Operationalizing a Structural Vulnerability Profile for forensic anthropology: Skeletal and dental biomarkers of embodied inequity

Allysha Powanda Winburn *, Katherine A. Miller Wolf, Meredith G. Marten

The University of West Florida Department of Anthropology, USA

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ABSTRACT

Human societies create and maintain structures in which individuals and groups experience varying degrees of inequity and suffering that may be skeletally and dentally embodied. It is necessary to foreground these social and structural impacts for forensic anthropologists to eschew biologically deterministic interpretations of human variation and overly individualistic interpretations of health and disease. We thus propose a ‘Structural Vulnerability Profile’ (SVP), akin to the Structural Vulnerability Assessment Tool of medical anthropology [1], to be considered along with the traditional ‘biological’ profile estimated by forensic anthropologists. Assembling an SVP would involve examining and assessing skeletal/dental biomarkers indicative of embodied social inequity—the lived experiences of social marginalization that can get ‘under the skin’ to leave hard-tissue traces. Shifting our emphasis from presumably hereditary variation to focus on embodied social marginalization, the SVP will allow forensic anthropologists to sensitively reconstruct the lived experiences of the people we examine.

1. Introduction

In segregated or oppressive societies, lived experiences of social marginalization can be embodied—literally incorporated into human bodies over a lifetime—with significant detrimental influences on health and wellbeing. Decades of research in social epidemiology and medical anthropology link the embodiment of structural inequity with early mortality and increased morbidity [2–8]. Bioarchaeological research indicates that inequity is embodied in the body’s hard tissues [9–20].

Yet, forensic anthropologists have only recently begun to use the lens of embodied inequity to examine contemporary human skeletal and dental variation, typically to differentiate the remains of deceased U.S. individuals from migrants to the U.S. Specifically, forensic anthropologists working in the region of the U.S.-Mexico border have demonstrated high prevalences of chronic-stress markers [21–29], indicators of developmental instability [24–26], and dental pathological conditions [27] among Central American and Mexican migrants dying in the U.S. southwest. In turn, these traits have been utilized to differentiate the remains of migrants from the remains of U.S. residents of the U.S.-Mexico border region [21]. This approach builds on the considerable theoretical and methodological work done among structurally marginal Latin American immigrants at the southern U.S. border in subdisciplines including not only forensic anthropology [22,23,27,28], but also archaeology [29] and medical anthropology [1,30–32]. Importantly, however, lived social inequities can also be detected in the skeletal and dental remains of modern U.S. citizens [33]. Yet, given that most donors to modern U.S. skeletal collections are older males who identify as white [34], the hypothesis that embodied social inequity will be evident in the skeletal and dental remains of modern U.S. individuals of different social races, sexes, and life experiences has still not been explicitly tested. We maintain that attention must be drawn to the presence of skeletal and dental biomarkers of inequity in individuals living, and dying, both within and beyond U.S. social systems [35]. We propose that a faithful accounting of these systemic inequities is necessary and herein highlight the need to fully operationalize structural vulnerability in forensic anthropology. Structural vulnerability is defined as a positionality that highlights an individual’s experiences of hierarchical processes of discrimination, exploitation, and oppression, processes which produce population-level patterns in suffering and poor health among marginalized peoples [30]; see also [1,32].

Our move to incorporate structural vulnerability into the purview of forensic anthropology parallels the call by Bourgois and colleagues (2017) to bring a structural vulnerability framework to the practice of clinical medicine, which resulted in the development of medical anthropology’s Structural Vulnerability Assessment Tool (SVAT). Designed to address poor health outcomes that emerge from social and...
structural determinants of health, the SVAT guides clinicians through questions regarding patients’ financial security, housing, legal status, experiences of discrimination, food access, education, and social network, in an effort to intervene and provide the kinds of social care typically outside the purview of biomedical health care workers [1]. Use of the SVAT assists health care workers in becoming more “structurally competent”—better able to understand and identify poor health outcomes that represent “the downstream implications of upstream decisions” [36]: 216. With this knowledge, health workers can contribute to models of structural change to improve human health.

