Epidemiology, Seasonality, and Burden of Influenza and Influenza-Like Illness in Urban and Rural Kenya, 2007–2010

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Background. The epidemiology and burden of influenza remain poorly defined in sub-Saharan Africa. Since 2005, the Kenya Medical Research Institute and Centers for Disease Control and Prevention–Kenya have conducted population-based infectious disease surveillance in Kibera, an urban informal settlement in Nairobi, and in Lwak, a rural community in western Kenya.

Methods. Nasopharyngeal and oropharyngeal swab specimens were obtained from patients who attended the study clinic and had acute lower respiratory tract (LRT) illness. Specimens were tested for influenza virus by real-time reverse-transcription polymerase chain reaction. We adjusted the incidence of influenza-associated acute LRT illness to account for patients with acute LRT illness who attended the clinic but were not sampled.

Results. From March 2007 through February 2010, 4140 cases of acute LRT illness were evaluated in Kibera, and specimens were collected from 1197 (27%); 319 (27%) were positive for influenza virus. In Lwak, there were 6733 cases of acute LRT illness, and specimens were collected from 1641 (24%); 359 (22%) were positive for influenza virus. The crude and adjusted rates of medically attended influenza-associated acute LRT illness were 6.9 and 13.6 cases per 1000 person-years, respectively, in Kibera, and 5.6 and 23.0 cases per 1000 person-years, respectively, in Lwak. In both sites, rates of influenza-associated acute LRT illness were highest among children <2 years old and lowest among adults ≥50 years old.

Conclusion. In Kenya, the incidence of influenza-associated acute LRT illness was high in both rural and urban settings, particularly among the most vulnerable age groups.

Influenza virus is a major cause of acute respiratory illness worldwide [1]. The epidemiology of influenza has long been well characterized in many countries in temperate settings [1], and recently, population-based studies have shown that influenza is associated with substantial burden in developing countries in Asia and Central America [2–5]. However, little is known about influenza in tropical sub-Saharan Africa [6, 7]. Ongoing, longitudinal, population-based surveillance for infectious disease syndromes in a rural area and an urban informal settlement in Kenya provided an opportunity to characterize the epidemiology of influenza-associated medically attended acute lower respiratory tract (LRT) illness and household-reported and medically attended influenza-like illness (ILI) in 2 ecologically different African settings.
METHODS

Surveillance Sites
The International Emerging Infections Program of the Kenya Medical Research Institute/Centers for Disease Control–Kenya (KEMRI/CDC) Research and Public Health Collaboration has conducted population-based infectious disease surveillance since 2007 in 2 sites in Kenya: Lwak, a rural location in western Kenya along Lake Victoria; and Gatwikira and Soweto villages within Kibera, an informal settlement (slum) in Nairobi.

The population within the 33-village (100-km²) Lwak surveillance area, holoendemic for malaria and with a human immunodeficiency virus (HIV) seroprevalence of 17.6% among adults in 2008 [8], is approximately 23 000 (population density, 325 persons/km²) [9]. The daily mean temperature in Nyanza, the province where Lwak is located, ranges from a high of 30.8°C in February to a low of 27.7°C in July. The rainfall level is approximately 1400 mm/year, peaking in April–May and November–December [10].

The second site includes approximately 28 000 people within 2 villages in Kibera (total area, 0.4 km²; population density, 77 000 persons/km²), a large informal settlement in Nairobi with a maze-like array of semipermanent housing with dirt paths and open sewers between the dwellings. Malaria is not endemic because of the high altitude, although cases of malaria occur [9]. In 2008, the estimated HIV prevalence in Kibera was 14.9% in adults [8]. Mean daily maximum temperature in Nairobi ranges from a high of 25.6°C in February and March to a low of 20.6°C in July. The rainfall level is approximately 1000 mm/year, with peak levels in April–May and November–December [10].

