Back-to-the-future potential for autochthonous transmission of *Aedes aegypti*-transmitted viruses in eThekwini and urban coastal KwaZulu-Natal Province, South Africa

The *Aedes aegypti* (Linnaeus) mosquito transmits several important arboviruses, principally chikungunya (CHIKV), dengue (DENV), yellow fever (YFV) and Zika (ZIKV).[1-4] Ninety years ago this journal featured an account of the DENV-1 epidemic that crippled Durban during the summer of 1926/27.[5,6] Summary estimates described 50 000 sufferers and 60 attributed deaths along the coast between Kelso Junction and Stanger (KwaDukuza) and inland as far as Pinetown.[7] Some residents suffered haemorrhagic manifestations now associated with repeat infections involving another of the four DENV types.[2,8-12]

A 1996 *SAMJ* editorial suggested that the 1926/27 epidemic occurred during a brace of remarkably wet years when the rainfall was five and eight times greater than the historical average.[13] However, the Durban rainfall during 1925/26 was the lowest then on record and drought persisted through the first months of the 1927 epidemic, before plentiful March rains.[14] Empty skies compounded structural water supply challenges later relieved by completion of the Shongweni Water Scheme.[15]

The 1926/27 epidemic was not an anomaly. In the early 1870s, a pandemic often identified as 'dengue' – but more likely in fact chikungunya – swept through Indian Ocean ports.[16-20] The pandemic reached Mauritius in 1873.[21,22] In late January 1874, an epidemic resembling chikungunya took hold in Durban: 'a low fever, accompanied by rheumatic pain', affecting black and white populations alike, 'almost put a stop to business'.[23] 'The first symptoms of the attack are stiffness and soreness in the legs and joints, pains in the head, and tightness in the chest,' *The Natal Mercury* detailed. 'Then the fever soon shows itself and prostrates the victim. There is nothing of fatal character about the sickness but it completely knocks up those it attacks, for at least two or three days.'[24] Four summers later, in March 1878, the port town's district surgeon reported that 'this is the first time dengue has shown itself epidemically in this Colony',[25] and *The Natal Mercury* observed that 'at least every other person has suffered'.[26]

In addition to the epidemics in 1874 and 1878, medical observers reported disease events they described as 'dengue' during 10 additional summers over the next 50 years.[27-28] Eight of those 12 years saw rainfall in Durban below the historical average (Table 1), often coincident with El Niño-associated drought.[29-31] While the precise viral aetiologies of outbreaks and epidemics prior to 1926/27 are elusive, the better documented occurrences of probable chikungunya or dengue point to the presence of human-biting, virus-transmitting *Ae. aegypti* populations and recurring intersections with water stress.

In 2016, during a summer marked by El Niño drought, eThekwini's dengue history went unmentioned after the World Health Organization declared Zika a public health emergency of international concern. Leading South African health officials made statements to the press[32-36] and Parliament's Portfolio Committee on Health,[37] dismissing the vector capacity and competence of the country's *Ae. aegypti* populations, regardless of region. All six urgent actions prioritised by the Department of Health focused on travellers and the translocation of mosquitoes from abroad.[38] The more nuanced assessment that National Institute for Communicable Diseases officials placed in this journal[39] referenced unspecified 'prediction models based on the distribution of *Ae. aegypti*' as indicating a low risk for autochthonous viral transmission.

Table 1. Summers with reports of dengue-like illness in the Durban area and recorded rainfall at Durban Botanical Gardens, 1873/74 - 1926/27

Year (July - June)/ summer	Number of days with recorded rainfall[14]	Recorded rainfall[14] (mm)*	Rainfall as % more or less than annual average 1871 - 1997 (1 002 mm)[31]
1873/74	137	1 283.5	+28.1
1877/78	136	865.3	–13.6
1891/92	126	783.5	–21.8
1895/96	136	917.7	–8.5
1896/97	119	954.0	–4.8
1897/98	138	992.8	–1.0
1899/00	127	686.5	–31.5
1900/01	127	1 119.3	+11.7
1901/02	127	1 242.0	+24.0
1913/14	107	878.0	–12.4
1925/26	98	669.0	–33.3
1926/27	106	842.7	–15.9

*Documentary records recorded in inches, converted here into millimetres.