2. Proposal of the SVP

Following the SVAT, we propose that forensic anthropologists consider a Structural Vulnerability Profile (SVP), which would consolidate skeletal and dental markers of inequity to compare to the social and economic stressors embodied as a result of common axes of marginalization (e.g., sex, social race, poverty; Fig. 1). Rejecting biologically determinist, often-racialized interpretations of human variation, the SVP allows anthropologists to augment the traditionally used ‘biological profile’ (i.e., age, sex, stature, and population affinity) with a focus not on the hereditary but the socially structured nature of this variation.

Our research group includes a forensic anthropologist, bioarchaeologist, and medical anthropologist. With support from the Wenner-Gren Foundation, we are actively engaged with the creation of an SVP tool, and as a first step in its development, are currently utilizing anonymized medicolegal CT imagery contextualized with demographic data provided by next of kin for research purposes (the New Mexico Decedent Image Database, NMDID; [37]). We aim to contribute to the growing body of knowledge regarding lived experiences of suffering and social marginalization—including racism, classism, and sexism—by identifying skeletal and dental indicators embodied over lifetimes. We envision leveraging these biomarkers of inequity to reject the dangerous ideas that (a) extreme social marginalization is only evidenced in the remains of non-U.S. peoples [33]; and (b) skeletal differences primarily derive from heredity, rather than the embodiment of the social structures we construct and maintain [38–41].

Our SVP tool will feature lists and descriptions of skeletal and dental biomarkers of inequity that our research identifies and interprets in relation to embodied forms of inequity (Table 1), evaluated in terms of presence/absence and severity on a continuum of expression. Those biomarkers of structural vulnerability may then be evaluated in collaboration with medical or cultural anthropologists, who may help forensic anthropologists to understand and identify the noxious social forces that contribute to poor health and early death in a particular location. For example, biomarkers observed disproportionately among some populations may provide evidence of the embodied consequences of social policies, such as the exclusion of dental care from Medicaid [42] potentially contributing to high rates of antemortem tooth loss among people living in poverty [43].

Sensitive use of the SVP may also enable the identification of positive social forces with the potential to combat these adverse effects. Akin to analyses developed in bioarchaeology (e.g. [44]), the SVP also charts skeletal and dental evidence of care, potentially identifying the structurally supportive systems that may buffer poor health and premature mortality. Pathways of care and resilience, which Panter-Brick [45]: 432 defines as “the process of harnessing key resources to sustain well-being, ” are under-examined compared with analyses of risk and vulnerability; we acknowledge that they may be difficult to identify forensically, unless relevant contextual data are available. Still, focusing on resilience rather than vulnerability or risk invites a “paradigm shift” toward care, strength, and dignity, offering insights into the agentic ways in which individuals persevere in creating good health and well-being despite considerable disadvantage [45]: 438; see also [46].

Addressing the potential for resilience thus aligns with the long-recognized bioarchaeological reality that evidence of disease severe enough to mark skeletal tissues may, paradoxically, indicate an individual’s immunological fortitude [47]. Risk of disease or death is inherently heterogeneous in any population, with differential rates of resilience and survival influenced by varied underlying, persistent, and structural factors [47]. Lived experiences may include biological and social forces that not only have the potential to increase risk of disease or death but also serve to buffer against them. As such, it may be productive to frame correlations between experiences of marginalization and biomarkers of stress or disease as possible evidence of resistance to adversity, rather than victimization by it [35]. For example, in a decedent for whom contextual data and evidence of gender-affirming surgery indicated transgender identity [48–50], evidence of repetitive trauma could indicate a lived experience that included exposure to targeted violence; yet, the very fact that they underwent gender-affirming surgery—prioritizing a costly and invasive surgical procedure regardless of their own socioeconomic status or precarity—could be interpreted as evidence of embodied resilience.

