Chapter 9. Malaria in School-Age Children

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Abbreviations
AQ amodiaquine
HIV human immunodeficiency virus
IPCs intermittent parasite clearance in schools
IPT intermittent preventive therapy
IRS indoor residual spraying
IST intermittent screening and treatment
ITN insecticide-treated bednet
RDT rapid diagnostic test
SMC seasonal malaria chemoprevention
SP sulfadoxine-pyrimethamine

Abstract
School-age children have attracted relatively little attention as a group in need of special protective measures against malaria. However, malaria can impair cognitive development and school performance. New approaches to the prevention of malaria in schoolchildren are being explored, including improved access to treatment, increased coverage with long-lasting insecticide-treated bednets, screening and treatment programs, and prophylactic use of antimalarial drugs. Such measures need to be incorporated into the broader programs being undertaken to enhance the health of school-age children in malaria endemic areas.

Introduction
The age distribution of malaria cases is influenced by the intensity of transmission. In areas where the population is exposed only occasionally to an infectious bite, malaria occurs in all age groups. In contrast, in high transmission areas the main burden of malaria, including nearly all malaria deaths, is borne by young children [figure 1]. These different age patterns
are seen because exposure to repeated malaria infections induces some protection against subsequent attacks. This immunity is seen first against death from malaria, then against clinical attacks of malaria, and finally against the infection itself. However, protection against infection is rarely complete.

Figure 1 Age Distribution of Cases of Severe Malaria by Intensity of Malaria

Figure 1.

Source: Roca-Felttrer and others 2010.

Because the age pattern of clinical malaria is determined by the level of transmission, and the consequent level of acquired immunity, it is sensitive to changes in the level of transmission (Okiro and others 2009; Carneiro and others 2010). In many malaria-endemic areas, successful control programs have recently reduced the level of malaria transmission substantially (Noor and others 2014; O’Meara and others 2010; WHO 2012). Consequently, in such communities, the peak age of clinical attacks of malaria is shifting from very young to older children. For example, in The Gambia the peak age of hospital admission for severe malaria increased from 3.9 years in 1999–2003 to 5.6 years in 2005–07 (Ceesay and others 2008); similar changes have been seen in Kenya (O’Meara and others 2008) and elsewhere. If the financial support for malaria control continues, further decreases in the intensity of malaria transmission can be anticipated in many highly endemic areas, which will lead to an increase in the incidence of clinical attacks of malaria, including severe attacks, in school-age
children. However, the epidemiology and management of malaria in school-age children has, until recently, received little attention. This chapter reviews knowledge on the current burden of malaria in school-age children, its clinical consequences, and approaches to controlling the disease in this increasingly vulnerable group.

**Prevalence of Malaria Parasitemia in School-Age Children**

The burden of malaria in school-age children is poorly defined because this age group is not included routinely in household-based cluster surveys. Information on the prevalence of malaria in this group is derived mainly from school-based surveys and from World Health Organization (WHO) estimates (WHO 2012). Research studies can provide a general view of the overall burden of disease in school-age children, but the shortcomings of data obtained in this way include the use of varying methodologies and the paucity of information from low transmission settings. Understanding the burden of malaria among school-age children is essential to justify investment in school-based malaria control interventions (Bundy and others 2000) and to finding delivery mechanisms to help control malaria in this underserved population.

More than 500 million school-age children worldwide are at risk of malaria infection, 200 million of whom live in Sub-Saharan Africa (table 1) (Gething and others 2011). Table 2 summarizes the results of studies on the prevalence of asymptomatic malaria parasitemia in this population. Map 1a shows the frequency with which malaria surveys have been undertaken in school-age children, with an increase in recent years in East Africa. Map 1b shows the prevalence rate observed in school-age children by geographical area, based on data provided by the Malaria Atlas Project (MAP) (http://www.map.ox.ac.uk). The next sections report the results, by region, of representative studies of prevalence.

**Map 1a  Frequency of Malaria Surveys in School-Age Children, 1985-2013**
Map 1b Prevalence Rate in School-Age Children by Geographical Area,

Source: Based on data provided by The MAP Project (http://Www.Map.Ox.Ac.Uk).
Table 9.1 Estimated School-Age (5 years to 14 years) Population at Risk of *Plasmodium falciparum* Malaria, 2010 in millions.

<table>
<thead>
<tr>
<th>Region</th>
<th>Unstable risk</th>
<th>Stable risk</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Americas</td>
<td>11.80</td>
<td>6.41</td>
<td>18.21</td>
</tr>
<tr>
<td>Africa plus the Republic of Yemen and Saudi Arabia</td>
<td>11.19</td>
<td>200.88</td>
<td>212.06</td>
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<tr>
<td>Central, South, and East Asia [[AQ: Is there any way to map these into World Bank regions, which would be Eastern Europe and Central Asia, South Asia, and East Asia and the Pacific?]]</td>
<td>205.43</td>
<td>132.28</td>
<td>337.71</td>
</tr>
<tr>
<td>World</td>
<td>228.41</td>
<td>339.57</td>
<td>567.99</td>
</tr>
</tbody>
</table>

*Source: Adapted from Gething and others 2011.*
Table 9.2 Recent Studies on the Prevalence of Malaria Parasitemia among Schoolchildren