Household Surveillance
Methods of population-based infectious disease surveillance involving households have been described previously [9, 11]. In Kibera, community interviewers made biweekly household visits from 1 March 2007 through August 2009. From September 2009 through January 2010, to more closely document illness during the initial circulation of 2009 pandemic influenza A virus subtype H1N1 (A[H1N1]pdm09), the frequency of visits was increased to weekly in 3 of 10 clusters in the surveillance area, and from 1 February 2010 onward, visits were conducted weekly throughout the Kibera surveillance area. In Lwak, visits were conducted biweekly from 1 March 2007 through 31 December 2009 and weekly from 1 January 2010 onward. For this analysis, the study period was from 1 March 2007 through 28 February 2010.

At each household visit, community interviewers asked each participant standardized questions about illnesses and outcomes. Residents were asked whether they had had an episode of cough, difficulty breathing, or pneumonia in the past 2 weeks and, if so, whether they had sought care at the study clinic. Persons >5 years old were personally interviewed. If persons >5 years were not at home or were unable to answer questions, a proxy member of household who was knowledgeable about the health of the participant was interviewed. For children <5 years old, the mother or other primary caretaker was interviewed. Community interviewers encouraged persons who were ill to go to the study clinic [9].

Clinic Surveillance
Centrally located study clinics—St. Elizabeth Lwak Mission Hospital, operated by the Franciscan Sisters of St. Anna, and Tabitha Clinic, operated by Carolina for Kibera—were identified and enhanced for each surveillance area. Lwak Hospital has 40 inpatient beds and manages most hospitalizations. Tabitha Clinic refers patients for hospitalization to a district hospital 3 km away.

All participants lived within 5 km from the study clinic in Lwak and within 1 km from the study clinic in Kibera, by road or pathway. KEMRI/CDC-trained staff provided free medical care to study participants at each study clinic for acute, potentially infection-related conditions. Structured questionnaires were completed for all visits for medical care at both study clinics.

Case Definitions
Patients who presented to either study clinic with signs and symptoms that met a case definition for acute LRT illness were eligible to have a nasopharyngeal and an oropharyngeal swab specimen collected. Acute LRT illness was defined in children <5 years old on the basis of a modified combination of the World Health Organization Integrated Management for Childhood Illness case definitions for pneumonia and severe pneumonia [12]: cough or difficulty breathing, as well as either an oxygen saturation level of ≤90% or at least 1 of the following danger symptoms or signs: (1) maternal report of convulsions; (2) inability to drink or breast-feed, or vomiting everything; and (3) lethargy, unconsciousness, lower- chest-wall indrawing, or stridor. For persons aged >5 years, acute LRT illness was defined as cough, difficulty breathing, or chest pain, as well as either a documented axillary temperature of ≥38.0°C or an oxygen saturation level of ≤90%. Hospitalization was not required. Not all patients with acute LRT illness were sampled; sometimes the clinician did not send the patient to be sampled, either because the clinic load was high and there were no available staff to collect specimens or because the clinician did not recognize the patient as an acute LRT illness case. Additionally, some patients with acute LRT illness refused to be sampled.

For clinic visits, we defined ILI as a documented temperature of ≥38°C plus reported cough or sore throat. For home visits, we defined ILI as reported feverishness or a documented
temperature of ≥38°C plus cough or sore throat. Specimens from medically attended patients with ILI were not collected during most of the study period, and therefore laboratory results from patients with ILI were not included in this analysis.

**Specimen Collection and Processing**

Trained laboratory technicians collected nasopharyngeal and oropharyngeal specimens only at the study clinics and according to procedures previously described. Specimens were maintained at 4°C for 0–24 hours, until they were frozen at ~80°C at CDC/KEMRI laboratories in Kisumu or Nairobi.

