The epidemiology of hospitalized pneumonia in rural Kenya: the potential of surveillance data in setting public health priorities

Jeffrey A. Tornheim\textsuperscript{a}, Ayub S. Manyab\textsuperscript{b}, Norbert Oyando\textsuperscript{c}, Stewart Kabaka\textsuperscript{c}, Robert F. Breiman\textsuperscript{a}, Daniel R. Feikin\textsuperscript{a,}\textsuperscript{*}

\textsuperscript{a}International Emerging Infections Program, Centers for Disease Control and Prevention, Unit 64112, APO, AE 09831, Kenya
\textsuperscript{b}Field Epidemiology and Laboratory Training Program, Centers for Disease Control and Prevention, Kenya
\textsuperscript{c}Bondo District Ministry of Health, Kenya Ministry of Health, Kenya

Received 20 December 2006; accepted 17 March 2007

Corresponding Editor: William Cameron, Ottawa, Canada

Summary

Introduction: Surveillance data from inpatient health facilities can be useful for prioritization of public health initiatives, but often are not collected or analyzed in developing countries. We evaluated data on hospitalized patients diagnosed with pneumonia in rural western Kenya to characterize pneumonia epidemiology and mortality.

Methods: Data were obtained from admission registers of all inpatient facilities from 2001 to 2003 in Bondo District (estimated 2003 population: 255901), which is holoendemic for malaria and has high HIV rates. Inpatients with diagnoses compatible with acute pneumonia were included, and census data (1999) were used to calculate incidence rates by age, sex, season, and residence.

Results: From 2001 to 2003, a total of 2466 patients diagnosed with pneumonia were hospitalized with 282 deaths (11.4%). Incidence peaked at 698 per 100 000 person-years among children <5 years of age. A second peak occurred among 20–29 year-olds at 356 per 100 000 person-years; rates were twice as high in women as men in this age group (p < 0.001). The incidence in persons >65 years was 121 per 100 000 person-years. Pneumonia incidence peaked during the twice-yearly high malaria seasons, 1–2 months after peak rainfall. Rates of pneumonia decreased with increasing distance of residence from the district hospital (p < 0.0001).

Discussion: In Bondo District, the pneumonia burden is greatest among young children and middle-aged adults, the latter peak reflecting the area’s HIV epidemic. Access to care likely...
Introduction

National surveillance for notifiable infectious diseases has been a cornerstone of the public health system in many developed countries,1 but such surveillance systems have been harder to establish and maintain in developing countries. Establishment of effective surveillance is precluded in many countries by scarcity of resources and inadequate infrastructure, as well as by an imperative to focus on other basic services, such as immunization. Yet it is precisely in developing countries, where infectious diseases still account for the majority of morbidity and mortality,2 that such surveillance systems can be most valuable today in recognizing outbreaks, tracking emerging diseases, and setting public health priorities for important infectious diseases.

Pneumonia is a serious public health problem in Kenya,3,4 and its prevention and control could benefit from a functional national surveillance system. Acute pneumonia is responsible for 19—23% of deaths among children under 5 years old in developing countries.5,6 As HIV predisposes to pneumonia, the HIV epidemic in countries like Kenya is likely to cause an excess of acute pneumonia.7 The epidemiology of pneumonia in Kenya has not been thoroughly characterized yet, so incidence, mortality, and risk factors are not well defined. National surveillance data on pneumonia can be useful in the implementation of strategies that can prevent pneumonia, such as new vaccines,8,9 zinc replacement,10 and hand-washing programs.11

In order to better define the epidemiology of hospitalized pneumonia in western Kenya and to show the utility of including such data in a national surveillance system, we reviewed pneumonia inpatient records from all admitting medical facilities in Bondo District, Kenya from January 1, 2001 to December 31, 2003.