<table>
<thead>
<tr>
<th>Country</th>
<th>Transmission setting</th>
<th>Age range (years)</th>
<th>Year of survey</th>
<th>Estimated prevalence (percent)</th>
<th>Source</th>
</tr>
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<tbody>
<tr>
<td>East Africa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uganda</td>
<td>High</td>
<td>8–14</td>
<td>2008</td>
<td>51</td>
<td>Nankabirwa and others 2010</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>5–9</td>
<td>2008</td>
<td>64</td>
<td>Pullan and others 2010</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>10–12</td>
<td>2009–10</td>
<td>46</td>
<td>Kabatereine and others 2011</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>6–14</td>
<td>2011</td>
<td>30</td>
<td>Nankabirwa and others 2013</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>6–15</td>
<td>2012</td>
<td>56.5</td>
<td>Uganda Malaria Surveillance Project (unpublished)</td>
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<tr>
<td></td>
<td>Moderate</td>
<td>6–15</td>
<td>2012</td>
<td>16</td>
<td>Uganda Malaria Surveillance Project (unpublished)</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>6–15</td>
<td>2012</td>
<td>14</td>
<td>Uganda Malaria Surveillance Project (unpublished)</td>
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<td>Kenya</td>
<td>High</td>
<td>8–14</td>
<td>2002</td>
<td>23</td>
<td>Clarke and others 2004</td>
</tr>
<tr>
<td></td>
<td>Epidemic prone</td>
<td>8–14</td>
<td>2002</td>
<td>47a</td>
<td>Clarke and others 2004</td>
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<tr>
<td></td>
<td>High</td>
<td>5–18</td>
<td>2005–06</td>
<td>41</td>
<td>Clarke and others 2008</td>
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<tr>
<td></td>
<td>High</td>
<td>5–18</td>
<td>2008–10</td>
<td>18</td>
<td>Gitonga and others 2012</td>
</tr>
<tr>
<td></td>
<td>Seasonal</td>
<td>5–18</td>
<td>2008–10</td>
<td>2</td>
<td>Gitonga and others 2012</td>
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<td></td>
<td>Moderate</td>
<td>5–18</td>
<td>2008–10</td>
<td>3</td>
<td>Gitonga and others 2012</td>
</tr>
<tr>
<td>Location</td>
<td>Severity</td>
<td>Range</td>
<td>Years</td>
<td>Mean</td>
<td>Authors</td>
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<tr>
<td>---------------</td>
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<tr>
<td>Tanzania</td>
<td>High</td>
<td>Mean 7.96</td>
<td>2005</td>
<td>35</td>
<td>Mboera and others 2011</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>0.5–14</td>
<td>2011</td>
<td>9–23</td>
<td>West and others 2013</td>
</tr>
<tr>
<td>West Africa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Senegal</td>
<td>Seasonal</td>
<td>≤ 9</td>
<td>2004–05</td>
<td>9</td>
<td>Dia and others 2008</td>
</tr>
<tr>
<td></td>
<td>Seasonal</td>
<td>6–14</td>
<td>2004–06</td>
<td>0.9</td>
<td>Ouldabdallahi and others 2011</td>
</tr>
<tr>
<td></td>
<td>Moderate-high seasonal</td>
<td>7–14</td>
<td>2011</td>
<td>54</td>
<td>Clarke and others 2012</td>
</tr>
<tr>
<td>The Gambia</td>
<td>Seasonal</td>
<td>6–12</td>
<td>2008–09</td>
<td>17</td>
<td>Oduro and others 2013</td>
</tr>
<tr>
<td></td>
<td>Seasonal</td>
<td>4–21</td>
<td>2011</td>
<td>14</td>
<td>Takem and others 2013</td>
</tr>
<tr>
<td>Côte d’Ivoire</td>
<td>High</td>
<td>5–9</td>
<td>1998–99</td>
<td>66</td>
<td>Assi and others 2013</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>6–10</td>
<td>2001–02</td>
<td>67</td>
<td>Raso and others 2005</td>
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<td>High</td>
<td>6–14</td>
<td>2006–07</td>
<td>58</td>
<td>Rohner and others 2010</td>
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<td>6–14</td>
<td>2007–08</td>
<td>42</td>
<td>Thuilliez and others 2010</td>
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<td>High, seasonal</td>
<td>7–14</td>
<td>2011</td>
<td>83</td>
<td>Clarke and others 2012</td>
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<td>Nigeria</td>
<td>High</td>
<td>8–16</td>
<td>2007–08</td>
<td>26</td>
<td>Ojurongbe and others 2011</td>
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<td>2002</td>
<td>30</td>
<td>Nkuo Akanji, Ajame, and Achidi2002</td>
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<td></td>
<td>High</td>
<td>4–16</td>
<td>2006</td>
<td>40</td>
<td>Wanji and others 2008</td>
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<td></td>
<td>High</td>
<td>4–12</td>
<td>2007</td>
<td>59</td>
<td>Achidi and others 2008</td>
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<tr>
<td></td>
<td>High</td>
<td>4–15</td>
<td>2009</td>
<td>34</td>
<td>Kimbi, Nformi, and Ndamukong</td>
</tr>
<tr>
<td>Region</td>
<td>Risk Level</td>
<td>Cases</td>
<td>Year</td>
<td>Cases Range</td>
<td>Source</td>
</tr>
<tr>
<td>-------------------------------</td>
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<td>---------------------------------------------</td>
</tr>
<tr>
<td>Congo, Rep.</td>
<td>High</td>
<td>1–9</td>
<td>2010</td>
<td>16</td>
<td>Ibara-Okabande and others 2012</td>
</tr>
<tr>
<td>Equatorial Guinea</td>
<td>High</td>
<td>5–9</td>
<td>2009–10</td>
<td>40</td>
<td>Rehman and others 2011</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>10–14</td>
<td>2009–10</td>
<td>42</td>
<td>Rehman and others 2011</td>
</tr>
<tr>
<td><strong>Other parts of Africa</strong></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ethiopia</td>
<td>Low</td>
<td>5–16</td>
<td>2009</td>
<td>0–15</td>
<td>Ashton and others 2011</td>
</tr>
<tr>
<td>Somalia</td>
<td>Low</td>
<td>5–14</td>
<td>2007</td>
<td>20.5</td>
<td>Noor and others 2008</td>
</tr>
<tr>
<td>Mozambique</td>
<td>High</td>
<td>5–7</td>
<td>2002–03</td>
<td>48.1</td>
<td>Mabunda and others 2008</td>
</tr>
<tr>
<td>Malawi</td>
<td>High</td>
<td>5–9</td>
<td>2009–10</td>
<td>53</td>
<td>Rehman and others 2011</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>10–14</td>
<td>2009–10</td>
<td>52</td>
<td>Rehman and others 2011</td>
</tr>
</tbody>
</table>

**Source:**

**Note:**

a. Recorded during an outbreak.
East Africa
Several studies of malaria in school-age children have been undertaken in Uganda; 11 to 70 percent were parasitemic at any time, with the parasite rate depending on the transmission setting and season (WHO 2012). A prevalence of greater than 50 percent was found in Tororo, a high transmission area (Nankabirwa and others 2013); a similarly high prevalence rate was found in children living in the lakeside and island communities of Lake Victoria (Brooker and others 2012; Kabatereine and others 2011). In Kenya, the prevalence varied widely (table 2), with a high prevalence found in Bondo district (Clarke and others 2004; Clarke and others 2008). A countrywide school survey conducted in 480 schools across different transmission settings found an overall prevalence of 4 percent in children ages 5 years to 18 years (Gitonga and others 2010; Gitonga and others 2012); a higher rate was found in the coastal areas (Halliday and others 2012).

West Africa
Surveys in Senegal found prevalence rates in school-age children that ranged from less than 10 percent in the Senegal River basin (Dia and others 2008; Ouldabdallahi and others 2011) to persistently high rates of up to 50 percent in Kedougou in the southwestern part of the country (Clark and others 2012). In The Gambia, community-based surveys found a prevalence in children aged 6 years to 12 years of 17 percent during the wet season and 5 percent during the dry season (Oduro and others 2013). A survey in the Upper River Region of The Gambia found similar rates using a sensitive polymerase chain reaction test (Takem and others 2013).