All nasopharyngeal and oropharyngeal specimens were tested in the KEMRI/CDC laboratory in Nairobi. An aliquot of each respiratory specimen was tested by real-time reverse-transcription polymerase chain reaction (RT-PCR) for influenza A and influenza B viruses after 1 freeze-thaw cycle. Specimens positive for influenza A virus were subtyped for seasonal H1, H3, H5, and 2009 pandemic H1 by real-time RT-PCR [13, 14]. Samples were aliquoted, and total RNA was extracted from 100-µL aliquots of each sample, using the QIAamp viral RNA minikit (Qiagen, Valencia, CA), according to the manufacturer’s instructions. One-step real-time RT-PCR was performed using AgPath kits (Applied Biosystems, Foster City, CA). Primers, probes, and positive controls for all influenza viruses were provided by the CDC (Atlanta, GA) [13, 14]. Fluorescence was read at the combined annealing-extension step at 55°C and was recorded as threshold cycle (Ct) values. A Ct value of ≤39.9 was regarded as positive for influenza virus; Ct values of ≥40.0 were regarded as negative for influenza virus.

**Data Analysis**

Incidence rates were calculated by dividing the number of disease episodes by person-time, using person-years as the denominator, and were adjusted monthly, incorporating information from persons who migrated into and out of the surveillance area and from those who died; 95% confidence intervals (CIs) were calculated around point estimates of incidence rates, using the exact Poisson confidence limits method. We defined an influenza-associated death as any death that occurred within 2 weeks of a medically attended episode of acute LRT illness involving laboratory-confirmed influenza virus. Statistical analysis was performed using SAS system for Windows (SAS Institute, Cary, NC).

We adjusted the incidence of laboratory-confirmed influenza to take into account patients who presented to the study clinic but were not sampled; for each age group, the total number of medically attended cases of acute LRT illness detected at the surveillance clinic was divided by the number of people who had medically attended acute LRT illness at the surveillance clinic and were sampled. This number was multiplied by the number of laboratory-confirmed influenza cases.

For household visits, in previous studies we have shown that there can be a significant decay in recall of symptoms over time before the date of home interview [9]. Therefore, to calculate rates from the household visits for both weekly and biweekly visits, we only used symptoms reported on the day of visit and the 3 previous days (days 0–3) for children and the day of visit and the 4 previous days for persons ≥5 years (days 0–4), and we adjusted the person-days calculations to only include these days in the denominator. [11]. We added temperature to graphs of monthly incidence of influenza-associated acute LRT illness and medically attended ILI because, although temperature is only one of many factors that have been shown to be associated with influenza activity, monthly temperature data were available for both sites in Kenya.

**Ethical Concerns**

Informed consent was obtained for data collection at the clinics and households. The protocol and consent forms were reviewed and approved by the KEMRI Ethical Review Board (protocol number 932) and the CDC Institutional Review Board (Atlanta, GA; protocol number 4566).

**RESULTS**

**Laboratory-Confirmed Influenza**

*Kibera*

During the study period, there were 4140 cases of acute LRT illness in Kibera, Nasopharyngeal/oropharyngeal specimens were collected from 1197 (28.9%) cases. Of the 1197 sampled cases of acute LRT illness, influenza viruses were detected in 319 (26.7%). There was no difference in mean age (9.8 vs 9.4 years; \( P = .27 \)) and the percentage of males (49.0 vs 49.3; \( P = 1.0 \)) between the sampled and the nonsampled patients. Sampled patients had a higher mean temperature than non-sampled patients (38.2°C vs 37.6°C; \( P < .01 \)), but sampled patients were less likely than nonsampled patients to be referred for hospitalization (0.3% vs 0.97%; \( P < .01 \)). On the basis of home-interview information, 53.3% of study residents attended any clinic for respiratory illness, and of these, 78.6% went to Tabitha Clinic for their care.

