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Operationalizing the structural vulnerability profile within the medical examiner context

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A B S T R A C T

The medicolegal death investigation process in the United States, historically focused on personal identification and determination of cause and manner of death, has evolved in recent decades to include space for advocacy centered around public health. Particularly, in the domain of forensic anthropology, practitioners have begun to incorporate a structural vulnerability perspective on human anatomical variation, with the goals of articulating the social determinants of ill health and early death and ultimately influencing public policy. This perspective has explanatory power far beyond the anthropological sphere. In this piece, we argue that biological and contextual indicators of structural vulnerability can be incorporated into medicolegal reporting with potentially powerful impacts on policy. We apply theoretical frameworks from medical anthropology, public health, and social epidemiology to the context of medical examiner casework, highlighting the recently proposed Structural Vulnerability Profile developed and explored in other articles in this special issue. We argue that: 1. Medicolegal case reporting provides a valuable opportunity to record a faithful accounting of structural inequities in the annals of death investigation, and 2. Existing reporting infrastructure could, with limited modifications, provide a powerful opportunity to inform State and Federal policy with medicolegal data, presented within a structural vulnerability framework.

1. Introduction

While the intersection of structural vulnerability with forensic anthropological practice has been interrogated for nearly a decade, the potential for the broader medicolegal system to productively apply this framework has been relatively underexplored. In this piece, we argue that a structural vulnerability perspective will amplify the vital roles played by medical examiners, coroners, death investigators, and other forensic practitioners not only in contexts of medicine, law, and justice but also as public health workers. In Box 1, we provide hypothetical vignettes intended to resemble forensic casework scenarios, with the goal of introducing our paper's dual theses: 1. That medicolegal case reporting provides a valuable opportunity to record a faithful accounting of structural inequities in the annals of death investigation, and 2. That existing reporting infrastructure could, with limited modifications, provide a powerful opportunity to inform State and Federal policy with medicolegal data, presented within a structural vulnerability framework.

We begin this piece by providing a brief, practical consideration of the medical examiner system, discussing its role in death investigation and its position reporting to the State. We then provide a theoretical background relevant to the application of a structural vulnerability framework to medical examiner's office (MEO) casework, including theories from social epidemiology, public health, medical anthropology, and biological anthropology. These theoretical frameworks serve to highlight the significance of a structural vulnerability approach for both death investigation and policies of public interest at large. Following Winburn and colleagues (this issue), we detail skeletal and soft-tissue biomarkers relevant to assembling an *SVP* or *Structural Vulnerability Profile* for forensic case decedents. We further outline how these biomarkers, as well as contextual data from scene recoveries, can be recorded by various forensic experts at various levels or stages in the death investigation process. We conclude with an examination of how existing structures for analysis and reporting can serve as a baseline for the application of a structural vulnerability framework.

The call to operationalize the SVP in the medical examiner context is relevant to forensic practitioners in general. This article focuses on the recording of biomarkers of embodied inequity, a practice which is most relevant to forensic pathologists, forensic anthropologists, and other individuals who both work with the physical remains of decedents and have appropriate training in human anatomy and physiology, medicine, or skeletal biology and pathology. However, at the heart of the SVP perspective is the principle that contextual information regarding vulnerability needs to be recorded, not just information observed in

Abbreviations: SVP, Structural Vulnerability Profile; ME, Medical Examiner.

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direct relation to cause and manner of death or identification [1]. The SVP lens is thus applicable to forensic practitioners at large, including autopsy technicians, law enforcement, medical examiners, and coroners, and requires a joint, and on-going, effort by involved parties.

2. Death investigation in the United States: an overview

In the United States, medicolegal death investigation systems include medical examiner (ME) systems, coroner systems, and combinations thereof. The coroner system was inherited from medieval England, during which time Crown-appointed coroners served as local officials that represented the Crown in judicial procedures and investigated deaths to ensure death duties were paid. In today's coroner systems, the first line of death investigation falls to coroners or deputy coroners—positions that are elected and typically do not require medical degrees—who then determine whether the case can be resolved without an autopsy or whether the expertise of a medical doctor, typically a board-certified forensic pathologist, is required. The ME system was later established in the 19th century by supplanting the coroner with appointed medical examiners—positions that require formalized medical training, typically in forensic pathology—and becoming the adopted system by various states and localities [2]. Due to this history, the death investigation system in the United States can take many forms, including a single, state-level, centralized ME office; multiple county/district-based ME offices; multiple county/district-based coroner's offices; or a county-based mixture of ME and coroner offices [3]. Deaths that are sudden and unexplained, suspicious, unusual, violent, and non-natural are typically investigated under these medicolegal systems, with the goal of determining how and why a decedent died, as well as their personal identity if unidentified. While this paper primarily focuses on the application of the SVP approach to the ME system because of the collective purview of the coauthors, we argue that the SVP approach can and should be adapted and applied to all death investigation systems, including coroner systems. We should also note that while our experience is within U.S. systems of death investigation, we anticipate that structural vulnerability approaches could be productively incorporated into death investigation globally.