Much higher prevalence rates of about 50 percent have been found in surveys conducted in Côte d’Ivoire (Assi and others 2013; Righetti and others 2013). In Mali, Thuilliez and others (2010) found parasitemia in 42 percent of school-age children during a longitudinal survey conducted between November 2007 and June 2008. Clarke and others (2012) found parasitememias ranging from 465 to 98% in 38 schools surveyed in southern Mali in 2011.

Central Africa
Several surveys in the Southwest province of Cameroon found parasite rates of approximately 50 percent in school-age children, with a lower rate among those living high up Mount Cameroon (Achidi and others 2008; Kimbi, Nforni, and Ndamukong 2005; Kimbi and others 2013; Nkuo Akenji, Ajame, and Achidi 2002). A study by Ibara-Okabande and others (2012) in the Republic of Congo found a 16 percent prevalence of *P. falciparum* infections among children ages one year to nine years.

Areas Outside of Sub-Saharan Africa
Few reports on the prevalence of asymptomatic malaria in African school-age children outside of Sub-Saharan Africa have been published recently. In Ethiopia, school surveys found a prevalence ranging from 0 percent to 15 percent (Ashton and others 2011). In the Republic of Yemen, Bin Mohanna, Bin Ghouth, and Rajaa (2007) found a prevalence of 13 percent in children ages 6 years to 11 years living in the Hajr valley.
Impact of Malaria on the Health and Development of School-Age Children

Most school-age children with malaria parasitemia do not have any symptoms because they have acquired some immunity. However, asymptomatic infections can contribute to anemia and to impairment of cognitive development. School-age children may be infected with a malaria parasite that expresses antigens to which they have not been exposed and to which they have little or no immunity resulting in the development of symptoms, such as fever and, more rarely, severe disease such as cerebral malaria or life-threatening anemia and even death.

Mortality

The WHO estimates that there were approximately 584,000 (uncertainty interval 367,000 – 755,000) deaths from malaria in 2013 with 90% of these deaths occurring in sub-Saharan Africa (WHO 2014). A comprehensive review of malaria-related deaths between 1980 and 2010 by Murray and others (2012) reports many more deaths than the WHO, mainly due to a disparity in deaths in adults. Murray and others (2012) estimate that 6 percent to 9 percent of malaria deaths occur in those aged 5 years to 14 years, corresponding to an annual figure in the range of 70,000 to 110,000 deaths. A lower malaria mortality rate was found in school-age children, compared with younger children, in Bangladesh and Sub-Saharan Africa (Adjouk and others 2006). A similar pattern was found in India, with an estimated malaria-related death rate of 29 per 1,000 in children ages five years to 14 years, compared with 55 per 1,000 in children under age five years in 2005 (Dhingra and others 2010).

Incidence of Clinical Malaria in School-Age Children

An estimated 198 (uncertainty range 124-283) million cases of malaria occurred worldwide in 2013, with more than 80 percent occurring in Sub-Saharan Africa (WHO 2014). However, data on the incidence of clinical malaria in school-age children are scarce. Review of the limited information published indicates that annual incidence can vary from 0.03 to 2.7 cases per child per year, depending on the transmission setting (table 3).
Table 9.3 Recent Studies Reporting the Incidence of Malaria in School-Age Children

<table>
<thead>
<tr>
<th>Location</th>
<th>Transmission setting</th>
<th>Year</th>
<th>Method</th>
<th>Follow-up period</th>
<th>Sample size</th>
<th>Age range (years)</th>
<th>Observed incidence</th>
<th>Calculated annual incidence Episodes/child/year&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year-round transmission</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Uganda</td>
<td>High perennial</td>
<td>2011</td>
<td>Active case detection through daily roll call&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12 months</td>
<td>740</td>
<td>6–14</td>
<td>83 episodes/242.7 child-years at risk</td>
<td>0.34</td>
<td>Nankabirwa and others 2014</td>
</tr>
<tr>
<td>Kenya</td>
<td>High perennial</td>
<td>2002</td>
<td>Active case detection by visiting children 2 to 3 times per week</td>
<td>11 weeks</td>
<td>276</td>
<td>8–14</td>
<td>0.005/child-weeks at risk</td>
<td>0.26</td>
<td>Clarke and others 2004</td>
</tr>
<tr>
<td>Kenya</td>
<td>Epidemic prone</td>
<td>2002</td>
<td>Active case detection by visiting children 2 to 3 times per week</td>
<td>11 weeks</td>
<td>330</td>
<td>8–14</td>
<td>0.029/child-weeks at risk</td>
<td>0.49 during an epidemic outbreak</td>
<td>Clarke and others 2004</td>
</tr>
<tr>
<td>Ghana</td>
<td>Moderate</td>
<td>2002</td>
<td>Active case detection through weekly visits</td>
<td>9 months</td>
<td>352</td>
<td>6–10</td>
<td>0.22–0.25/child/year</td>
<td>0.22–0.25</td>
<td>Dodoo and others 2008</td>
</tr>
<tr>
<td><strong>Highly-seasonal transmission</strong></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Burkina Faso</td>
<td>High, seasonal</td>
<td>2003</td>
<td>Active case detection through daily visits</td>
<td>4 months</td>
<td>51</td>
<td>6–8</td>
<td>2.7/child-year at risk</td>
<td>2.7</td>
<td>Nebie and others 2008</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>65</td>
<td>8–11</td>
<td>0.59/child-year at risk</td>
<td>0.59</td>
<td>Nebie and others 2008</td>
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<tr>
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<td></td>
<td></td>
<td>65</td>
<td>11–15</td>
<td>0.37/child-year at risk</td>
<td>0.37</td>
<td>Nebie and others 2008</td>
</tr>
<tr>
<td>Location</td>
<td>Type</td>
<td>Period</td>
<td>Method</td>
<td>Duration</td>
<td>Coverage</td>
<td>Incidence</td>
<td>Incidence at-risk</td>
<td>Reference</td>
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</tr>
<tr>
<td>Mali</td>
<td>High, seasonal</td>
<td>2007–08</td>
<td>Active case detection through monthly visits&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8 months</td>
<td>98</td>
<td>1.46/child-year at risk</td>
<td>1.46</td>
<td>Barger and others 2009</td>
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<td>The Gambia</td>
<td>Seasonal</td>
<td>2008–09</td>
<td>Active case detection through weekly visits</td>
<td>22 weeks</td>
<td>439</td>
<td>0.004/child-weeks at risk</td>
<td>0.025</td>
<td>Ceesay and others 2010</td>
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<tr>
<td>Other</td>
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<td></td>
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<tr>
<td>Ethiopia</td>
<td>Low</td>
<td>2009–11</td>
<td>Active case detection through weekly visits and passive detection of cases between weekly visits</td>
<td>101 weeks</td>
<td>2,075</td>
<td>110/2,075 for 101 weeks</td>
<td>0.03</td>
<td>Loha and Lindtjørn 2012</td>
<td></td>
</tr>
</tbody>
</table>