Methods

Site

Bondo District is a rural district in Nyanza Province in western Kenya bordering Lake Victoria. The projected 2003 population of the district was 255 901, with 20.4% under 5 years of age. The majority of residents is ethnically Luo and earns a living through agriculture or fishing. It is a poor district, where average household wealth is estimated at $600—700, the infant mortality rate is 120 per 1000, and life expectancy at birth is approximately 40 years.12—14 Rates of HIV disease in Nyanza Province are the highest in Kenya, reported as 15.1% in the 2003 demographic and health survey.3

Data collection

We reviewed records on hospitalized acute pneumonia at all eight medical facilities that admitted patients in Bondo District between 2001 and 2003. Admission registers were reviewed for all patients with diagnoses consistent with acute pneumonia including the following terms: acute respiratory infection, pneumonia, aspiration pneumonia, bronchopneumonia, lobar pneumonia, chest infection, acute chest infection, respiratory tract infection, and lower respiratory tract infection. Diagnoses using the following terms were not considered to be acute pneumonia: cough, respiratory distress, upper respiratory tract infection, bronchitis, tuberculosis, and chronic respiratory illness. Admission diagnoses were made most often by clinical officers, clinicians with 3 years of post-secondary school training who serve as the sole clinicians in most medical facilities in Kenya. In some facilities, nurses made the admitting diagnoses. Clinical officers and nurses were trained according to Kenya Ministry of Health clinical guidelines.15 In the guidelines, pneumonia is defined according to Integrated Management of Childhood Illness (IMCI) criteria in children aged 2 months to 4 years of age.15,16 In adults, pneumonia is defined as a constellation of clinical criteria including the following: breathlessness, cough with or without sputum which may be rust-colored, fever, pleuritic chest pain, bronchial breathing, reduced chest movements, reduced breath sounds, tachypnea, and crackles.15 During the study period, Bondo District had 2—3 doctors, who were all based at the district hospital. The following variables were available from the admission registers: date of admission, age, sex, residence and co-diagnoses on admission. We attempted to find the medical record for each pneumonia admission in the admission register to determine outcome and length of stay.

If a patient’s specific age was not listed, but it was recorded that they were 'adult' or the wife of another person, this data was collected. Patients with no recorded sex were assigned the gender of their first names. Because 'HIV' or 'AIDS' was rarely written in the record, the diagnoses of AIDS related complex (ARC) and immunosuppression were considered to indicate HIV disease. Outcomes were recorded as discharged, died, referred, or absconded. Patients with no explicit indication of death noted in the medical record were assumed to have been discharged alive. The death register at Bondo District Hospital was later reviewed for patient identification numbers matching those in the database. Patients considered alive from the medical record who were listed in the death register with dates consistent with the admission for pneumonia were reclassified as dead in a second analysis specific to Bondo District Hospital. Rainfall data were obtained from the Kenya Meteorology Department, which were collected at Kisumu Airport approximately 50 kilometers from Bondo town.
Analysis

Data were entered and analyzed in Epi Info (version 3.3.2, CDC, Atlanta, GA, USA). Further analyses of rates were performed in PEPI (version 4.0, Sagebrush Press), and distance analysis in SAS for windows (version 8.2, SAS Institute, Cary, NC, USA). Patients residing outside of Bondo District were excluded from analyses (5.5% of patients). To calculate incidence rates, we used annual population projections for 2001–2003 by age, sex, and location, from the Kenyan Central Bureau of Statistics, which used the 1999 census results and assumed constant rates of birth, death, and migration. Confidence intervals around incidence rates were calculated using the exact binomial method. Fisher’s exact two-tailed method was used to calculate the significance of differences between incidence rates. To calculate incidence rates by age, the patients in our database with missing age were redistributed between age groups in proportion to the distribution of patients with known age, and those listed as ‘adult’ or ‘spouse’ were distributed only among patients 10 years and older. To calculate incidence rates by location, patients with missing residence were redistributed in proportion to the distribution of patients with known residence; this was done separately for each hospital.

Distances to the facilities were calculated by taking the straight-line distance from the centroid point of each sub-location in the district to the facility as defined by GIS using ArcView software (version 3.2). The association between rates by sub-location and distance was evaluated using Poisson regression with rates as the dependent variable, using the events/trials syntax, and distance to facility in kilometers as the independent variable (PROC GENMOD). Overdispersion was corrected using the “pscale” command.

Overall case-fatality ratios (CFR) were calculated and deceased patients with missing exact ages were redistributed as above for age-specific CFRs. We adjusted the overall CFR using the proportion of patients at Bondo District Hospital who were registered as discharged alive in their medical records, but registered as deceased in the hospital death register. The death rate from hospitalized pneumonia was calculated as an incidence rate of death, and a Chi-square test was employed to determine differences between age groups and sexes.