In ME offices, the personnel responsible for medicolegal death investigation include forensic pathologists, autopsy technicians, forensic photographers, medicolegal death investigators (MLIs or MLDIs), administrators, operations directors, and a cadre of other specialists dependent on the size of the office (e.g., in-house forensic anthropologists, toxicologists, DNA technicians). Generally, investigating the death scene is the purview of the MLIs, and conducting the autopsy is the purview of the pathologists, with other personnel supporting these activities. In many jurisdictions, the ME is the individual responsible for determining a decedent's cause of death (i.e., the precise medical reason for death), manner of death (i.e., natural, accidental, homicide, suicide, or undetermined), and personal identity; while in others, the ME makes recommendations that the coroner ultimately decides.

A combination of state laws, precedent, office protocols, and interests of investigating agencies can dictate whether an autopsy is performed. If not, forensic pathologists may conduct external examinations of the decedent. The information that medicolegal practicioners document for each decedent is also highly context-dependent and depends on the circumstances surrounding the death, state laws, and protocols. For instance, while some offices take standard computed tomography (CT) scans of every decedent at in-take, others only complete imaging (e.g., radiographs) in specific situations, such as in cases of infants and children under two dying of unknown causes or suspicious causes, gunshot wounds, fire, possible neonaticide, or unidentified decedents. In another example, biological samples might be taken for toxicology for every decedent regardless of the circumstances, or the samples might only be collected to help determine cause of death (e.g., in an overdose death) or to clarify circumstances surrounding the death (e.g., drugs in system during pedestrian-involved car accident).

In general, forensic autopsy reports include external and internal descriptions of the decedent, including information related to the cause of death, as well as incidental findings not necessarily related to cause of death (e.g., general demographic information like age, sex, race, ethnicity), congenital anomalies, and evidence of other conditions that may be pertinent to their family's health. The external description of the decedent can include clothing and personal effects; pertinent trace evidence and documentation of collection thereof; physical characteristics including height, weight, scars, and tattoos; evidence of medical treatment; and injuries. The decedent's dentition may be examined and described by the pathologist, if not prevented by rigor mortis, though in some instances a dental examination is performed by an odontologist or forensic anthropologist. For each of these descriptors, the level of detail recorded may be dependent upon the context of the case (e.g., if identity

Box 1
Hypothetical vignettes presenting fictional forensic casework scenarios. Throughout the article, we refer to these vignettes to illustrate how ME data are relevant to public health and could inform public policy.

The three-month-old infant is lying on his back when the death investigator arrives on the scene. In subsequent interviews, however, his mother reveals that when she awoke to find him lifeless, he had been face down in the bed she shares with the baby, her partner, and their two-year-old, wedged between a pillow and his father's arm. The death investigator takes in the cramped and well-worn apartment with broken windows, noting the presence of empty cigarette packs and the absence of a crib. According to standardized reporting forms, he also documents the baby's social race. At autopsy, the pathologist documents evidence of positional asphyxia and ultimately, it is determined that the manner of death is accidental.

The medical examiner's office is compiling data for their end-of-year report, and the administrative assistant inputting data on motor vehicle accidents notices that most of the pedestrian and bicycle fatalities cluster within the same zip code. She recognizes it as corresponding with the southwest edge of town, a neighborhood where the poorly lit streets are characterized by fast-moving traffic and a lack of sidewalks and bike lanes.

In the woods outside town, on the outskirts of a makeshift tent city, a death investigator is taking custody of a decedent's partially mummified remains. An official estimate of postmortem interval will have to wait on the forensic anthropologist, but to the death investigator, time since death seems consistent with last month's cold snap. She writes, "exposure?" in her notes. When the anthropologist's report comes in, it confirms the investigator's rough estimate of time since death and also details a litany of antemortem injuries and infections. There are carious lesions, periodontal abscesses, extensive antemortem tooth loss, poorly set fractures, and evidence of active periosteal inflammation throughout the lower limb.