a. Calculation of the annual incidence assumes uniform incidence throughout the year for areas of perennial transmission; in areas of highly seasonal transmission where transmission is limited to a few months each year, total annual incidence is assumed to equate to that measured during the period of observation.
b. When data were collected during an intervention trial, incidence data refer to observations in the control arm.
Clarke and others (2004) find an incidence of clinical attacks of malaria in children ages 8 years to 14 years of 0.47 per child per year during a 2002 outbreak in Nandi, Kenya, an area with low and unstable seasonal transmission, and an incidence of 0.23 attacks per child per year in Bondo, a high transmission setting. In Tororo, Uganda, 7 percent of children ages six years to 14 years experienced a clinical attack of malaria during 42 days of follow-up (Nankabirwa and others 2010). A repeat study in children in the same age group enrolled in the control arm of an intervention trial in Tororo in 2011 recorded an incidence of 0.34 clinical episodes of malaria per child per year. The incidence of clinical episodes of malaria in children enrolled in the control arm of a trial in Côte d’Ivoire was 39 percent during a six-month period of follow-up (Rohner and others 2010); in a trial in Mali, it was 56 percent during a nine-month period of follow-up (Barger and others 2009). A study that evaluated the impact of malaria prevention on the educational attainment of school children aged 6 years to 12 years in Sri Lanka recorded an incidence of clinical malaria of 44 percent and 49 percent per year in the chloroquine and placebo arms, respectively, during the seven months before the intervention (Fernando and others 2006). These figures suggest that in malaria-endemic areas, it is not unusual for school-age children to experience one clinical attack of malaria severe enough to warrant treatment once every one to two years.

**Malaria as a Cause of Anemia in School-Age Children**

Anemia is a common problem among school-age children in the tropics. Its etiology is usually multifactorial, and the relative importance of different causes varies from place to place. It is difficult to separate malaria as a causative agent from other factors, such as nutritional deficiencies (iron deficiency being especially important), helminth infections, and HIV, which are often found together in the same communities (Stephenson and others 1985). A study in Accra, Ghana, found that 14.1 percent of patients admitted to a children’s hospital had severe anemia; 259 of the anemic children died. However, malaria was considered to be the cause in only 21.6 percent of these deaths, while 52.1 percent were attributed to nutritional deficiencies (Comme and Deyem 1995). A cross-sectional study in Cameroon showed that the mean hemoglobin concentration in Cameroonian children with parasitemia was lower than in those without parasitemia, but the difference between groups was not statistically significant (Nkou Akenji, Ajame, and Achidi 2002). Many other cross-sectional surveys carried out in highly endemic areas have found a significant association between the prevalence of anemia and parasitemia, but these studies were conducted mainly in preschool-age children.

The strongest evidence for the role of malaria as a cause of anemia in school-age children comes from the results of intervention studies. Clarke and others (2008) show that intermittent preventive therapy (IPT) with sulfadoxine-pyrimethamine (SP) in combination with amodiaquine (AQ) significantly reduced the prevalence of anemia during 12 months of follow-up in a large trial conducted in Kenyan schoolchildren. Similarly, Nankabirwa and others (2010) demonstrate that IPT with SP + AQ or dihydroartemisinin-piperaquine improved the hemoglobin concentration of Ugandan school-age children over a follow-up period of 42 days, although not statistically significantly. In West Africa, a number of trials of intermittent preventive treatment have have demonstrated significant reductions in anemia among school-aged children (Barger and others 2009; Clarke and others 2013a; Tine and others 2011). One of these trials that tried to separate the effects of iron deficiency, helminth infections, and malaria on anemia was conducted in 591 children ages six years to 14 years by Rohner and others (2010) in Côte d’Ivoire. Children were randomized to receive iron-
fortified biscuits, IPT with SP, antihelminthic therapy, or a combination of all three. Only antihelminthic therapy reduced anemia. However, the malaria control strategy used in this trial failed to lower the incidence of malaria, so its results do not disprove a role for malaria as a cause of anemia in schoolchildren in this community.

Overall, it is difficult to differentiate the effect of malaria on anemia in school-age children from other confounding factors; the limited evidence available suggests that it does have a significant role. Although administration of supplementary iron can increase the incidence of clinical attacks of malaria in some circumstances, most studies have shown only a modest effect (Ojukwu and others 2009). The WHO and other health authorities (Raiten, Namasté, and Brabin 2011) recommend that iron supplementation is indicated in areas in which iron deficiency is a major problem, even if these areas are endemic for malaria, provided that malaria control measures, such as distribution of insecticide-treated bednets (ITNs), are put in place at the same time.

**Malaria as a Cause of School Absenteeism**

The impact of malaria on school absenteeism has been evaluated in a limited number of studies. One of the first shows that malaria was the most important health-related cause of school absenteeism (Erinoso and Bamgboye 1988). In a subsequent study, Mills (1993) reports that the average loss of school days per malaria infection per child ranged from 4 days to 14 days. A study conducted in Dakar, Senegal (a low transmission region), by Trape and others (1993) assesses the impact of malaria in 343 children over a one-year period. During the malaria transmission season, malaria accounted for 36 percent of school absenteeism due to medical reasons. In Kenya, malaria caused a loss of 11 percent and 4.3 percent of the school year for primary and secondary school students, respectively (Leighton and Foster 1993). Another study in Kenya, undertaken during the peak of the annual malaria transmission season, estimates that malaria-related absenteeism in primary school pupils varied between 17.6 percent and 54.4 percent (Some 1994). The estimated annual loss in Kenya due to malaria in 2000 was estimated to be 4 million to 10 million school days (Brooker and others 2000).

In rural Sri Lanka, the average loss of school days per child per episode of malaria was 3.8 (range 0–9) (Konradsen and others 1997). During the annual school year, 2.7 percent of school days lost were due to malaria whereas all other illnesses together caused a loss of only 3.2 percent. In a cross-sectional study undertaken in the Republic of Yemen, parasitemia was found significantly more frequently in those absent from school than in regular attendees (Bin Mohanna, Bin Ghouth, and Rajaa 2007). Although these children were asymptomatic, their previous ill health had kept them from school; had they not been tested for malaria these episodes would have gone undiagnosed and their school absenteeism attributed to another cause.

