIV-infected patients admitted to the PICU incurred higher hospital bed costs, as reflected by a longer duration of stay compared to non-HIV-infected patients in both sectors. The duration of hospitalisation was 1.8 days longer in the ward and 5.7 days longer in the public sector PICU. This was also reflected in the fee-for-service sector, where the duration of hospitalisation for HIV-infected children was 4.1 days longer in the ward and 11.1 days longer in the PICU. The pattern of organisms identified from blood culture among these children is similar to that described from other similar African settings.[15] Lack of positive yield on blood culture is a universally acknowledged phenomenon in childhood pneumonia.[16] The greater likelihood of culturing an organism from blood specimens in HIV-infected children has also been described previously.[16]

Study limitations

Study limitations include the small numbers of patients in the public sector analysis and the retrospective nature of the study. Some data, such as anthropometric measurements, were not recorded. The fee-for-service costs represent all children admitted to hospital for the whole country, but from a single funder. This might result in real bias if such patients represented a single economic group. This is not, however, the case. These limitations may be overcome by a more robust prospective and comparative study. However, it is unlikely that additional data would change the main conclusions: pneumonia is both common and costly in children and prevention strategies should be sought to reduce suffering and cost.

CONCLUSIONS

Children hospitalised for pneumonia represent a significant annual cost in the public and fee-for-service sectors, and HIV-infected children represent a greater cost burden. These costs need to be borne in mind when preventive campaigns are embarked upon. The public sector spends a significant amount on antiretroviral treatment for HIV-infected patients and treating the consequences of uncontained HIV disease. These costs are set to escalate unless authorities and medical personnel alike re-enforce preventive strategies such as reducing mother-to-child HIV transmission and promoting vaccines that prevent infectious diseases. An estimation of this has been demonstrated in this study. This should be coupled with reducing new infections in the parents of these children. Only when all preventive strategies are utilised in conjunction will the burden of pneumonia and its attendant costs fall. This study adds to mounting evidence that childhood pneumonia is a costly illness,[17] and that all efforts should be focused on preventing its occurrence.

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