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Relationship between exposure to malaria and haemoglobin level of children 2–9 years old in low malaria transmission settings

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ABSTRACT

In the context of reduced transmission of malaria, it is essential to examine the association between exposure to malaria and haemoglobin level. This study measured the Haemoglobin level of children 2–9 years of age and examined its association with malariometric indices. A cross sectional study was conducted, during June 2016, on 763 children 2–9 years old, recruited from ten sites representing different malaria transmission settings in Ethiopia. Haemoglobin concentration was determined using HemoCue analyzer. Malariometric indices (splenomegaly rate, parasite rate and serological marker) were measured. The overall prevalence of anaemia was 17.3% (95% CI: 14.6–19.9) in the study population. Mild, moderate and severe anaemia accounted for 7.3%, 7.2% and 2.8% respectively. Of the children with anaemia (132), only 7 (5.3%) had malaria parasitaemia. The prevalence of malaria parasitaemia was 3.6% (2/56), 9.1% (5/55) and 0.0% (0/21) among children with mild, moderate and severe anaemia, respectively. Malaria reactive antibody and anaemia co-occurred in 3.13% (21/672) of the samples. Seroprevalence and parasitaemia did not have significant association with anaemia ($p > 0.05$). However, splenomegaly was significantly associated with increased risk of anaemia (AOR = 14.93; $p = 0.001$). Anaemia was significantly higher among children 2–4 years old (22.2%), and children living in households without any insecticide treated bed net (34.0%). The prevalence of anaemia was lower by 55.0% among children living in households with at least one net (AOR = 0.45, 95% CI: 0.21–0.96). Repeated exposure to malaria infections (seropositive) and parasitaemia was less likely to contribute to development of anaemia among children 2–9 years in this study setting. Thus, in low malaria endemic settings, anaemia prevention and control program required to reconsider the historical evidence that suggests malaria is one of the major risk factor for anaemia.

1. Introduction

Anaemia is a condition in which the haemoglobin concentration falls below an established cut-off value thereby consequently impairing the capacity of the blood to transport oxygen around the body (World Health Organization, 2014). In anaemic individuals, the number of red blood cells and their oxygen carrying capacity is inadequate to meet physiologic needs, resulting in an increased morbidity (World Health Organization, 2014, 2008). In developing countries, over half of preschool children are estimated to be anaemic (World Health Organization, 2014, 2008). In Ethiopia, 43.1% and 6.9% of the children under the age of five had mild and moderate anaemia, respectively (EHNRI, 2012). According to the Ethiopian Demographic and Health Survey (EDHS), about 44% of Ethiopian children were anaemic in which mild, moderate and severe anaemia accounted for 21%, 20% and 3% respectively. According to this report, the prevalence of anaemia was higher among rural children (45%) as compared to children urban settings (35%) (Central Statistical Agency of Ethiopia, 2011). Similar community based studies also reported a magnitude of anaemia that is as high as 66.6% (Gutema et al., 2014; Mesfin et al., 2015; Assefa et al., 2014; Deribew et al., 2010). According to the World Health Organization (WHO), anaemia is a major public health problem in Ethiopia

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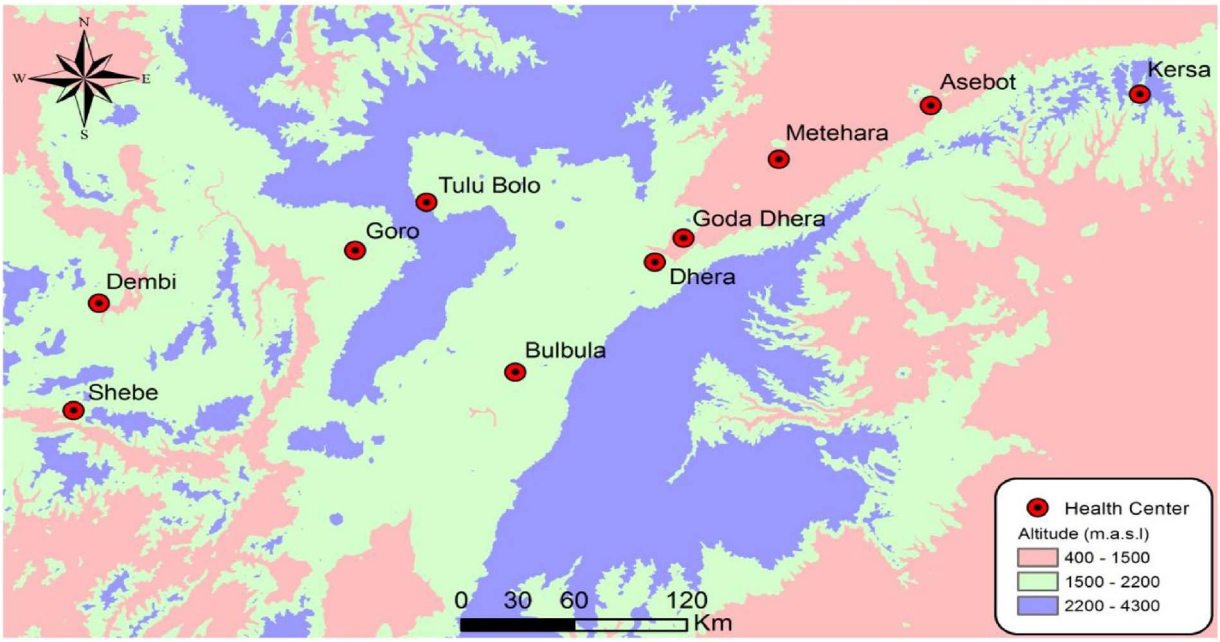

Fig. 1. Map of the study area.