Because malaria is an important cause of school absenteeism, preventive efforts should significantly improve school attendance. Ogutu and others (1992) demonstrate that school health education programs directed at malaria reduced absenteeism by 25 percent among Kenyan schoolchildren. In a randomized, placebo-controlled, double-blind, clinical trial of malaria prevention with chloroquine prophylaxis conducted in Sri Lanka, Fernando and others (2006) report a 55 percent reduction in malaria incidence and a 62.5 percent reduction in school absenteeism during a nine-month period among children who received prophylaxis.

Despite the limited number of studies, the available evidence suggests that the cumulative effect of school absenteeism due to malaria for children in endemic areas is considerable,
preventing children from achieving their full academic potential and causing a loss to the state with regard to its investment in education.

The Impact of Malaria on Cognitive Function

Studies conducted in Africa and Asia provide strong evidence that malaria can impair the cognitive function of school-age children (Kihara, Carter, and Newton 2006; Fernando, Rodrigo, and Rajpakse 2010). Descriptive studies have evaluated the impact of severe malaria, uncomplicated malaria, and asymptomatic parasitemia on various aspects of cognition.

In Kenya, Carter, Mung’ala-Odera, and others (2005); Carter, Ross, and others (2005); and Carter and others (2006) assess retrospectively a cohort of children ages six years to nine years who had experienced an episode of cerebral malaria. Three groups of children were studied: those with a past diagnosis of cerebral malaria, those with malaria with seizures (without coma), and healthy community controls. Follow-up was undertaken 20 months to 112 months after the illness. Children with a past history of cerebral malaria fared significantly worse than control children \(p < 0.05\) in speech and language tasks and cognition. The malaria-with-seizure group also showed impairment in the speech and language domain and in behavior but not in cognition. Active epilepsy after malaria was associated with significant impairment \(p < 0.05\) in all domains. In another prospective study, Boivin and others (2007) assess long-term cognitive impairment in 44 Ugandan children who had experienced cerebral malaria, in 54 children who had experienced uncomplicated malaria, and in 89 healthy community controls. Cerebral malaria was significantly associated with impairment of one or more cognitive domains \(p = 0.006\). The deficits were most marked in the attention domain. Using multiple linear regression to adjust for confounding factors, a diagnosis of cerebral malaria carried a relative risk of 3.7 for cognitive impairment. Cognitive defects persisted for at least two years (John and others 2008). Similar findings were recorded in Ugandan children who had experienced cerebral malaria (Boivin and others 2007) and in Malawian children with retinopathy-positive cerebral malaria (Boivin and others 2011).

Cerebral malaria is not a prerequisite for cognitive impairment as a consequence of malaria infection; a number of studies have suggested that uncomplicated episodes of malaria can adversely affect cognition. Studies conducted in Sri Lanka show that school-age children scored significantly lower on tests of mathematics and language during an episode of clinical malaria than control children (Fernando and others 2003a). In another study conducted in Sri Lanka, Fernando and others (2003b) find a negative correlation between mathematical and language skills and a past history of repeated attacks of malaria during the preceding six years among children ages six years to 14 years, even after correcting for socioeconomic factors. A study of school-age children in Mali reaches similar conclusions (Thuilliez and others 2010). Some of the potential ways in which children with cognitive impairments following cerebral malaria can be helped are discussed by Bangirana and others (2006).

Asymptomatic parasitemia can also impair cognitive function. In the Republic of Yemen, Al Serouri and others (2000) show that children with parasitemia performed poorly on formal cognitive testing compared with those without parasitemia after adjusting for confounding factors. This was also the case in Mali, although the effect was not as marked as in children with clinical malaria (Thuilliez and others 2010). Nankabirwa and others (2013) find that children ages six years to 14 years resident in Tororo, Uganda, who had asymptomatic parasitemia had depressed test scores in abstract reasoning and sustained attention compared with a parasitemic children. A large cluster study undertaken across Zambia, based on
parasitological data collected during malaria indicator surveys, shows a strong association in young children (mean age 74 months) between exposure to malaria, as judged by the parasite rate in a cluster, and cognitive skills and socioemotional development (Fink and others 2013). However, an association between asymptomatic parasitemia and cognitive function has not been found in all studies (Halliday and others 2012).

The strongest evidence to support the view that malaria impairs cognitive function comes from intervention trials. In Sri Lanka, a randomized, placebo-controlled, double-blind trial of chloroquine prophylaxis in children ages six years to 12 years showed that educational attainment improved and that school absenteeism was reduced significantly \( (p < 0.0001) \) in children who took chloroquine prophylaxis (Fernando and others 2006). Gambian children aged three months to 59 months who participated in a trial in which they were randomized to receive malaria prophylaxis with dapsone-pyrimethamine or placebo during the malaria transmission season for three successive years (Greenwood and others 1988) were reassessed when their mean age was 17 years (Jukes and others 2006). Educational attainment was better in children who had received prophylactic treatment than in children in the placebo group, but the scores for the cognitive tests were not significantly different between groups. Prophylaxis substantially increased the school enrollment of girls. In a large, stratified, cluster-randomized, double-blind, placebo-controlled trial conducted in schools in Kenya, IPT with SP + AQ significantly improved sustained attention of schoolchildren ages 10 years to 12 years (Clarke and others 2008). Significant effects on sustained attention are also reported from a trial in schools in southern Mali (Clarke and others 2013).

Overall, these studies strongly suggest that both clinical malaria and asymptomatic parasitemia can adversely affect the cognitive skills of school-age children, but how this is brought about is still uncertain.

**Approaches to the Control of Malaria in School-Age Children**

A range of strategies is available for the control of malaria among school-age children, delivered either through schools or as part of community-wide control. The optimal approach to delivering interventions, including their frequency and timing, and their ultimate effectiveness will vary according to the local intensity of malaria transmission. Interventions against malaria are delivered best as part of an integrated package, for example, as part of a school health program that also delivers deworming (see chapter x) or school feeding (chapter y).

**Treatment of Clinical Attacks**

Ease of access of school-age children to effective treatment for clinical attacks of malaria is an essential component of any effective national malaria control program. However, in many parts of Sub-Saharan Africa, geographic and financial barriers still prevent children from obtaining rapid access to diagnosis and treatment.

Schools can play a vital role in ensuring that their pupils obtain rapid access to diagnosis and treatment of malaria by providing appropriate health education activities in school, but information about the treatment of malaria is rarely part of the curriculum. A content analysis of school textbooks in malaria endemic countries (Laos, Cambodia, Nepal, Bangladesh, Sri Lanka, Zambia, Niger, Benin, and Ghana) [Q: East Asia and Pacific, South Asia, or both?] found that most included information on modes of
transmission, mosquitoes, and signs and symptoms of malaria but little about ITNs or about the need for prompt and appropriate treatment (Nonaka and others 2012). These findings suggest that improving textbook content in accordance with the national malaria control strategy should be a priority.