Results

During the 3-year study period, 2466 Bondo District residents were hospitalized with pneumonia. The number of pneumonia patients was relatively stable between years, with 827 in 2001, 782 in 2002, and 857 in 2003. Overall, 43.7% of pneumonia admissions were in children under 5 years of age, and 58.3% were females. Of all admissions, 1604 (65%) were admitted to Bondo District Hospital.

Pneumonia admissions accounted for 12.8% (95% confidence intervals (CI) 12.3—13.3%) of all admissions in the district, ranging by facility from 7.8% to 19.3%. The percentage of admitted children under 5 years old who had pneumonia was 21.6% (95% CI 21.1—22.2%) compared with 9.8% (95% CI 9.4—10.2%) of patients 5 years and older (13.5% of non-maternity admissions). The median length of hospital stay among the cases with this information available was 3 days (range 0—242 days), and the mode was 2 days.

Incidence rates

The overall annual incidence rate of hospitalized pneumonia in Bondo District was 324 per 100 000 persons (95% CI 311—337), but rates varied significantly by age. The annual incidence was 698 (95% CI 656—739) and 229 (95% CI 217—241) per 100 000 persons for those <5 years old and ≥5 years old.

![Figure 1](attachment:average_annual_incidence_and_case-fatality_ratio_of_hospitalized_pneumonia_in_bondo_district_by_age_group_2001-2003.png)
respectively (rate ratio (RR) = 3.04, 95% CI 2.81–3.30, Figure 1). This is equivalent to one out of every 143 children in the district being hospitalized for pneumonia each year, and one out of every 437 adults. The incidence of hospitalized pneumonia was highest in infants less than 1 year old at 1370 (95% CI 1259—1481) per 100 000 person-years. Incidence decreased substantially after the age of 5 years, increasing again in older adolescents aged 15—19 years to reach a second peak of 356 (95% CI 325—387) per 100 000 person-years for people 20—29 years old. Incidence for persons over 65 years was lower than for middle-aged adults at 121 per 100 000 person-years (95% CI 76—165).

There were also significant differences in pneumonia incidence between the sexes. In children less than 5 years of age, the incidence was lower among females (RR = 0.84, 95% CI 0.75—0.95, Table 1). Conversely, among adults aged 15—49 years old, incidence for persons over 65 years was lower than for middle-aged adults at 121 per 100 000 person-years (95% CI 76—165).

Pneumonia incidence by location of residence was found to be highest in Bondo Township with a rate of 763 (95% CI 707–820) per 100 000 person-years and lowest in Mageta Island in Lake Victoria with a rate of 89 (95% CI 38–139) per 100 000 person-years. The incidence rate of pneumonia decreased significantly with distance from Bondo District Hospital (Figure 2, p < 0.0001). For each one kilometer of increased distance, the incidence rate decreased by 5% (95% CI 4—7%). There was also a marginally significant decrease in incidence rate with increased distance to the nearest inpatient health facility (Figure 2, p < 0.05).

Pneumonia incidence varied by season. Monthly incidence among children under 5 years old ranged from 253 per 100 000 in December 2003 to 1175 per 100 000 in July 2003 (Figure 3). Monthly incidence among people 5 years and older ranged from 95 per 100 000 in May 2003 to 356 per 100 000 in July 2002. Incidence in both age groups had peaks each year in January—February and June—August, 2—3 months after each rainy season.

Patients with co-diagnoses of malaria, tuberculosis, and HIV represented 60.7%, 14.9%, and 1.5% of hospitalized pneumonia cases, respectively (Figure 4).
malaria was most common in children under the age of 5 years, among whom 73.3% had a malaria co-diagnosis. The percentage of pneumonia inpatients with malaria co-diagnoses was highest in the same months that the incidence rates of pneumonia peaked, which are also the months that malaria peaks in this area. Tuberculosis and HIV co-diagnoses were concentrated in the 20—49 year-old patients.