(World Health Organization, 2008).

Anaemia has numerous short and long term health impacts on children: It affects their cognitive and psychomotor development and learning performance; impairs behavioral and physical growth with increased risk of morbidity and mortality (World Health Organization, 2014; WHO et al., 2001). Furthermore, anaemia impairs language coordination capacity of children and is also linked to poor intelligent quotient (WHO et al., 2001). Overall, anaemia remains one of the obstacles to national development, and it is an indicator of both poor nutrition and poor health status (World Health Organization, 2008).

Even though anaemia involves a variety of causes, the majority of *Plasmodium* infections are concomitant with some degree of anaemia among children especially in tropical areas where malaria is endemic (WHO et al., 2001; Douglas et al., 2012; Collins et al., 2003; Satpathy et al., 2004). Although its severity depends on a number of factors including individual and parasite-specific factors, malaria anaemia is capable of causing severe morbidity and mortality especially in individuals infected with *P. falciparum* (World Health Organization, 2008; Douglas et al., 2012; Collins et al., 2003). Essentially, severe form of malaria contributes up to 62% of severe malaria admissions in malaria endemic settings (Satpathy et al., 2004). Thus, malaria anaemia, particularly, severe malaria anaemia (SMA) is a complex disease leading to rapid haemoglobin reductions of 20–50% (Sowunmi et al., 2011). Studies done in Ethiopia and elsewhere widely documented that infections with malaria parasite associated with anaemia (Gutema et al., 2014; Douglas et al., 2012; Collins et al., 2003; Satpathy et al., 2004; Jamal et al., 2015; Newton et al., 1997; Carneiro et al., 2006; Rogerson, 2017; Sumbele et al., 2016; Deribew et al., 2013; Gari et al., 2017; Ketema and Bacha, 2013; Kateera et al., 2015; Alemu et al., 2012; Barreiro et al., 2017; Magalhães and Clements, 2011; Menendez et al., 2000; Safeukui et al., 2015; Erhabor et al., 2014; Crawley, 2004). Moreover, systematic reviews and meta-analysis also support that malaria is one of the major risk factors for anaemia (Kassebaum et al., 2014; McCuskee et al., 2014; Korenromp et al., 2004; World Health Organization, 2015a; Brooker et al., 2007). In addition, some evidences implied that the amount of anaemia in a population is a proxy for estimating the endemicity and burden of malaria (World Health Organization, 2015a; Brooker et al., 2007; Korenromp et al., 2004; McCuskee et al., 2014; Senn et al., 2010; Savage et al., 2007).

In tropical areas, malaria control measures have significant impacts on overall reduction of anaemia, and as a result, malaria control program is considered to be a collateral strategy for reduction of anaemia particularly among highly susceptible group (Korenromp et al., 2004; World Health Organization, 2015a; Brooker et al., 2007; Crawley, 2004). These days, malaria elimination program has received utmost global and national priorities (World Health Organization, 2015b, 2016). Likewise, Ethiopia has given a considerable attention to malaria elimination program with the aim to maintain the current gains and accelerate the progress towards elimination targets (Ministry of Health, 2014). Hence, malaria elimination program has great advantage for anaemia prevention and control efforts suggesting the need to carefully combine anaemia prevention strategies with malaria elimination initiatives. In malaria endemic settings and in areas with recently reduced malaria transmission, many children with malaria parasitaemia are asymptomatic, thus malaria remains undiagnosed (Okell et al., 2012; Okell et al., 2009; World Health Organization, 1988). This situation could also contribute to under-diagnosis of anaemia associated with malaria. Therefore, it is vital to measure the association between exposure to malaria and anaemia, particularly in the context of reduced transmission of malaria. Previous scientific inquiries mainly focused on classical metrics of malaria such as parasitaemia and spleen size to assess the association between exposure to malaria and haemoglobin level and little is known about the association between cumulative exposure (i.e. presence of anti-malarial antibodies) to malaria and its effects on haemoglobin level among children in most malaria endemic settings including Ethiopia. Therefore, this study aimed at examining the association between malariometirc indices (parasitaemia, spleen rate and anti-malarial antibody levels) and haemoglobin level/anaemia among children of 2–9 years old living in different malaria transmission settings of Ethiopia. Consequently, this study could add to a growing body of literature on effects the relationship between malaria and anaemia in the context of malaria elimination targets.

2. Material and methods

2.1. Study setting

The study was conducted in June 2016 as part of a larger