Access to prompt treatment can be improved by providing antimalarials to schools and by training teachers to administer antimalarial treatments correctly. In the past, when first-line treatment was either chloroquine or SP given presumptively, training teachers to provide treatment was shown to be both feasible and to reduce school absenteeism and malaria deaths (Pasha and others 2003; Afenyadu and others 2005). However, WHO now recommends diagnosis before any antimalarial treatment is given (WHO 2012). This problem could be overcome by training teachers to use rapid diagnostic tests (RDTs), building on recent efforts to expand diagnosis and treatment of malaria outside the formal health sector.

Vector Control
The main methods of vector control of malaria are ITNs, indoor residual spraying (IRS), and reduction of mosquito breeding sites.

Insecticide-Treated Nets
Strong evidence indicates that regular use of ITNs substantially lowers the risks of clinical malaria and all-cause mortality in children under age five years and reduces the burden of malaria among pregnant women (Lengeler 2004; Lim and others 2011). For these reasons, large-scale ITN distribution programs initially focused on these two vulnerable groups. However, following appreciation of the indirect “herd” effect of a high level of ITN coverage in a community, the development of long-lasting insecticide nets, and an increase in the financial and political support for ITN programs, there has been a shift from prioritizing vulnerable populations to protecting everyone with an ITN, including school-age children. However, an analysis of household surveys undertaken between 2005 and 2009 in 18 African countries found that school-age children were the group least likely to sleep under an ITN the previous night, with between 38 percent and 42 percent of school-age children being unprotected (Noor and others 2009) (figure 9.2). Similar low ITN usage rates have been observed among school-age children in Cameroon (Tchinda and others 2012), Kenya (Atieli and others 2011), and Uganda (Pullan and others 2010).

Figure __.2 Prevalence of Malaria Parasitemia by Age (Solid Circles) and of Reported Use of a Bednet on The Previous Night in Uganda; Panel A Females, panel B Males.

Source: Pullan and others 2010.

Few studies have investigated the efficacy of ITNs in school-age children. An early trial undertaken among children in a rural boarding school in central Kenya showed that sleeping under an untreated mosquito net following a round of effective antimalarial treatment reduced the incidence of clinical malaria by 97 percent, but it did not reduce anemia (Nevill and others 1988). A reduction in the incidence of malaria was shown in a randomized trial among children ages four years to 15 years undertaken in an area of low and unstable transmission on the Thai-Burmese border (Luxemburger and others 1994). In a rural area of western Kenya, where malaria transmission is perennial and high, a community-based trial showed
that ITNs halved the prevalence of mild, all-cause anemia in adolescent schoolgirls ages 12 years to 13 years but ITNs were less effective in preventing anemia among schoolgirls ages six years to 10 years (Leenstra and others 2003). Additional evidence provided by cross-sectional survey data suggests that net use among school-age children is associated with a 71 percent and 43 percent lower risk of P. falciparum infection in, respectively, Somalia (Noor and others 2008) and Uganda (Pullan and others 2010). An analysis of countrywide data from school surveys in Kenya (Gitonga and others 2012) shows that ITN use was associated with a reduction in the odds of malaria infection and anemia in coastal areas, where malaria transmission is low to moderate, and among boys in western lakeshore Kenya, where transmission is high. In addition, ITN use reduced the risk of parasitemia in the western highland epidemic zones and the risk of anemia in coastal areas where transmission is low.

As children become more independent with increasing age, parents have less control over their bedtimes, where they sleep, and whether they use a net, resulting in low use of nets e in teenage children. Education targeted directly at older children, for example through malaria education in schools, is likely to be the most effective way of increasing regular use of ITNs.

**Indoor Residual Spraying**
IRS, the application of long-acting insecticides to the walls and roofs of houses and, in some cases, public buildings and domestic animal shelters, is an effective method of malaria control. IRS implemented as a community-wide campaign can achieve remarkable reductions in the incidence and prevalence of malaria infection in all age groups (Pluess and others 2010). Repeated IRS campaigns conducted between 1955 and 1959 in the Pare-Taveta area of Tanzania were associated with a reduction in malaria parasitemia from 73 percent to 7 percent in children ages five years to nine years and from 62 percent to 4 percent in children ages 10 years to 14 years (Draper 1960). Targeted IRS conducted over 12 months in the epidemic-prone Kenyan highlands halved the monthly prevalence of asymptomatic infection in school-age children and reduced the incidence of clinical disease (Zhou and others 2010).

**Reduction of Breeding Sites**
Breeding sites of malaria anopheline vector mosquitoes can be controlled in some epidemiological situations through application of larvicides, introduction of predator species, or habitat destruction and drainage (Tusting and others 2013). However, achieving a significant reduction in malaria transmission in many parts of Sub-Saharan Africa is difficult because of the multiplicity and changing nature of breeding sites of the main vector species such as Anopheles gambiae (Fillinger and Lindsay 2011). Thus, little health benefit is likely to accrue from encouraging schoolchildren to destroy potential breeding sites in school grounds, although this may help to reduce numbers of “nuisance” mosquitoes.

**Malaria Chemoprevention**

There are two main approaches to the use of antimalarial drugs to prevent malaria infection are chemoprophylaxis and intermittent preventive treatment.

**Chemoprophylaxis**
Chemoprophylaxis involves the regular administration of antimalarial drugs to those at risk over a sustained period to provide persistent, protective blood levels. There is compelling evidence for the benefits of chemoprophylaxis in school-age children. Chemoprophylaxis in schools in Ghana reduced absenteeism (Colbourne 1955) and halved the incidence of clinical attacks in children ages two years to nine years in Liberia (Björkman and others 1986) and in
those ages five years to nine years in Tanzania (Lemnge and others 1997). A 2003 review of trials of malaria chemoprophylaxis in the population of malaria-endemic areas reported significant health impacts in nearly all studies (Prinsens Geerligs, Brabin, and Eggelete 2003). Most of these studies focused on young children, but in 30 of the 36 trials that examined infection rates in children over age five years, reductions in malaria parasitemia ranging from 21 percent to 100 percent were seen (Prinsens Geerligs, Brabin, and Eggelete 2003). A 2008 review confirmed these findings (Meremikwu, Donegan, and Esu 2008). Chemoprophylaxis with chloroquine not only reduced the incidence of clinical malaria and absenteeism in Sri Lankan schoolchildren, but also significantly improved educational attainment (Fernando and others 2006).