Of the influenza virus–positive specimens, influenza A virus was identified in 262 of 319 (82.1%), influenza B virus was identified in 52 (16.3%), and influenza A and B viruses were identified in 5 (1.6%). Of the influenza A virus–positive samples, 32 (12.2%) were subtype H3N2, 65 (24.3%) were seasonal subtype H1N1, 125 (47.5%; all identified after August 2009) were A(H1N1)pdm09, and 45 (17.1%) were unsubtypable. One (0.3%) influenza virus–positive patient with acute LRT illness was referred for hospitalization, and one patient, a 13-year-old girl who had seasonal influenza A virus H1N1 infection in June 2009, died. Information was not available on whether the patient was referred for hospitalization.
The crude rate of medically attended influenza-associated acute LRT illness was 4.0 cases per 1000 person-years (95% CI, 3.5–4.4) (Table 1). After analysis was adjusted for the patients who had acute LRT illness but did not have specimens taken, the incidence of medically attended influenza-associated acute LRT illness was 13.7 cases per 1000 person-years. The adjusted incidence ranged from a high of 32.8 cases per 1000 person-years among individuals <1 year old to a low of 4.0 cases per 1000 person-years among persons aged ≥50 years. Influenza viruses were detected year-round in Kibera (Figure 1A). In 2008 and 2009, the monthly adjusted incidence of influenza-associated acute LRT illness was highest, at >20 cases/1000 person-years, in July and August (Supplementary Figure 1).

**Table 1. Medically Attended Influenza-Associated Acute Lower Respiratory Tract (LRT) Illness, by Age—Kibera and Lwak, March 2007–February 2010**

<table>
<thead>
<tr>
<th>Age</th>
<th>Kibera Crude</th>
<th>95% CIs</th>
<th>Adjusted*</th>
<th>95% CIs</th>
<th>Lwak Crude</th>
<th>95% CIs</th>
<th>Adjusted*</th>
<th>95% CIs</th>
<th>Combined Crude</th>
<th>95% CIs</th>
<th>Adjusted*</th>
<th>95% CIs</th>
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<tr>
<td>&lt;1 y</td>
<td>8.9</td>
<td>5.8–13.7</td>
<td>32.8</td>
<td>21.4–50.2</td>
<td>6.2</td>
<td>3.4–11.6</td>
<td>42.1</td>
<td>22.7–78.3</td>
<td>7.8</td>
<td>5.3–11.1</td>
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<td>5.7–11.7</td>
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<td>4.0–11.5</td>
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<td>5.6–10.3</td>
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<td>7.5–9.2</td>
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<td>18 to ≤34 y</td>
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<td>4.7</td>
<td>3.7–6.0</td>
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</tr>
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<td>35–49 y</td>
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<td>0.7–2.2</td>
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<td>1.4–3.8</td>
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<td>3.6–9.5</td>
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<td>4.8</td>
<td>3.8–5.9</td>
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<tr>
<td>≥50 y</td>
<td>1.0</td>
<td>0.3–3.2</td>
<td>4.0</td>
<td>1.3–12.5</td>
<td>1.1</td>
<td>0.6–2.0</td>
<td>2.7</td>
<td>1.5–4.8</td>
<td>1.1</td>
<td>0.6–1.8</td>
<td>3.0</td>
<td>2.1–4.1</td>
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<tr>
<td>Total</td>
<td>4.0</td>
<td>3.5–4.4</td>
<td>13.7</td>
<td>12.2–15.2</td>
<td>5.6</td>
<td>5.1–6.2</td>
<td>23.0</td>
<td>20.8–25.5</td>
<td>4.8</td>
<td>4.5–5.2</td>
<td>16.3</td>
<td>15.7–17.0</td>
</tr>
</tbody>
</table>

Data are cases per 1000 person-years.

* Adjusted rates were used to account for individuals with acute LRT illness who presented to the health facility but were not sampled. For this adjustment, for each age group, the total number of medically attended cases of acute LRT illness detected at the surveillance clinics was divided by the number of people who had medically attended acute LRT illness at the surveillance clinic and were sampled. This number was multiplied by the number of laboratory-confirmed influenza cases to get the adjusted rate.

**Figure 1.** Monthly incidence of medically attended influenza-like illness (ILI) and adjusted incidence of influenza-associated acute lower respiratory tract (LRT) illness, as well as average monthly outdoor ambient temperature—Kibera and Lwak, March 2007–February 2010.
Influenza A virus was the predominant influenza virus type in all 3 years. Subtypes varied, with seasonal influenza A virus subtype H3N2 and seasonal influenza A virus subtype H1N1 predominating from 2007 through early 2009 and A(H1N1)pdm09 predominating in late 2009. Influenza B viruses were detected briefly in 2008 and 2009, mostly at times when influenza A viruses were not circulating (Supplementary Figure 1).