The identified decedent's official determination of cause and manner await toxicology results, but the scene narrative provides strong evidence of overdose. During external examination, the medical examiner notes the disconnect between the decedent's past dental care and the present lack thereof; a mandibular permanent retainer is still in place, though many posterior teeth have been lost antemortem, and the remaining anterior teeth show evidence of tobacco staining. The medical examiner notes that the decedent is emaciated, observes perioral wrinkling, and comments that he appears considerably older than his documented age of 32 years.

is unknown, decomposition is advanced, or remains are skeletonized).

Recording and utilization of the data collected during autopsy can be just as variable as the death investigation systems themselves, reflecting differences in office policies and protocols as well as differences among individual pathologists' education, training, work experiences, cultural background, and personal preferences. Examples of these differences may include whether CT or radiographic images are taken and analyzed, and whether demographic data like social race, gender, and sex are attributed, versus describing observed skin tones and external genitalia. These recording differences may also vary depending on jurisdiction; for example, standardized forms might conflate social identities, such as gender, with biological classifications, such as sex, and be aggregated into recording systems whose structural rigidity prevents appropriate documentation of transgender or nonbinary decedents [4]. In mixed ME/coroner jurisdictions, officially reported demographic data such as race and gender may come directly from the coroner and conflict with observations made during examination.

Vital data collected from examinations are ultimately used to complete death certificates. While this information is recorded in narrative reports, only some of it is tabulated for statistical analysis beyond death certificates; which of this information is emphasized may also vary from office to office. Some of this information is then aggregated into an annual report and made publicly available, again depending on the jurisdiction of the ME/coroner's office. These reports include summary statistics on general demographic information and death circumstances (e.g., Ref. [5]. Those mortality data are collected by states and compiled by the National Center for Health Statistics (NCHS), which can be used to track national trends and, ultimately, be used to prevent deaths. These data have been used to recognize concerning trends and implement change. For instance, autopsy technician Susan Baker's observation of increased mortality rates among infants compared to older children in car crashes led to laws requiring infant car seats. This in turn led to a decrease in the car crash death rate, hailed as "one of the greatest public health achievements of the 20th century" [6]:xiv). Vital statistics have allowed for the tracking of trends related to homicides, suicides, and accidental deaths and contributed to efforts such as safe work regulations, targeted public health interventions, and recognition of the opioid epidemic [6]. In Kentucky, where some of our coauthors practice, increases in overdose deaths observed from vital statistics have inspired calls to implement a state-wide, comprehensive, multisource drug overdose fatality surveillance system that would more efficiently inform policies aimed at addressing the drug overdose fatality crisis in the state [7]. While forensic pathologists are often primarily categorized as an arm of the criminal justice system, the application of vital statistics in avoiding preventative death among the general population highlights their importance as public health practitioners as well. As we explore below, forensic pathological findings may prove particularly powerful when informed by a structural vulnerability perspective.

3. Structural vulnerability: a theoretical background

Structural vulnerability refers to experiences of "hierarchical processes of discrimination, exploitation, and oppression" that structure suffering and poor health disproportionately among people who experience social marginalization [8,9]., this issue:1). These hierarchical processes influence forces of domination, extraction, and exploitation and result in the structured positionality of groups and individuals [10]. In societies where inequity is maintained along axes such as class, gender, and race, externally generated stressors like marginalization and depreciated status can become *embodied*–physically incorporated into bodies over lifetimes with detrimental impacts on health and wellbeing [11–14]. In the medicolegal sphere, physical violence forms the focus of analyses, but violence can also be embodied more insidiously, via a continuum of social forces. This *violence continuum* [15] includes *direct political violence*, in which oppressive regimes and resisting forces indeed enact physical violence upon bodies. However, the violence continuum also includes *structural violence* [16–18], wherein political and economic structures inhibit the opportunities and potential of marginalized groups (e.g., City-level decisions in Flint, MI leading to significant health impacts on children living in poverty [19]; and *everyday violence* [20], in which violence is routinized, legitimated, and maintained (e.g., societal indifference to unhoused people resulting in a lack of social support networks that could provide healthcare and/or housing and prevent avoidable suffering; [1,21]. The violence continuum also includes *symbolic violence*, through which structurally vulnerable people internalize their marginalized social positions and come to view their place in socioeconomic and political hierarchies as natural, via the process of "depreciated subjectivity formation" [8]:340).