**Intermittent Preventive Treatment**
An alternative to chemoprophylaxis is IPT, the periodic administration of a full therapeutic dose of an antimalarial or antimalarial combination to groups at increased risk of malaria. IPT clears existing asymptomatic infections and prevents new infections during the period after treatment when protective blood levels are present. IPT is currently being evaluated in schoolchildren in two ways: intermittent parasite clearance in schools (IPCs) and seasonal malaria chemoprevention (SMC).

IPCs involves the administration of IPT on a periodic basis to schoolchildren, with the aim of clearing asymptomatic malaria infections and aiding hematologic recovery during the ensuing malaria-free period. Studies that have evaluated IPCs in school-age children are summarized in table 9.4. The first study of IPCs (called IPT in that study), conducted in schools in western Kenya, showed that IPCs with SP + AQ given once a term significantly reduced malaria parasitemia and anemia and significantly improved sustained attention (Clarke and others 2008). However, the spread of parasites resistant to SP, and the consequent withdrawal of SP and AQ in many East African countries, precluded further investigation of IPCs using these drugs in this area. Studies using alternative drugs, including dihydroartemisinin-piperaquine, conducted in a range of settings show effects on parasitaemia, anemia, and clinical malaria to those obtained with SP + AQ (Barger and others 2009; Nankabirwa and others 2010; Clarke and others 2013b) (table 9.4).
Table 9.4 Summary of the Results of Recent Trials of Chemoprevention in School-Age Children

<table>
<thead>
<tr>
<th>Study setting</th>
<th>Population</th>
<th>Type</th>
<th>Treatment regimen</th>
<th>Study drug</th>
<th>Protective efficacy</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Clinical malaria (percent)</td>
<td>Malaria parasitemia (percent)</td>
</tr>
<tr>
<td>Year-round transmission</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Western Kenya</td>
<td>6,735 children ages 5–18 years; 30 schools</td>
<td>IPCs</td>
<td>Treatment once every school term (3 treatments per year)</td>
<td>SP + AQ</td>
<td>Not examined</td>
<td>89 (73–95)</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>591 children ages 6–14 years; 1 school</td>
<td>IPCs</td>
<td>IPCs at month 0 and month 3 (2 treatments per year)</td>
<td>SP</td>
<td>Not examined</td>
<td>No impact</td>
</tr>
<tr>
<td>Uganda</td>
<td>780 children; 3 schools</td>
<td>IPCs</td>
<td>Single course of treatment; protective efficacy measured after 42 days</td>
<td>SP</td>
<td>Not examined</td>
<td>No impact</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SP + AQ</td>
<td>Not examined</td>
<td>48.0 (38.4–51.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DP</td>
<td>Not examined</td>
<td>86.1 (79.5–90.6)</td>
</tr>
<tr>
<td>Uganda</td>
<td>740 children; 1 school</td>
<td>IPCs</td>
<td>Treatment once a school term (4 treatments per year)</td>
<td>DP</td>
<td>No impact</td>
<td>54 (47–60)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>IPCs</td>
<td>Treatment once every month (12 treatments per year)</td>
<td>DP</td>
</tr>
<tr>
<td>Highly seasonal transmission</td>
<td></td>
<td></td>
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<tr>
<td>Mali</td>
<td>262 children ages 5–10 years; 1 village</td>
<td>SMC</td>
<td>Two treatments 8 weeks apart during the malaria season: (2 treatments per year)</td>
<td>SP</td>
<td>36 (12–53)</td>
<td>Not examined</td>
</tr>
<tr>
<td>Country</td>
<td>Age Group</td>
<td>Program Details</td>
<td>Treatment Details</td>
<td>Cure Rates</td>
<td>Barger and others 2009</td>
<td></td>
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<tr>
<td>Mali</td>
<td>6–13 years; 1 village</td>
<td>SMC</td>
<td>Two treatments 8 weeks apart during the malaria season: (2 treatments per year)</td>
<td>SP + AS 66.6, AQ + AS 46.5</td>
<td>80.7, 75.5, 59.8, 54.1</td>
<td></td>
</tr>
<tr>
<td>Mali</td>
<td>6–14 years; 38 schools</td>
<td>IPCs</td>
<td>Single treatment at end of the malaria season (1 treatment per year)</td>
<td>SP + AS Not examined</td>
<td>99 (98–100), 38 (9–58)</td>
<td></td>
</tr>
<tr>
<td>Senegal</td>
<td>Under age 10 years; 8 villages</td>
<td>SMC</td>
<td>Two treatments given monthly toward end of malaria season: (2 treatments per year)</td>
<td>SP + AQ 79 (10–96)</td>
<td>57 (5–81), 41 (18–58)</td>
<td></td>
</tr>
</tbody>
</table>

**Source:**

Note: AQ = amodiaquine; AS = artesunate; DP = dihydroxy-piperaquine; IPCs = intermittent parasite clearance in schools; Hb = hemoglobin; IST = intermittent screening and treatment; SMC = seasonal malaria chemoprevention; SP = sulphadoxine-pyrimethamine.
A number of conclusions can be drawn from these studies. First, IPCs is highly effective in reducing the burden of malaria among school-age children. Second, the drug used for intermittent preventive therapy in children (IPCs), and the timing of treatments, need to be adapted to suit the local epidemiology. Third, IPCs is likely to be most effective in settings where a high proportion of children harbor asymptomatic infections, where malaria is a major cause of anemia, or both.

**Seasonal Malaria Chemoprevention**
SMC involves administration of treatment on a monthly basis to coincide with the annual peak in malaria transmission. This intervention has been highly effective in reducing the incidence of clinical malaria and anemia in young children (Wilson 2011) and, in 2012, the WHO recommended implementation of SMC for children under five years in areas of the Sahel subregion of Africa with highly seasonal transmission. This recommendation is now being implemented increasingly widely in countries of the Sahel. Although less extensively researched, and not yet recommended by the WHO, evidence suggests that SMC is as effective in school-age children as in children under age five (Barger and others 2009; Dicko and others 2008; Tine and others 2011; Tine and others 2014) (table 9.4). and Senegal is extending SMC to this older age group.

**Intermittent Screening and Treatment**
An alternative to IPCs or SMC is intermittent screening and treatment (IST), an intervention in which individuals are screened periodically for malaria infection using an RDT, and those infected (whether symptomatic or not) treated with a full course of an effective antimalarial drug or drug combination. A recent population-based study of IST in Burkina Faso showed no impact on the incidence of clinical malaria in children under the age of five years or on malaria transmission (Tiono and others 2013), and a cluster randomized trial in schools on the coast of Kenya, where transmission is low to moderate, found no impact on health or cognition (Halliday and others 2014). Possible reasons for the absence of an impact in these studies are the inability of some of the currently available RDTs to detect low-density parasitemia and the rapid rate of reinfection following treatment in the areas in which these studies were done. The potential of this approach to control of malaria in school-age children needs further investigation.