The overall case-fatality ratio (CFR) was 9.9% (95% CI 8.8—11.2%), which increased to 11.4% (95% CI 10.2—12.7%) when using the death register. (The remainder of this report uses CFRs derived only from medical records.) The CFR was highest at the extremes of life — 11.0% for those under five and 20.0% for adults 65 years and older — and lowest from 10 to 14 years of age (4.8%, Figure 1). CFRs did not vary with malaria co-diagnosis (9.8% for pneumonia alone versus 8.6% for pneumonia with malaria). Among persons 20—49 years of age, compared with pneumonia alone, the risk of fatality increased with a co-diagnosis of either tuberculosis (15.5%, RR = 1.59, 95% CI 1.14—2.21) or HIV (22.2%, RR = 2.28, 95% CI 1.19—4.37).

The total death rate from hospitalized pneumonia in Bondo District was 32 deaths per 100 000 person-years (95% CI 28.2—36.4). The death rates for children <5 years and patients ≥5 years were 65 and 24 per 100 000 person-years, respectively (RR = 2.76, 95% CI 2.11—3.60). There was no difference in death rates between sexes.

Discussion

This study reveals important epidemiologic findings about pneumonia in western Kenya. Hospitalized pneumonia was
common and often resulted in death. As shown in studies elsewhere, the rate of pneumonia was highest in young children, especially among infants who had an annual rate of 1370 cases per 100,000 children.4 Although lower than the rate of hospitalized pneumonia among infants found in The Gambia (5270 cases/100,000), the rate found among infants was comparable to a study from Mali (998 cases/100,000).18,19 Mortality among children under 5 years admitted with pneumonia (11%) was similar to rates found in several developing countries (12—15%),19—21 but high compared to hospitalized pediatric pneumonia mortality in several other developing countries, as well as in developed countries.4,12,23 Death registry data were only found in the district hospital. We therefore relied upon medical records to calculate overall case—fatality ratios, but this is likely to slightly underestimate true fatality rates, since at the district hospital the case—fatality ratio increased from 9.9% to 11.4% when we included death registry data. Though treatment regimens were not analyzed, the local standard of care for inpatient pneumonia is penicillin plus gentamicin, which should have been consistent for all pneumonia cases in the district.

The excess pneumonia found among boys has been previously described elsewhere;4,18,24 it is unclear if this is due to variability in susceptibility between boys and girls or to selection bias from preferential care-seeking. In either case, the data clearly show that children carry a considerable burden of pneumonia morbidity and mortality in Kenya, making them a group that would benefit significantly from existing preventive interventions. One such intervention is a conjugate vaccine against Streptococcus pneumoniae, the leading cause of pneumonia deaths among children.25,26 It has been shown to decrease overall mortality by 16% in Gambian children and is also effective in HIV-infected children.25,26

The second relevant age-specific finding of our study was the high incidence of hospitalized pneumonia among young adults. After reaching a low among children aged 5—14 years, the incidence rate rose again, peaking in 20—29 year-olds. This pattern of pneumonia is very different from that observed in most developed and developing countries without a high prevalence of HIV, where the incidence of pneumonia remains lower throughout most of young and middle adulthood before rising among the elderly.27—30 Moreover, we found that women had rates of pneumonia approximately twice those of men in this age group. The most likely explanation for the high rates in this age group and the variation between the sexes is the impact of the HIV epidemic in Nyanza Province, where in 2003 the rates of HIV (15.1%) were over double the national average (6.7%), and within Nyanza Province the rates were higher in women (18.3%) than men (11.6%).4 In both developed and developing countries, pneumonia is 25 times more common in HIV-infected persons than non-infected persons, and HIV infection occurs in 28—95% of African patients with pneumococcal bacteremia.7 Despite the apparent association between pneumonia admissions and HIV infection among middle-aged adults in this part of Kenya, the HIV status of most pneumonia patients remains unknown. Given the relationship between pneumonia and HIV and the epidemiology of pneumonia in Bondo District, it is reasonable to conclude that strategies aimed toward HIV diagnosis (such as diagnostic counseling and testing among inpatients) and toward HIV care (such as widespread introduction of highly active antiretroviral treatment) would have beneficial effects on hospitalized pneumonia incidence. Moreover, such data as produced in this study could contribute towards monitoring the impact on morbidity by implementation of such strategies.