Ultimately, we hope that allied scholars from multiple subdisciplines contribute to the building of structural vulnerability method and theory in tandem with, and complementary to, our work on the SVP tool. Multiple forms of evidence are necessary to elucidate associations between osteological biomarkers, embodied social processes, and peoples’ lived experiences. Ethnographic and archaeological data, coupled with

![Fig. 1. The Structural Vulnerability ProfileSVPwill allow evidence of embodied, lived experiences to be read from skeletal and dental biomarkers.](image-url)
### Table 1 Examples of Structural Vulnerability Profile (SVP) biomarkers with social processes and interpretations.

| Biomarker                                      | Embodied Social Process (es) | Interpretations/Implications of the Lived Experience                                                                 |
|------------------------------------------------|-------------------------------|-------------------------------------------------------------------------------------------------------------------|
| Dental pathological conditions (e.g., abscesses, caries, calculus, antemortem tooth loss) | Lack of access to dental care | Poverty and/or precarious household environment; Labor precarity; Unequal access to safety networks; Unemployment employment in a society dispossessed of safety nets; Treatable conditions allowed to linger and affect dental tissues. |
| Enamel defects                                 | Episodic stress during growth and development | Disease, trauma, neglect or abuse, nutritive or other stress during childhood; Poverty and/or precarious household environment during childhood. |
| Craniofacial asymmetry                         | Episodic stress during growth and development | Disease, trauma, neglect or abuse, nutritive or other stress during childhood; Poverty and/or precarious household environment during childhood. |
| Porotic lesions (e.g., cribra orbitalia, scurvy) | Malnutrition; Vitamin deficiency; Physiological stress | Poverty and/or precarious household environment; Food insecurity; Weakened immune system; Malnutrition; Vitamin deficiency. |
| Active skeletal infections                     | Lack of access to medical care and/or a support network | Poverty and/or precarious household environment; Labor precarity; Treatable conditions allowed to linger and affect skeletal tissues. |
| Severe/un-treated manageable chronic skeletal conditions (e.g., rheumatoid arthritis) | Lack of access to medical care and/or a support network | Poverty and/or precarious household environment; Labor precarity; Manageable conditions allowed to linger and affect skeletal tissues, reducing quality of life or ability to work. |
| Isolated, improperly set fractures             | Lack of access to medical care; Receipt of non-medical palliative care; Undocumented accident, violence, and/or trauma | Poverty and/or precarious household environment; Labor precarity; Patterns of injuries may indicate a social environment characterized by interpersonal violence; Socioeconomic or culturally structured risk. |
| Repetitive fractures or injuries               | May be treated or untreated accident, violence, and/or trauma | Social environment characterized by greater risk of violence; Patterns of injuries may indicate repeated instances of interpersonal violence (e.g., domestic violence, child abuse, elder abuse) or a dangerous occupation. |
| Evidence of surgical interventions             | Treatment of bodily injury (e.g., remediated cranial fracture); Management of chronic pain (e.g., joint replacement, sinus surgery) | Financial security; Access to strong social or structural support networks (e.g., health insurance, social safety nets, familial care and support); Increased risk of opioid use/addiction due to chronic pain before and/or after surgery. |
| Evidence of gender-affirming surgeries         | Transgender or gender-nonconforming (TGNC) identity | Financial security; Access to strong social or structural support networks (e.g., health insurance, social safety nets, familial care and support); Increased risk of opioid use/addiction due to chronic pain before and/or after surgery. |

### Table 1 (continued) Biomarker Embodied Social Process (es) Interpretations/Implications of the Lived Experience

| Biomarker                                      | Embodied Social Process (es) | Interpretations/Implications of the Lived Experience                                                                 |
|------------------------------------------------|-------------------------------|-------------------------------------------------------------------------------------------------------------------|
| Early onset of age-related pathological conditions (e.g., osteoarthritis) | Repetitive and/or physically dangerous work | Death precipitated by neglect of preventable/ manageable condition; Trauma or violence; Or after life-long struggle for health. |
| Early death                                     |                                | Premature decline in health or skeletal weathering; Occupational inequity; Difficult or hazardous workplace with injurious physical labor or hazardous conditions; Culmination of lack of social, economic, and/or familial care. |

The kinds of demographic evidence of suffering the SVP could generate, may illuminate some of the tangled ways in which violence and inequity are embodied and further strengthen claims of systemic failure [5,33,51,52]. For example, medical anthropologists might engage with the SVP to investigate whether untreated childhood dental disease correlates with experiences of chronic stress, life-long patterns of growth, or familial structure. Bioarchaeologists might couple the SVP with biological profiles, isotopic assays on diet or migration, and material cultural data from the mortuary context. They might use the tool to evaluate social inequities among different groups during archaeologically identified periods of colonialism or imperial control, shifting agricultural strategies, famine or plague, violence and warfare, shifts in social or political organization, and the development of complex societies. This approach would allow relationships between socially constructed mechanisms and skeletal stress markers, lesions, or traumas to be identified and named (e.g., classism, racism, migration, sexism) for individuals and populations in prehistory.

