Dam-induced displacement and disruption are associated with cortisol concentration and patterns of diurnal variation

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Introduction

Upon completion, the Thwake Multi-purpose Dam in Makueni County, Kenya is expected to provide electricity, alleviate experiences of water insecurity, and increase socio-economic development[1].

Hydroelectric dams have been widely regarded as integral to economic development in low- and middle-income countries[2,3]. However, infrastructure development projects can be disruptive to the surrounding communities[4,5].

The development of hydroelectric dams significantly alters local ecologies, impacting the livelihood of nearby communities[6,7,8]. Additionally, the biosocial implications of infrastructure development are not well understood, particularly among women and children[8].

Hypothesis: Women who have been *resettled* by or live *downstream* of the construction of the Thwake Dam will have stress related hormonal differences compared to women who live in the surrounding area but are not directly impacted.

Data

Participants:

- 221 women living in the region surrounding the proposed Thwake Multipurpose Dam project area in Makueni county in 2019[9]
- Displacement status:
  - *Comparison*: women living in nearby communities and not directly impacted by dam development
  - *Downstream*: women living downstream of dam development
  - *Resettled*: women displaced and resettled by dam development

Cortisol:

- Previous evening and morning after salivary cortisol collected using passive drool
- Salimetrics Expanded Range High Sensitivity Salivary Cortisol Enzyme Immunoassay Kit (Salimetrics Assay #1-3002).
- Waking cortisol concentration, log-transformed evening cortisol concentration, and diurnal difference (waking cortisol concentration subtracted from evening cortisol concentration)

Sample Characteristics

Table 1. Descriptive characteristics of the women included in this analysis.

Characteristic	N	n (%); Mean (SD)
Displacement Status	221	
Comparison		115 (52.0%)
Downstream		27 (12.2%)
Resettled		79 (35.7%)
Age	219	37.1 (15.7)
CES Depression	218	35.2 (9.40)
Domestic Violence	219	0.260 (0.819)
Has Children Under 5	221	
Yes		95 (43.0%)
No		126 (57.0%)
HFIAS	217	10.3 (8.70)
HWISE	219	8.67 (8.25)
Minimum Dietary Diversity for Women	221	5.72 (2.01)
Perceived Stress	210	18.4 (5.92)
Self or Spouse Occupation	221	
Farming or Livestock		169 (76.5%)
Not Farming or Livestock		52 (23.5%)
Social Support	217	24.6 (6.07)
Wealth Index	217	0.070 (0.901)

Cortisol Across Displacement Status

In adjusted regressions, there was no difference in waking cortisol concentration across displacement status (downstream: β=-0.019, p=0.409; resettled: β=-0.004, p= 0.791). Both *downstream* and *resettled* groups had significantly higher log-transformed evening cortisol concentration (downstream: β=0.499, p=0.021, resettled: β=0.339, p=0.018). Both *downstream* and *resettled* groups had significantly less diurnal difference (downstream: β=0.047, p=0.050; resettled: β= 0.033, p=0.042).

