

Skeletal fluorosis in a resettled refugee from Kakuma refugee camp

"I suspected some contamination of the water of the much-frequented street pump in Broad Street, near the end of Cambridge Street", said John Snow, about the contaminated water pump of the cholera outbreak of 1854, in London, UK.¹

In September, 2015, a Somali man aged 46 years presented to a refugee clinic within 1 month of resettlement to Canada. From 2009 to 2015, this patient had lived in the Kakuma refugee camp (Rift Valley Province, Kenya), which houses 184 966 inhabitants.^{2,3} He had chronic, debilitating, diffuse axial bone pain, insidiously worsening over the previous 5 years, beginning with lumbar and hip pain. In the year before presentation, he was no longer

able to rise from a chair alone and had an antalgic, shuffling gait with pronounced kyphosis. His sclerae were white and dentition poor. Spinal and hip mobility was severely limited in all directions, and point tenderness was present throughout the lumbar spine, sacro-iliac joints, and chest wall.

Clinical investigation revealed elevated serum alkaline phosphatase with normal serum calcium, albumin, and 25-hydroxyvitamin D. All

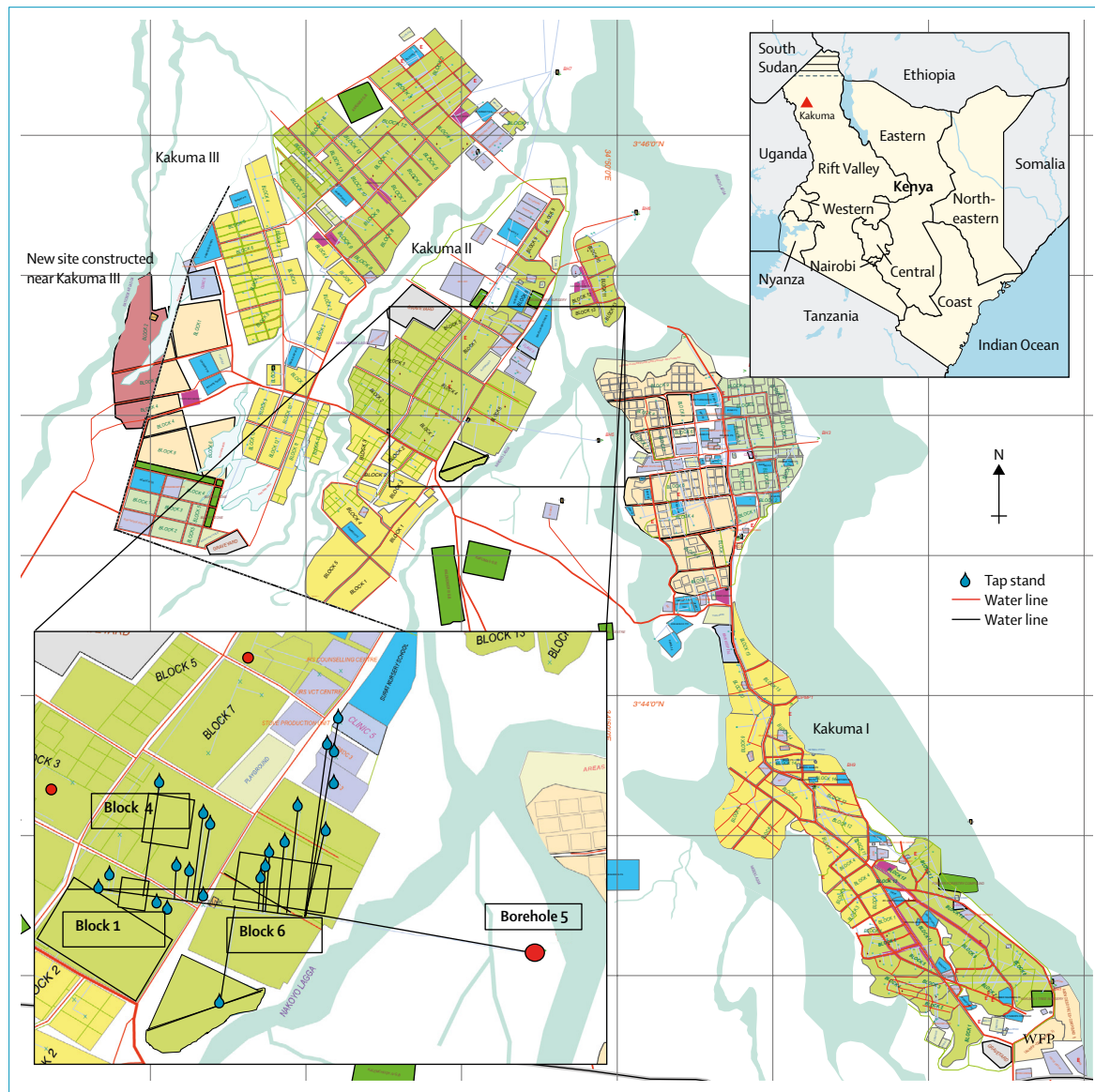


Figure: Map of Kenya and of the Kakuma refugee camp highlighting borehole 5 and associated water lines, tap stands, and the drinking water-dependent residential areas where the patient had lived.^{5,6}

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investigations are summarised in the appendix. Pelvic radiograph, CT scan, and a whole body technetium-labelled bisphosphonate bone scan revealed diffuse osteosclerosis with ligamentous calcifications. Bone densitometry (Hologic Discovery W; Marlborough, MA, USA) showed lumbar spine and femoral neck Z scores of 8·7 and 3·7, respectively.

The extensive osteosclerosis led to measurement of serum and urine fluoride; both were within the normal range for someone drinking municipally fluoridated water (appendix). In October, 2016, a tetracycline-labelled iliac crest open bone biopsy for histomorphometry revealed a combination of osteosclerosis with severe low turnover osteomalacia, suggesting skeletal fluorosis (appendix). Additional bone biopsy specimen sections were ashed for direct bone fluoride content measurement, revealing 6·73 g/kg fluoride ash weight (normal range 0·5–1·2 g/kg), confirming severe skeletal fluorosis.