**Lwak**

During the study period, there were 6733 visits for acute LRT illness at the study clinic in Lwak, of which 1641 (24.4%) were sampled. In total, 359 (21.9%) of the sampled cases of acute LRT illness at Lwak clinic were positive for influenza. There was a statistically significant difference in the mean age of sampled and nonsampled patients (13.2 years vs 7.3 years; \( P < .01 \)). There also was a difference in the mean temperature at the time of the visit between sampled and nonsampled patients (38.7°C vs 38.2°C; \( P < .01 \)), the percentage of males (50.3 vs 48.9%; \( P < .01 \)), and the rate of hospitalization (32.8% of sampled cases of acute LRT illness vs 24.6% of nonsampled cases; \( P < .01 \)). During the study period, 37.3% of study residents attended any clinic for respiratory illness. Of these, 58.3% went to Lwak Clinic for their care.

Of influenza virus–positive specimens from Lwak, influenza A virus was identified in 284 of 359 (79.1%), influenza B virus was identified in 72 (20.1%), and both influenza A and B viruses were identified in 3 (0.8%). Of the 263 influenza A virus–positive specimens subtyped, 33 (12.5%) were influenza A virus subtype H3N2, 37 (14.1%) were influenza A virus subtype H1N1, 145 (55.1%; all identified after September 2009) were A(H1N1)pdm09, and 48 (18.3%) were unsubtypable. Of the influenza-positive patients with acute LRT illness, 36 (10%) were admitted to the hospital. The average length of hospital stay was 3 days. Most hospitalized patients (30 of 36 [83%]) had influenza A virus, of which 8 were A(H1N1)pdm09. Among influenza-positive children <5 years old with acute LRT illness, 15 of 46 (22%) were hospitalized, compared with 21 of 313 (7%) influenza-positive patients aged ≥5 years old with acute LRT illness. None of the patients with influenza-associated acute LRT illness died. No patients at either site were treated with oseltamivir.

The crude rate of medically attended influenza-associated acute LRT illness was 5.6 cases per 1000 person-years (95% CI, 5.1–6.2). After adjusting for patients who met the case definition but did not have specimens taken, the incidence of medically attended influenza-associated acute LRT illness was estimated as 23.0 cases per 1000 person-years. The adjusted incidence was highest among individuals <1 year old and lowest among persons ≥50 years old (Table 1).

During the 2-year period, influenza viruses circulated year-round in Lwak. The proportion of influenza-positive specimens was highest in July and August of 2008 (Figure 1B). Influenza A viruses predominated during the 3-year surveillance period. Seasonal influenza A virus H3N2 and seasonal influenza A virus H1N1 cocirculated in all 3 years. A(H1N1)pdm09 accounted for 2 peaks in influenza activity, the first in late 2009 and the second in early 2010. Influenza B viruses were detected briefly multiple times during the surveillance period, always at times when influenza A viruses were circulating (Supplementary Figure 1).

**Combined**

Combined acute LRT illness–associated incidence for the 2 sites generally mirrored the incidence for the individual sites; adjusted incidence was highest among children <2 years old and declined with increasing age (Table 1). For all specimens from both sites, the median number of days between symptom onset and collection was 2 days. This number (2 days) was the same for influenza-positive and influenza-negative specimens.

**Household-Reported and Medically Attended ILI**

**Kibera**

During the study period, 35 652 episodes of ILI were reported during household visits in Kibera. The crude incidence of household-reported ILI was 1675.5 cases per 1000 person-years. The highest incidence occurred in children <1 year old (Table 1). The incidence of household-reported ILI was highest in children <5 years old and lowest in adults 18–34 years old.

