Humanitarian water at risk: Chlorine decay in refugee camp water supply in South Sudan

*Syed Imran Ali[1,2], Jean-Francois Fesselet[1], Syed Sa'ad Ali[3], Biserka Pop-Stefanija[1], Matt Arnold[1], Cono Ariti[4]

[1]Médecins Sans Frontières (MSF), Amsterdam, Netherlands; [2]University of California Berkeley, CA, USA; [3]University of Waterloo, Waterloo, ON, Canada; [4]London School of Hygiene and Tropical Medicine, London, UK

*Email: imran.ali@berkeley.edu

Background
In South Sudan, Maban County, 2012-2013, refugee camps faced hepatitis E and other waterborne disease outbreaks. The effectiveness of chlorination of drinking water supplies was questioned. Current emergency guidelines on free residual chlorine (FRC) concentrations (0.2–0.5 mg/L in general; 0.8–1.0 mg/L during outbreaks) are based on conventions from municipal piped-water systems rather than refugee camps. We aimed to characterize FRC decay and develop evidence-based guidance for centralised batch chlorination in emergency settings, and identify factors that preserve the safe water chain.

Methods
We conducted a cross-sectional study of water quality in Jamam, Batil, and Gendrassa refugee camps in March-April 2013. Water supply was primarily groundwater and came from multiple borehole sources managed by several non-governmental organisations (none by MSF at the time of the study). Outbreak FRC targets were in place but seldom achieved. We selected a geographical cross-section of all boreholes in each camp and initiated and continued sampling if FRC was detectable at associated tap-stands. We preferentially initiated sampling when FRC was 0.2–2.0 mg/L as we sought to understand FRC decay in a range relevant to practice. We randomly selected water-users at tap-stands and analysed water quality in 500 mL samples at four points: directly from tap-stands; after collection; after transport to households; and on follow-up after 3-9 hours of household use. Water quality parameters were analysed, ambient air temperature monitored, and water handling practices of all participants documented via spot checks and self-report. We collected 220 unique samples, on the basis of previous studies. FRC decay was modelled using MATLAB and stratified by initial FRC at the tap-stand. Associations between FRC decay and water handling practices were explored in STATA. The study met the criteria of the MSF Ethics Review Board for exemption from full ethics review.

Results
We sampled 100%, 71%, and 63% of boreholes in Jamam, Batil, and Gendrassa, respectively. Detectable FRC at tap-stands ranged widely (0.01–5.2 mg/L), both spatially and temporally. A high level of agreement with second-order FRC decay was observed across strata. For initial FRC at 0.5–1.5 mg/L, a decay rate of ~$5x10^{-3}$ $L \cdot mg^{-1} \cdot min^{-1}$ was found across all camps. Initial FRC, electrical conductivity, and ambient air temperature were significantly associated with FRC decay. The only water handling practice that preserved FRC was covering storage containers.

Conclusions

Chlorination control pre-distribution was poor. In addition, the current general FRC guideline offers insufficient protection post-distribution. In light of the rapid decay observed, we recommend the guideline for FRC be revised to 1.0 mg/L in all situations. Modelling indicates this will provide FRC protection of at least 0.2 mg/L for up to 10 hours post-distribution. Our study is the first attempt to derive a target for FRC grounded in field evidence. It may better protect drinking water from pathogenic recontamination and thereby limit the spread of waterborne diseases in refugee camps. However, our findings may not be generalisable to other camps. Further research is needed to determine the effectiveness of this recommendation.