In July 2016, 15 water wells supplying drinking water for Kakuma's residents had fluoride concentrations of 1·5–8·4 mg/L.³ WHO drinking water guidelines⁴ recommend fluoride concentrations of 1·5 mg/L or less. Our patient lived in a camp section exclusively supplied by a single well (borehole 5; figure),^{5,6} which consistently contained high fluoride concentrations between 2014 and 2016 (8·4 mg/L in July, 2016).³

Symptomatic skeletal fluorosis from either environmental or toxic exposure has been described globally, with the highest reported burden in China and India.^{4,7} There, the reported prevalence of skeletal fluorosis among populations exposed to drinking water with high fluoride concentrations (>4·8 mg/L) ranged from 26% to 63%.⁴ Other potential toxic exposures, most often reported in modern cases, include consuming teas containing the fluoride-concentrating tea plant *Camellia sinensis*.^{8,9} Fluoride is a naturally occurring element in all natural waters

and is associated with geological environments containing volcanic rocks.^{3,4,7} The east African Rift Valley, where the Kakuma refugee camp is located, geologically comprises volcanic rock aquifers with naturally high fluoride concentration groundwater.^{3,4,7} Dental fluorosis has been reported in this region, but to our knowledge, no cases of severe skeletal fluorosis have been reported in inhabitants of Kakuma refugee camp.^{4,7}

Clinical diagnosis of fluorosis is challenging and requires multidisciplinary collaboration (appendix). Clinicians in migrant-receiving nations often lack awareness of, and available diagnostic tests for, fluorosis, which probably leads to under-reporting. No treatment exists for fluorosis other than halting exposure, with symptom resolution as fluoride mobilises slowly from bone.⁸ The patient's symptoms markedly improved with reduced pain and with improved mobility and daily activity over the subsequent 9 months after diagnosis, nearly 2 years after fluoride exposure cessation.