**Vaccination**
Development of an effective malaria vaccine has proved to be a major challenge, despite the exploration of many innovative approaches. One vaccine (RTS,S/AS01) has shown partial efficacy in a large-scale phase 3 clinical trial and could become the first approved malaria vaccine in 2015 or 2016 (RTS,S Clinical Trials Partnership 2011, 2012). However, the duration of protection provided by RTS,S/AS01 is relatively short, and vaccination in early life is, therefore, unlikely to provide protection that lasts into school age. However, longer-duration protection might be provided by a booster dose, as is being investigated currently in the RTS,S/AS01 phase 3 trial. If a booster dose does provide a further period of sustained protection, consideration could be given to administration of a booster dose on school entry. However, only very limited data are available on the safety and immunogenicity of RTS,S/AS01 in school-age children (Bojang and others 2005). RTS,S/AS01 is currently the most advanced malaria vaccine, but several other vaccines are making steady progress.
(Schwartz and others 2012), and in the longer term, vaccination may have an important role in the prevention of malaria in school-age children.

**Costs and cost-effectiveness of different control strategies**
Very few data exist on the cost or cost-effectiveness of malaria control measures in school-age children, with estimates available only for IPCs and IST. The delivery of IPCs by teachers was estimated to cost US$1.88 per child per year, with drug and teacher training constituting the largest cost components (Temperley and others 2008). A comprehensive school-based malaria prevention program, which combined education, ITNs, and IPCs, cost $8.66 per year per child, with the IPCs component accounting for $2.76 per year (Roschnik, personal communication). Because of the costs of RDTs, IST is more expensive than IPCs, with the cost of IST per child screened estimated to be US$6.61 (Drake and others 2011). The estimated cost per anemia case averted through IPCs is estimated to be US$29.84, and the cost per case of malaria parasitemia averted estimated to be US$5.36 (Temperley and others 2008). These estimates fall within the range of per capita costs of other malaria control strategies, but are more expensive than school-based deworming programs. However, the simultaneous delivery by teachers of both IPCs and deworming as part of an integrated school health package may yield economies of scope and increase cost-effectiveness. Studies are required on the cost-effectiveness of malaria control in schoolchildren using an integrated school health package.

**Conclusions and Recommendations**
On the basis of the data currently available, some recommendations can be made about the management of malaria in school-age children (box 9.1), but much more needs to be learned about the effectiveness of different approaches (box 9.2). The potential role of new interventions, such as SMC and the RTS.S/AS01 vaccine, which have so-far focused on preschool children, needs to be evaluated in school-age children.

**Box 9.1 Policy Recommendations for the Control of Malaria in School-Age Children**
- Education about causes of malaria, its clinical features, and ways of diagnosing, treating, and preventing the infection should be an integral part of the curriculum of all schools in areas in which the school-age population is at risk of malaria infection.
- National malaria control programs need to pay increasing attention to the problem of malaria in school-age children, as the overall incidence of malaria declines and, as a consequence, the proportion of cases of malaria in older children increases.
- All school-age children resident in an area in which they are at risk from malaria should sleep under an insecticide-treated bednet.
- School-age children who develop clinical malaria must be able to recognize the nature of their illness and have easy and rapid access to reliable diagnosis and effective treatment, either in their school or at a nearby health facility.

**Box 9.2 Key Research Priorities for a Better Understanding of the Challenges of Malaria in School-Age Children**

**Epidemiology**
• Acquisition of better knowledge of the magnitude and features of malaria in school-age children, especially in areas in which the overall incidence of malaria is declining

Pathogenesis
• Investigation of the importance of malaria as a cause of anemia in school-age children and of how anemia is caused by the malaria parasite
• Investigation of the mechanisms by which severe, uncomplicated and asymptomatic malaria impair cognition

Treatment
• Investigation of how effectively, and cost-effectively, malaria can be diagnosed using a rapid diagnostic test and treated effectively by school staff in different settings

Prevention
• Exploration of ways to improve coverage with insecticide-treated bednets among school-age children
• Investigation of the comparative advantages and cost-effectiveness of screening and treatment programs and of intermittent preventive treatment in the prevention of malaria in school-age children in high-risk areas and of the circumstances that favor one or another approach
• Exploration of the potential for vaccination to prevent malaria in school-age children.

Better data are needed on the burden of malaria in school-age children. A standardized approach to data collection would improve the ability to monitor progress in this at-risk group. Systems to capture episodes of clinical and fatal malaria in school-age children need not be school based, but should summarize data for this specific risk group. The potential of serological tests to help in evaluating the burden of malaria in school-age children needs to be evaluated. Improved information on extent of the burden of malaria in school-age children would enhance awareness at multiple levels. Globally, policy makers and multilateral funding organizations would pay more attention to this issue. Nationally, interactions between education, health, and potentially other sectors would be catalyzed. Finally, at the local and individual level, families and schoolchildren would be better able to take the necessary steps to prevent and treat malaria.

Operational research is needed to determine how best to raise awareness of the importance of malaria in school-age children, how to manage it, and how to improve the use of established control measures such as ITNs in this group. Improving the malaria-relevant content of school curricula will help children to help themselves and equip them with the understanding needed to accept new approaches to the control of malaria, such as the value of blood testing for parasitological diagnosis to guide appropriate treatment. School-age children can become an important route for disseminating information on malaria control to the rest of the family.

Further studies are needed to understand the potential role of drugs in preventing malaria in school-age children. Chemoprophylaxis, SMC, IPCs, and IST may all be beneficial, but it is not clear yet in which settings each might be most effective or cost-effective. Some sort of chemoprevention is likely to be useful in high transmission settings. Chemoprevention is less likely to be cost-effective in low transmission settings, where most recipients are unlikely to have malaria. However, the transmission threshold at which to introduce, or withdraw,
chemoprevention will only become clear through the modelling of empirical data. The optimal characteristics of drugs for SMC, IPCs and IST are likely to include low cost, a very good safety profile, exceptional tolerability, long half-life, and single-dose treatment. Development of a rigorous target product profile would help guide the development of drugs for the prevention of malaria in school-age children. The potential of IST programs to identify and help not only individuals but also communities at elevated risk of malaria warrants further exploration.

More effective control of malaria is only one part of the drive to improve the health and potential of school-age children. More work is needed on how and when to integrate malaria control strategies with other school-based programs at the local and national levels.

An increase in malaria among school-age children can be anticipated as malaria control improves across the developing world. National malaria control programs need to have in place effective strategies to deal with this new challenge.
References


WHO (World Health Organization) 2014 “‘World Malaria Report 2014’” Geneva, Switzerland