Initially, however, our work on the SVP tool will be forensically focused, as we feel that the engagement of forensic anthropologists with the SVP will be particularly powerful. As applied anthropologists, forensic anthropologists report analytical results—frequently about the bodies of individuals who experienced social marginalization during their lifetimes [33,34,53,54]—to stakeholders in a diversity of lay contexts, including medicolegal and law enforcement authorities, lawyers, judges, jury members, and next of kin. Racial inequities exist in many of these systems (e.g. [55–60]), and forensic anthropological reporting has long been complicated by racialized approaches to human variation [61–65]. In a rejection of these racialized approaches, the SVP instead presents a powerful opportunity to make legible to forensic stakeholders the embodied effects of social marginalization. The SVP will reveal evidence of decedents suffering, struggling, and resisting—shared human experiences that will hopefully inspire more humanistic interpretations of skeletal variation, while still enabling identifications and advancing case investigations. Indeed, understanding experiences
of social marginalization for particular groups and individuals can inform multiple facets of forensic casework, from suggesting communities to canvas for leads to considering collective grief and harm-reduction strategies in interactions with next of kin. Importantly, the SVP will enable skeletal and dental biomarkers of embodied inequity become visible not only in past peoples or non-U.S. peoples, but also among current members of the U.S. populace. The U.S. is at a critical moment in which we understand, for example, how racial injustice impacts exposure to and severity of COVID-19 infection among communities of color [67,69]. The lack of recognition among forensic anthropologists that inequity is marked in the hard tissues of modern U.S. peoples—as it does not occur among our citizens—has influenced the interpretation of medical and anthropological data. While we acknowledge the disparities that can exist across borders, inattention to the potential for embodied inequity among U.S. groups can exaggerate the difference between suffering here in the U.S. versus lower-income elsewhere, erasing experiences of Americans’ suffering. As Abu-Lughod [76]: 222 noted in her critique of U.S. military interventions in Afghanistan, “sanctimoniou talk about women’s suffering elsewhere in the world” has served to obfuscate the “terrible inhumanity in our own world.” Deemphasizing socially constructed health impacts among modern U.S. groups has also enabled the reification of categorical races as descriptors of human biological variation [34,70], while ignoring the fact that where race does impact biology, the mechanism is not heredity but embodiment [71,72].

Following DiGangi and Bethard [62] and Ross and Williams [64], we argue that forensic anthropology’s historically typological—and potentially harmful—practice of parsing human variation into racialized categories must cease. Further, since race, racism, and the experience of living in a racialized society are real, we argue that the subdiscipline’s focus must shift from predicting social categories to identifying the biologized factors that stem from living within them. Extending the framework of embodiment to the skeletal and dental tissues of contemporary U.S. peoples will allow us to reject biologically deterministic approaches to human variation altogether. It will open the door for further investigation into how social marginalization impacts quality of life and survivorship and how embodied inequity impacts individuals, families, and communities. It will illuminate the ways in which violence that has been rendered socially invisible (e.g., everyday violence and other aspects of the violence continuum; see [73]) is embodied among members of systematically marginalized groups—including Black, Indigenous, and People of Color, socioeconomically disadvantaged people, people without houses, transgender and nonbinary people, and those struggling with addiction. In addressing the intersectional dynamics of social marginalization on the body in ways that go beyond the biological and behavioral determinants of health [72,74], operationalizing structural vulnerability in forensic anthropological analyses will aid us in identifying ‘upstream’ factors—social, political, economic, and environmental health determinants—de-emphasizing individual behavior and the cultural narrative of ‘personal responsibility’ that undergirds much of the medical gaze [31]. By examining structural processes and policies that cause suffering, injury, and premature death [1,30], we can thus center equity and justice in our research and practice, potentially impacting policy change [75]. Operationalizing structural vulnerability for forensic anthropology has the potential not only to help the discipline to live up to its disciplinary potential, but also to transcend the racist foundations on which it was built.

Declaration of competing interest

None.

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