Here we have presented a single case of severe skeletal fluorosis; however, entire populations, such as Kakuma's approximately 185 000 residents, who depend on naturally occurring fluoride-contaminated well water, might be affected en masse.²⁻⁴ Many countries with naturally high water-fluoride concentrations host large refugee populations, including Ethiopia, Iraq, Kenya, South Sudan, Syria, and Turkey.^{4,7,10} Displaced populations who depend on well water in these areas can be at particular risk, especially children with developing skeletons and lower volumes of distribution. We relayed our clinical information to the Kakuma refugee camp UNHCR Water, Sanitation, and Hygiene officers, who subsequently successfully drilled three new water wells with safe fluoride concentrations (<1·5 mg/L) for the first time.^{3,4} Boreholes 13, 14, and 15 produced well water with fluoride concentrations of 1·1 mg/L, 0·9 mg/L, and 0·6 mg/L, respectively (personal

communication; Paul Bauman, Advisian, Worley Parsons Group).

The prevalence of skeletal fluorosis in Kakuma could be under-reported. As the numbers of forcefully displaced persons rise globally,¹⁰ clinicians in refugee host nations should maintain a broad approach to newcomers' health issues and consider potentially important environmental exposures in addition to infectious pathogens. Ultimately, safe drinking water endures as a fundamental principle of human health.

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- 6 TUBS. “Kenya, administrative divisions - de-monochrome”. Adapted by GE Fabreau to change language and merge with map of Kakuma refugee camp. https://commons.wikimedia.org/wiki/File:Kenya_administrative_divisions_-_de_-_monochrome.svg. Licenced under CC BY-SA 3.0 (accessed Nov 21, 2018).
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Expanding safe waste management to public health systems

Media focus on plastic waste, urban air pollution, and the way it affects our environment, health, and communities has been increasing. Environmental pollution has been recognised as a growing public health problem for many years, but the size of the problem and the urgency of a solution have risen only recently to a higher level of public consciousness. Although the media are effective mobilisers for these issues, they do not articulate who is responsible for leading or assisting solutions. This may be because we are all individually, communally and globally responsible. We choose to advance by new technologies that consume materials and energy, but we are reluctant to address the risks associated with the resulting waste.

Panel: Key milestones for waste management

- Establishing leadership, commitment, and country planning, to link waste management budgeting to medical supply services that generate waste and mobilise financing that establishes and maintains waste management infrastructure
- Linking regulatory and procurement mechanisms that control waste choices, to reduce the volume of product presentation and packaging and avoid polluting materials
- Creating an infrastructure of public health waste management, to collect, transport, recycle, or incinerate at high temperature outside urban areas, and install effective on-site destruction of waste at remote health facilities
- Monitoring supply, consumption, and destruction of syringe waste

Health services are obliged to treat and care for illnesses caused by environmental pollution. However, few countries act to prevent, control, or eliminate the pollution; low-income and middle-income countries are particularly affected because they lack policies, standard operating procedures, equipment, and resources to maintain a safe and effective waste management infrastructure. Isolated efforts have been made in specific public health programmes. For example, between 2002 and 2006 and under the auspices of the Children’s Vaccine Program, PATH and WHO coordinated waste management development activities in east and west Africa, India, and southeast Asia as an informal consortium with UNICEF. They addressed three key issues: on-site, small-scale incineration was adopted for dry sharps waste at rural or dispersed health facilities, replacing the common practice of burial or open burning of syringes; syringe-safe incineration boxes and needle cutters were adopted to prevent reuse and protect against needlestick injuries during waste handling; and auto-disable syringes were developed and introduced to prevent reuse of infectious materials and reduce risk to the users.

This initiative stimulated routine and mass immunisation activities to collect and destroy sharps waste in participating countries. However, the initiative was neither sustained nor expanded to the whole public

health system once funding ended. With increased focus on integrated programmes in global health and synergy for health systems, it is time to fully address waste management across the entire public health system in an integrated and effective way.

Key milestones (see panel) towards this goal should be prioritised by governments, UN agencies, multilateral organisations, and donors. A sound foundation has already been laid by immunisation services, but much remains to be done to reduce the waste footprint of public health services in a responsible and sustainable way.

I declare no competing interests.

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Credibility in published data sources

Boerma and colleagues (Aug 18, 2018, p 607)¹ do well to raise the issue of reliability and credibility of computed mortality statistics.¹ However, this is not just a problem for lower-income countries. The Models of Child Health Appraised Project,² funded by the EU Horizon 2020 programme, is charged with assessing the primary health-care systems for children in the 30 EU and European Economic Area countries.² We have found worrying discrepancies