The crude incidence of medically attended ILI for all ages was 64.3 cases per 1000 person-years. The highest incidence of medically attended ILI occurred among individuals aged <1 year. In contrast to home-reported ILI, medically attended ILI was lowest among adults ≥50 years old. The monthly incidence of medically attended ILI varied throughout the study period but was relatively lowest in December and January (warm and dry months) in most years (Figure 1).

**Lwak**

During the study period, there were 25 799 reported episodes of ILI during household visits in Lwak, and the incidence of ILI was 4156.0 cases per 1000 person-years (95% CI, 4131.3–4180.9). The incidence of ILI was nearly 5 times greater in children aged <1 year and declined with increasing age (Figure 1). The highest incidence of medically attended ILI in Lwak also predominated in late 2009. In early 2010, influenza B viruses were detected briefly during the surveillance period, always at times when influenza A viruses were circulating (Supplementary Figure 1).
Table 2. Incidence of Home-Reported and Medically Attended Influenza-Like Illness (ILI), by Age—Kibera and Lwak, March 2007–February 2010

<table>
<thead>
<tr>
<th>Age</th>
<th>Kibera Home-Reported ILI</th>
<th>Kibera Medically Attended ILI</th>
<th>Lwak Home-Reported ILI</th>
<th>Lwak Medically Attended ILI</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 y</td>
<td>Crude 95% CIs</td>
<td>Crude 95% CIs</td>
<td>Crude 95% CIs</td>
<td>Crude 95% CIs</td>
</tr>
<tr>
<td>≤17</td>
<td>9334.9 9070.1 9607.3</td>
<td>295.7 274.5 307.6</td>
<td>13606.8 13298.0 13926.4</td>
<td>351.4 326.1 361.9</td>
</tr>
<tr>
<td>1 to &lt;2 y</td>
<td>6613.0 6422.7 6808.9</td>
<td>248.5 232.8 263.7</td>
<td>10852.3 10604.7 11105.7</td>
<td>297.7 275.1 308.1</td>
</tr>
<tr>
<td>2 to ≤4 y</td>
<td>4272.1 4182.5 4363.6</td>
<td>184.9 176.2 203.6</td>
<td>9064.0 8930.8 9199.1</td>
<td>238.2 226.1 256.7</td>
</tr>
<tr>
<td>5 to 17</td>
<td>1026.3 1002.8 1050.4</td>
<td>49.9 47.1 62.2</td>
<td>3508.1 3471.5 3545.1</td>
<td>79.9 76.0 94.6</td>
</tr>
<tr>
<td>18 to ≤34 y</td>
<td>865.3 844.4 886.7</td>
<td>18.5 17.0 26.9</td>
<td>1834.1 1802.0 1866.7</td>
<td>21.2 18.9 28.9</td>
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<tr>
<td>35 to ≤49 y</td>
<td>1086.2 1046.5 1127.4</td>
<td>14.5 12.2 20.5</td>
<td>3506.1 3434.9 3578.8</td>
<td>21.2 18.0 27.6</td>
</tr>
<tr>
<td>≥50 y</td>
<td>1119.3 1040.3 1204.3</td>
<td>6.6 4.2 9.0</td>
<td>5506.7 5430.1 5584.4</td>
<td>6.6 5.2 11.1</td>
</tr>
<tr>
<td>Total</td>
<td>1675.5 1657.9 1693.2</td>
<td>64.3 62.5 79.8</td>
<td>4156.0 4131.3 4180.9</td>
<td>72.7 70.6 88.9</td>
</tr>
</tbody>
</table>

Data are cases per 1000 person-years.

DISCUSSION

To our knowledge, this is the first population-based study to evaluate and compare home-reported ILI, medically attended ILI, and influenza-associated acute LRT illness in urban and rural settings in Africa. The findings suggest that influenza-associated acute LRT illness and ILI are associated with substantial health burden, especially among children, in both rural and urban communities. The burden of influenza-associated acute LRT illness and home-reported and medically attended ILI was highest among children <2 years old. This finding is consistent with results from other studies in Kenya and other countries, where young children have been shown to have the highest incidence of influenza [1–3, 15–17] and ILI [16, 18, 19].

