Long Term Effects of the 2004 Indian Ocean Tsunami on Hair Cortisol Concentration

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This paper provides evidence on whether exposure to exogenously-induced acute stress has long-term consequences as indicated by elevated levels of cortisol concentrations measured in hair collected 14 years after the exposure. Specifically, we compare cortisol levels of individuals who were directly exposed to the devastation of a major earthquake and tsunami relative to individuals who were living in neighboring communities and were not directly exposed. Over and above determining whether such differences persist over the long-term, we investigate whether the extent of differences depends on the nature of the acute stressor, on the extent to which those who were exposed have personally recovered, and any interaction with the external disaster recovery effort. The nature of the stressor is measured by exposures that include struggling in the water, seeing family and friends struggle, loss of family and friends and loss of livelihoods. Recovery is measured by markers of pscyho-social well-being, economic prosperity and re-building family networks.

Chronic adversity and stress are well-known to be associated with a range of negative effects on health. The hypothalamus-pituitary-adrenal (HPA) axis is a key mediator of the effects of stress on health, and leads to the secretion of the hormone cortisol. Measures of cortisol can therefore be used to determine the biological stress levels an individual experiences (Chrousos, 2009). Elevated cortisol levels are linked to cardiovascular conditions, immune suppression, insulin resistance, intestinal problems, and other stress-related health conditions (Pereg 2011, Bjorntorp 1997, Samra et al. 1998). High measured cortisol levels, as a result, would imply both a chronic physiological or psychological stressor has been impacting the well-being of an individual within the past three months, and is linked to a host of other adverse health outcomes. Measurement of cortisol in blood, saliva, or urine, some of the common methods, presents a challenge in that cortisol levels vary over the course of the day. Generally, levels start higher and trend downwards, and are prone to short-term fluctuations (Hellhammer et al. 2007). This makes it difficult to get good measures of chronic-level stress that are comparable across individuals, and unaffected by time of measurement.

As hair grows, it incorporates substances found in the bloodstream, including hormones such as cortisol. In addition, it incorporates cortisol-containing sweat and sebum over time, providing multiple pathways through which cortisol can be incorporated into hair strands over time (Henderson, 1993). This provides a highly stable measure of chronic stress, creating a cumulative measure of cortisol levels over time. Since hair grows approximately 1cm/month, use of the 3cm of hair closest to the scalp results in a measure of the last 3 months.

A growing body of work has been done linking hair cortisol to different social factors. Elevated hair cortisol has been documented with regards to perceived weight discrimination (Jackson, Kirschbaum, and Steptoe, 2016), withdrawing alcoholics (Stalder et al. 2010), chronic pain (Van Uum et al. 2008), long-term unemployment (Dettenborn et al. 2010), low SES children (Vliegenthart et al. 2016), BMI, ethnicity (Rippe et al. 2016), number of traumatic/stressful life events in black women (Schreier et al. 2016), and early negative psychosocial exposure in infants (Karlen et al. 2015). While stressors tend to lead to higher cortisol levels as we'd predict, the literature on patients with very high level PTSD is mixed, as PTSD may lead to hypocorticolism, which implies reduced cortisol and most regulatory hormones (Steudte et al. 2011, Steudte-Schmiedgen et al, 2015). In addition, one study done in the short-term aftermath of the 2008 Wenchuan Earthquake showed elevated hair cortisol with exposure. There remain significant gaps in the literature, however, especially regarding long-term effects of specific events. In particular, the literature is weak in developing contexts.

In order to evaluate whether the 2004 Indian Ocean Tsunami has long-term effects on the biological stress levels of exposed individuals, we drew a subsample for hair collection of 750 individuals over the age of 35 from the Study of Tsunami Aftermath and Recovery (STAR). The STAR dataset is a uniquely rich longitudinal study combining individual health information, family, community, and economic data. It includes pre-tsunami baseline information, and has annual follow-ups the first 5 years, as well as data collection at the 10 and 14-year time points. For each individual, there is information both on community tsunami exposure, personal tsunami exposure, and post-traumatic stress reactivity scores. In addition, biomarkers collected at the same time as the hair samples establish longer-term impacts of exposure to the tsunami on inflammation (C-reactive protein) as well lipids (high-density lipoprotein and total cholesterol) and a marker of glucose dysregulation, glycated hemoglobin (HbA1c). This evidence points to longer-term impacts of an acute stress on cardio-metabolic health; this specific research will document whether the long-arm of stress exposures reach into markers of cortisol.

This population provides the unique opportunity to powerfully link variation in tsunami exposure with long-term biological stress, as well as connect cortisol levels to a uniquely rich dataset including socioeconomic and health data. In particular, this will enable us to contribute to the literature with rich data specifically focused on the long-term impacts of an event in the developing country context.

The hair samples are being assayed in our laboratory in Indonesia and all assays will be completed and analyzed by the end of this year. We have rigorously validated the laboratory using matched-hair samples that were assayed both in Indonesia and in a reference laboratory at University of Massachusetts – Amherst.

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