Shelby Yamamoto

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Investigating the effects of biomass smoke on the risk of malaria in Nouna, Burkina Faso

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Doktorvater: Prof. Dr. Dr.med. Rainer Sauerborn

Most of the world's population uses unprocessed solid fuel such as wood and crop residues to meet their energy needs. Dependency on such fuels can have economic, social and most importantly health consequences. Exposure to pollutants that are the by-product of biomass combustion has been linked to acute respiratory infections and chronic obstructive pulmonary disease thus reducing exposures is desirable. However, an unintended consequence of reducing biomass exposure may be an increase in the risk of malaria. Biomass smoke may act as a repellent, discouraging malaria vectors from entering and biting, which subsequently lowers the risk of the disease. Research and evidence concerning this relationship is weak. Hence, the purpose of this study was to investigate the effects of biomass smoke and household aspects on the risk of malaria.

This matched case-control study was conducted in the semi-urban area of Nouna, Burkina Faso, where the use of biomass solid fuel use is very high and malaria remains a major health issue. Confirmed cases (117) of malaria were recruited retrospectively and matched to 221 controls on age (±3 years), gender, ethnic group and residence (town sector). Household and behavioural risk factors, mosquitoes and concentrations of particulate matter (PM_{10}) and carbon monoxide (CO) were assessed.

Higher exposures to PM_{10} in sleeping rooms were associated with a strongly protective effect against malaria in children. However, no significant associations between PM_{10} and *An. gambiae* abundance were observed. Nor were sleeping room and kitchen PM_{10} concentrations or exposures correlated with each other. Thus, cigarettes or outdoor air pollution may be of greater importance than cooking in contributing to the PM_{10} levels observed in sleeping rooms. Paradoxically, greater numbers of *An. gambiae* mosquitoes were associated with a lower risk of malaria. However, higher numbers of infective bites may not necessarily result in an increased incidence of clinical malaria.

No significant associations between area and personal CO concentrations and exposure with the risk of clinical malaria were observed, although effects by location may have been obscured as only overall means were measured. Strong correlations between area PM_{10} and area CO levels could suggest a good proxy relationship, although this association may break down if the emission source is weak (gas stove) or if measures are conducted over shorter time periods. The weak correlation between area PM_{10} and personal CO as well as area CO and personal CO concentrations suggest that these measures should be sampled separately.

Earth brick floors, running tap water within a household's neighbourhood and knowledge of treatments (tablets) lowered the risk of malaria in the study. People who live in houses with earthen floors may be more likely to sleep on raised beds to avoid moisture that may penetrate floors from the rain, which can protect against malaria vectors like *Anopheles gambiae* that often search for blood close to the ground. Likewise pools, created from running water taps in the neighbourhood, are protective compared to pools that are created closer to homes. Mosquitoes breeding at sites further away from homes may have fewer opportunities to feed. Similarly, treatment knowledge can lower the risk of clinical malaria if prompt and appropriate treatments are sought, thereby reducing the number of recurrent episodes.

Household characteristics that increased the risk of malaria were house age less than 10 years, electricity in the home, larger door areas and gas stoves. Newer houses of poorer construction may erode more quickly, increasing the opportunities for mosquitoes to enter

houses. Similarly, larger door areas could also encourage mosquito access. Electricity and gas stoves may increase the risk of malaria because of reduced levels of biomass smoke in the home.

Evidence from this study suggests biomass smoke may be protective against malaria among children, however cooking may not be the primary contributor to levels observed in sleeping rooms. Thus, the findings from this study provide further evidence to support the reduction of kitchen pollutant exposures. Furthermore, the modification of the household environment could also be a feasible and effective way to lower malaria risk. Investments in training and campaign programs may also provide additional ways of managing malaria and introducing new treatments. These findings could have important ramifications for both malaria and indoor air pollution control policies and interventions.