The adjusted rates of influenza-associated acute LRT illness in Kibera and Lwak were slightly lower than annual rates reported in Thailand for hospitalized influenza pneumonia (21.7–83.3 cases per 100 000 persons) [3] but similar to reported rates in the United States for outpatient influenza-associated acute respiratory tract infection (10.2–19.4 cases per 1000 children <5 years old) [1]. However, healthcare utilization that we report for respiratory illness in Kibera and Lwak is lower than in these 2 countries; a healthcare utilization survey in Thailand found that 58% of persons with probable pneumonia reported seeking healthcare at hospital facilities [20]. Therefore, our reported rates for influenza-associated acute LRT illness in Kibera and Lwak are conservative and likely underestimate the true rates.

Given the limited clinic utilization, the incidence of acute LRT illness influenza may be as much as 3 times higher in Kibera and 5 times higher in Lwak than what we have reported.

Our surveillance system allowed us to compare the seasonality, epidemiology, and burden of acute influenza-associated LRT illness and ILI in an urban and rural setting in Kenya. Because these were 2 different settings in different parts of the country, we analyzed the 2 sites separately. We found that while influenza viruses circulated year-round in both sites, there was increased activity during colder months in the middle of the calendar year. However, the activity of A(H1N1)pdm09 differed in the 2 sites. In Kibera, there was one distinct peak of A(H1N1)pdm09 infection, during late 2009. In contrast, Lwak had a broader peak, with increased activity initially in late 2009 and later in early 2010. This difference may reflect the possibility that most residents in the dense urban site of Kibera were exposed to A(H1N1)pdm09 during its initial introduction, while in rural Lwak, possibly because of greater distances and reduced numbers and intensity of interactions among community residents, many people were not exposed to A(H1N1)pdm09 during its initial introduction into the area.

The incidence of acute influenza-associated LRT illness and home-reported ILI were higher in Lwak than in Kibera. The incidence of medically attended ILI was also higher in Lwak, but this difference was not statistically significant. These differences may be the result of a different profile of comorbidities in the 2 sites. Malaria is endemic in Lwak and much less common in Kibera because of Nairobi’s high altitude. About 16% of febrile patients in Kibera have malaria parasitemia (KEMRI/CDC, unpublished data, 2011), but >50% of ILI cases in western Kenya are associated with malaria-positive blood smears [21]; this finding could explain higher rates of ILI, since the case definition of ILI is not highly specific. It is possible that primary malaria infection could have made people more likely to seek care at Lwak Hospital, where coexisting influenza could be diagnosed. Of note, malaria rates usually peak in western Kenya following the long rains, during July–October, the same period when influenza rates were highest.

In both sites, the rates of acute influenza-associated LRT illness, medically attended ILI, and home-reported ILI were
Our study, because we did not have a control group, we could not be certain that identification of influenza in a patients with acute LRT illness always implied causality. At the same time, in some influenza-negative cases of acute LRT illness, influenza may have been part of the causal chain but undetectable at the time of testing. Finally, the PCR C<sub>c</sub> cutoff of 39.9 for positives may have resulted in some false-positives and, thus, a substantial number of unsubtypable specimens.

In conclusion, acute influenza-associated LRT illness and medically and nonmedically attended ILI caused a considerable burden of disease in an urban and rural community during a 3-year period in Kenya. While transmission patterns varied between the rural and urban site, incidence was fairly similar. Burden for all 3 outcomes was greatest among young children. If interventions such as influenza vaccine are to be considered, young children should be included among those targeted.

**Supplementary Data**

Supplementary materials are available at *The Journal of Infectious Diseases* online (http://jid.oxfordjournals.org/). Supplementary materials consist of data provided by the author that are published to benefit the reader. The posted materials are not copyrighted. The contents of all supplementary data are the sole responsibility of the authors. Questions or messages regarding errors should be addressed to the author.

**Notes**

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