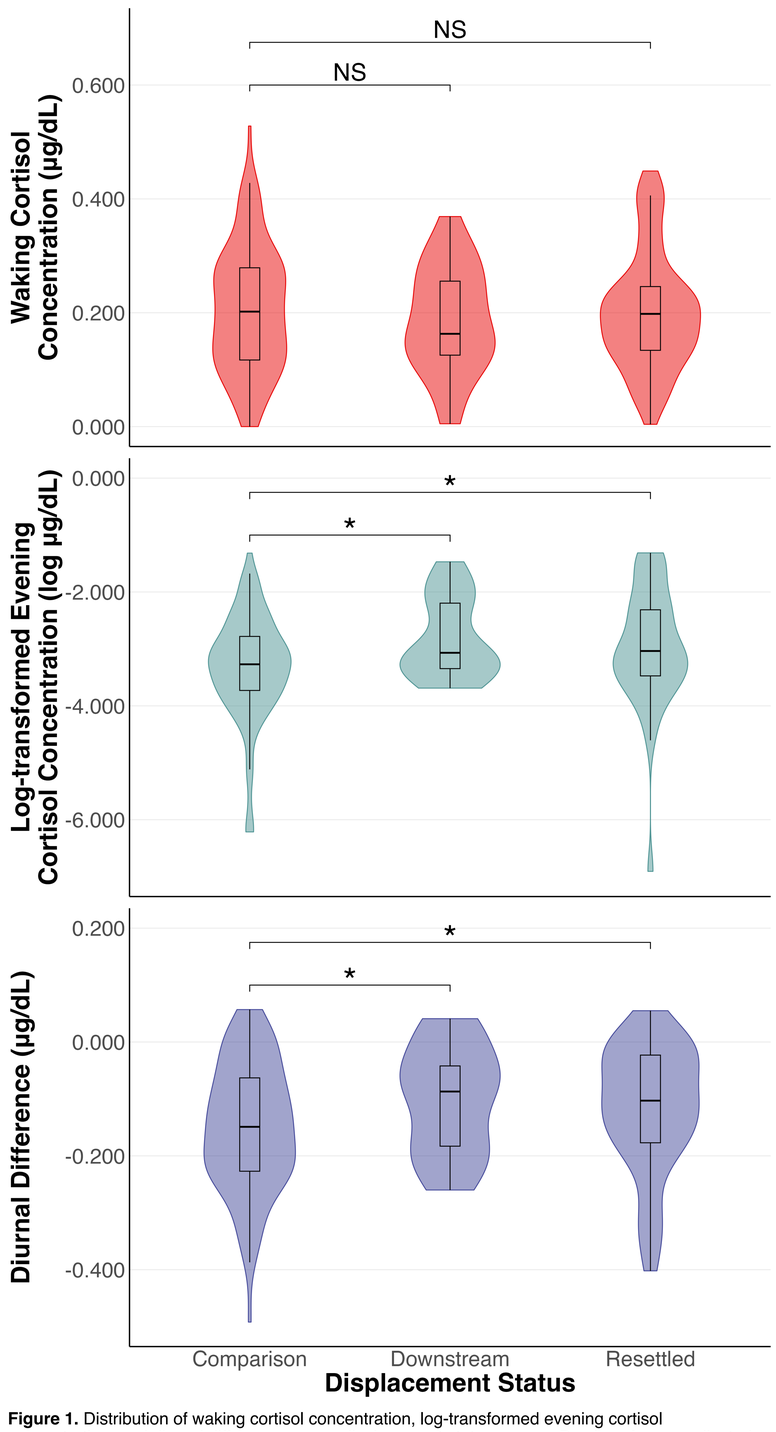

Figure 1. Distribution of waking cortisol concentration, log-transformed evening cortisol concentration, and diurnal difference across displacement status groups. P-values from unadjusted linear regression models, with the *comparison* group as the baseline. Y-axes are not fixed. *=p<0.05; NS=not significant.

Multivariable Regressions

Table 2. Results of multivariable linear regression models including displacement status, domestic violence score, minimum dietary diversity for women score, perceived stress score, and wealth index.

Characteristic	Waking Cortisol (N=206)		Log Evening Cortisol (N=199)		Diurnal Difference (N=201)	
	Beta[1]	SE[2]	Beta[1]	SE[2]	Beta[1]	SE[2]
Displacement Status						
Comparison	—	—	—	—	—	—
Downstream	-0.016	0.025	**0.689****	0.242	**0.058***	0.026
Resettled	-0.004	0.016	**0.375***	0.152	**0.038***	0.017
Domestic Violence	0.004	0.009	0.012	0.089	0.000	0.010
Minimum Dietary Diversity for Women	0.000	0.004	-0.048	0.039	-0.004	0.004
Perceived Stress	0.000	0.001	-0.020	0.012	-0.001	0.001
Wealth Index	-0.001	0.008	0.014	0.079	0.001	0.009

[1] *p<0.05; **p<0.01; ***p<0.001

[2] SE = Standard Error

Discussion and Conclusion

Results: Women who were *resettled* by and those who live *downstream* of the Thwake Dam showed stress related hormonal differences:

- Elevated evening salivary cortisol concentration
- Decreased magnitude of diurnal difference

Implications:

- Elevated evening cortisol concentration and less diurnal difference ⇔ flatter cortisol diurnal slope[10,11]
- Flatter cortisol diurnal slope ⇔ increased psychosocial stress and poor mental and physical health outcomes[10,11]

Policy considerations and future research:

- Research and policy often exclude *downstream* communities[12]
- Women living *downstream* experience stress related hormonal differences comparable to individuals *resettled* by dam development
- *Downstream* communities were not compensated for disruptions caused by infrastructure development[13]

Research should explore the health impacts of hydroelectric dam development on *downstream* communities to guide more equitable policies regarding measures taken to support those impacted by development.

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