Another interesting variant in the age distribution of pneumonia in Bondo District is the relatively low rate of pneumonia in the elderly. Studies in developed countries have found hospitalized pneumonia incidence rates to rise in the elderly with rates of over 1000 per 100,000 person-years, which is at least 10 times the incidence we found.27,30—33 The lower rates of pneumonia among the elderly might be because older Kenyans are not as comfortable with Western medicine and often prefer to go to traditional healers or remain at home. Additionally, travel to facilities in most of Bondo District is difficult due to a lack of paved roads and limited means of transport. Older people, especially if ill, could be less likely to travel these distances. It is also possible that the rate of pneumonia in the elderly was falsely low due to our methodological assumption that patients without documented ages had the same age distribution as those of known age. If adult patients without a documented age were more likely to be elderly, we might have under-represented cases among those over 65 years of age, resulting in an erroneously low rate in this age group.

Our study had several important limitations. We relied on the admission registers to define cases of pneumonia. Admitting diagnoses were usually made only on clinical grounds by the clinical officers or nurses working in the hospitals’ outpatient clinics. Though the clinical officers were trained with a standard curriculum for pneumonia diagnosis, some might have varied the criteria used to diagnose pneumonia.15 For instance, although trained in the World Health Organization’s IMCI criteria, we could not verify that these criteria were consistently applied to diagnose pneumonia in children during the period reviewed.16 Only the district hospital had an X-ray machine, which was rarely used for acute pneumonia cases. As discharge diagnoses were rarely found in the medical records, it was difficult to assess how often the admitting diagnosis changed after review during the hospital course. Moreover, the clinical staff changed over time, leading to possible lack of diagnostic consistency even within each hospital. The difficulty in distinguishing malaria and pneumonia on clinical grounds alone is a well-known phenomenon,34,35 and such lack of specificity in diagnosis of pneumonia could explain part of the observed overlap of malaria and pneumonia seasonality in Bondo District. Another limitation was that in calculating incidence rates we only used hospital admissions in Bondo District. Though we excluded non-Bondo residents from our rate calculations (5.5% of admissions), we did not include pneumonia admissions for Bondo residents who were hospitalized outside of the district. This would have underestimated the true incidence rate of pneumonia. Reviews of admission logbooks from the district hospital in neighboring Siaya District and the Provincial Hospital in Kisumu, however, showed that patients admitted with pneumonia rarely had Bondo District residences.

Another issue of concern is that people in Bondo District might not access health facilities when they have pneumonia. The district is largely rural with few paved roads. The
decrease in incidence rate with distance to the district hospital suggests that poor access to care may indeed have lowered overall incidence rates of hospitalized pneumonia in the district. Distance to hospital has been shown before to influence rates of pneumonia among Gambian children. In conducting facility-based surveillance in African settings, the effects of distance and access to care need to be factored in when interpreting incidence rates.

Lastly, Bondo District might not be representative for all of Kenya in terms of pneumonia incidence and epidemiology. As discussed, the rates of HIV disease are higher in this part of Kenya than elsewhere in the country, which should affect the rate and distribution of pneumonia admissions. Malaria rates are also very high in Bondo, which likely decreased specificity of a pneumonia diagnosis compared to areas with lower prevalence of malaria.

These limitations — the lack of specificity of the pneumonia diagnosis, hospitalization outside the district, and poor access to care — along with the variability and difficulty in diagnosing pneumonia in most developing country settings, make comparison of the rates of pneumonia we found with rates from other studies an imprecise exercise. A review of childhood pneumonia found that incidence rates obtained from active surveillance at the home were up to 10 times higher than incidence of severe pneumonia likely to be hospitalized. For these reasons, our study likely underestimates the true figures for severe pneumonia in Bondo District. Nevertheless, the data from this study are internally consistent and therefore are useful in defining epidemiologic patterns and in monitoring trends in pneumonia within Bondo District. These data can be used by the Kenyan Ministry of Health in setting public health priorities, such as the introduction of new vaccines for childhood pneumonia, and increased access to antiretroviral therapy for HIV-infected persons. Moreover, ongoing surveillance can monitor the impact of these interventions over time, and a functioning national surveillance system for pneumonia could help detect and define emerging infectious disease epidemics in Kenya as they arise.

Conflict of interest: No conflict of interest to declare.

References

The epidemiology of hospitalized pneumonia in rural Kenya