Ae. aegypti is a polymorphic species whose populations exhibit variable traits influenced by genetics and environment – for example, colour pattern, bloodmeal preference, egg-laying site selection and vector competence.[40] A 1991 morphology-focused study reached a similar conclusion: 'in South Africa *Ae. aegypti* is a single polymorphic species displaying plasticity in its man-biting behavior'.[41] Entomologists in the 1950s and 1990s described focally abundant, domestic, human-biting *Ae. aegypti* populations in eThekwini and the KwaZulu-Natal (KZN) coast.[42-44] Between 1970 and 2002, vector competence tests yielded the following results: *Ae. aegypti* populations from both ends of KZN – a forest population from Ndumu and another from Glenmore Beach – were readily infected with CHIKV at viral titres >5.3 logs and capably transmitted the virus;[45,46] *Ae. aegypti* from eThekwini were competent vectors of DENV-1 and DENV-2, albeit with lower efficiency than seen in South America;[47] and *Ae. aegypti* from eThekwini were relatively poor vectors of YFV.[48]

Less competent vectors still warrant consideration.[49] From November through April, eThekwini summers favour *Ae. aegypti* abundance, with average high temperatures of 25 - 28°C, relative humidity around 80%, and summer rainfall.[50-54] If the city's *Ae. aegypti* mosquitoes obtain bloodmeals containing CHIKV, DENV or ZIKV from infected visitors or returning residents – and subsequently survive beyond the virus's extrinsic incubation period (EIP) within mosquitoes – local transmission could result. Most of eThekwini's 3.5 million residents presumably have no acquired immunity to these viruses.

Entrenched inequality deprives many eThekwini residents of protection against blood-feeding *Ae. aegypti* afforded by good-quality dwelling construction, in-house piped water, and air-conditioning.[55-57] A third of eThekwini households are located in informal settlements.[58] Barely 60% of city households enjoy in-house piped water.[59] Where piped water is present, residents

may still collect and store water to hedge against prohibitive costs or restrictions and interruptions.

This is not to suggest that eThekwini's well-to-do are unlikely to be affected. Their disposable income and international travel make them candidates for virus importation. As in 1927 – when dengue beset Berea households – water-holding receptacles and vegetation prized in the gardens of the wealthier classes can foster and shelter *Ae. aegypti*, while outdoor living areas can increase vector exposure during peak morning and evening biting times.[60,61]

Up to 80% of ZIKV and 75% of DENV infections may be asymptomatic.[62,63] Moreover, a 2015 study revealed that people with asymptomatic DENV infections can still infect biting mosquitoes.[64] Visitors or returning residents may infect blood-feeding *Ae. aegypti* without displaying signs of illness. This understanding – and the reality that 7 in 10 eThekwini households depend upon public healthcare facilities[65] – blunts the sensitivity of passive disease surveillance focused on recent travellers and dominated by private sector test requests.

Looking forward, resident mobility as well as expansionary goals for the city's aerotropolis[66,67] and international tourism[68] could increase the possibilities for virus importation. In addition, climate change may make summers more conducive to virus transmission. Projections suggest temperature increases in eThekwini of 1.5 - 2.5°C by 2065 and, by 2100, a rise of 3 - 5°C.[69] Higher temperatures shorten EIPs in *Ae. aegypti*. One DENV study found EIPs of ≥12 days at 30°C, but 7 days at 32 - 35°C;[70] another reported EIPs of 9 days at 26 - 28°C that fell to 5 days at 30°C.[71] While the net influence rising temperatures will exert on larval development, adult size and abundance, female biting rates, EIPs and adult longevity is complex, warmer summers in eThekwini may increase the likelihood that *Ae. aegypti* – if infected – will survive long enough to deliver infecting bites.

Human adaptation to water insecurity and climate change may influence eThekwini's disease ecology more than the direct impact of rising temperatures.[72,73] Rainwater tanks were a common feature of Durban's urban ecology during its dengue past.[74-79] Residents, climate change planners, water officials and NGOs who practise or promote rainwater harvesting unwittingly restore one of *Ae. aegypti's* most prolific larval habitats from yesteryear.[80-85] These considerations warrant further study and engagement beyond the health sector with the potential for *Ae. aegypti*-transmitted viruses in urban coastal KZN.

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Acknowledgements. I am grateful for stimulating exchanges with past and present staff of South Africa's National Institute for Communicable Diseases and the eThekwini Health Unit from 2014 to 2016. Any errors are wholly my own.

Author contributions. Sole author.

Funding. This text draws on dissertation fieldwork supported by a Graduate Research Abroad Fellowship from Boston University and a Fulbright-Hays Doctoral Dissertation Research Abroad Fellowship from the US Government's Department of Education. The composition of a more expansive essay on this subject (in press) received support from the Pardee Center for the Study of the Longer-Range Future at Boston University.

Conflicts of interest. None.

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