These various and intersecting forms of violence can affect a human body in similar ways to the trauma typically studied by forensic anthropologists and pathologists, leaving behind physical markers that are observable postmortem. In fact, decades of research in medical anthropology and social epidemiology link the embodiment of structural inequity with conditions including cardiovascular disease; psychological distress; cancer, diabetes; COPD; HIV/AIDS; maternal, fetal, and infant mortality; and most recently, COVID-19 [22–29]. This elevated risk of negative health outcomes also occurs as the product of historic systems of inequity, such as structural racism and redlining of marginalized communities, that reconfigure the biocultural environment and subsequently influence behavior. For instance, historical redlining in the United States as a product of structural racism contributes to neighborhood disinvestment including environmental pollution and a lack of easily accessible and affordable healthcare facilities, food stores, social service facilities, and more, and consequently embodied exposures such as health behaviors [30]. Historical redlining in New York City specifically has been associated with an increased risk of preterm birth [30], which itself, then, represents a biological vulnerability contributing to risk of infant mortality [31].

The factors that pattern health disparities in human populations can be conceptualized as the *social and structural determinants of health (SSDH)*, with the former (social) describing the downstream factors that lead to poor health outcomes (e.g., lack of access to housing and medical care) and the latter (structural) describing the upstream causes that shape them (e.g., economic and social policies that dictate working conditions). Shifting the emphasis away from individual decisions and heritable variation, perspectives emphasizing SSDH acknowledge that social conditions structure health outcomes and that the health of vulnerable peoples will only be improved through structural changes in policy and infrastructure [14,32–34]. In clinical medicine, this framework assists clinicians and practitioners to work in solidarity with their communities by highlighting the inequitable systems contributing to poor health outcomes and challenging the stigmatization of structurally vulnerable groups that can negatively impact their care [10,35,36]. Clinical perspectives focused on identifying and aiding structurally vulnerable individuals have also found success, with approaches like Bourgois and colleagues' (2017) Structural Vulnerability Assessment Tool (SVAT) serving to connect patients with social services and care typically conceived as outside of the biomedical purview.

A structural vulnerability framework may be equally relevant in the forensic context. Data recorded by forensic pathologists from the bodies of decedents and context surrounding death and commonly aggregated into annual MEO reports serve to provide insight into public health and safety concerns that contribute to mortality. Various skeletal and dental biomarkers, not currently amassed in these reports, have been established as reliable indicators of embodied marginalization across the life course, especially when contextualized with biocultural stressors, and many of these biomarkers can be seen postmortem [9,37]. Forensic case decedents frequently include individuals who have lived through social marginalization [38–40]. As such, the medicolegal experts who serve them are uniquely poised to observe and describe the skeletal, dental, and soft-tissue impacts of that marginalization. We argue that medicolegal practitioners can play a vital role in articulating social inequities to

the agencies we serve, potentially impacting policy change and improving the social conditions that structure ill health and disease.

To illustrate the utility of employing a lens that centers a structural vulnerability framework, we draw your attention to sudden unexpected infant death (SUID) in the United States. The U.S. Centers for Disease Control and Prevention (CDC) uses the term SUID to describe infants who die a sudden and unexpected death under the age of one, most often happening in a baby's sleep area [41]. The nature of these deaths leads them to fall under the purview of the medicolegal system, as further investigation is warranted. Public health and safety efforts to prevent SUID have commonly focused on educating the public about bed-sharing and proper sleeping areas for infants—in essence, highlighting behavioral risk factors. However, recent research indicates that social and structural determinants of health are equally powerful contributors to differential risk for SUID. In 2019, Bartick and Tomori examined SUID prevalence across historically marginalized populations in the United States, Canada, and Britain, finding that increased infant mortality risk clusters in populations experiencing poverty and discrimination. This concentration of SUID risk in groups already facing externally generated marginalization through economic and social processes reflects how vulnerability can become embodied in behaviors affecting risk. Bartick and Tomori [22] argue that prevention efforts focused on modifying isolated risk factors, such as bedsharing, may have actually diverted efforts from more impactful interventions that account for historically structured inequities that shape SUID's disproportionate prevalence among segments of the population. Intervention practices should rather address the root causes of infant mortality, including poverty interventions and culturally appropriate support to families, to enact real change.

Analyses like Bartick and Tomori's are made possible by the association of contextual, socioculturally meaningful data with infant deaths. Like these infants, other medicolegal decedents are likewise embedded within socio-political contexts which produce vulnerabilities that can subsequently become embodied and contribute to death. Cause and manner of death are largely driven by an interaction between both the biological and social, leading to the different gradients in health, *and death*, across social groups that we can observe in the United States. Yet, the theories underlying the SVP approach also help to highlight why recording data beyond cause and manner of death is relevant to both medicolegal death investigation and broader public health and safety initiatives. The various forms of violence described by the violence continuum act throughout the life course; even early life experiences can alter the trajectory of the body's developing physiology and subsequently an individual's health outcome into adulthood [42]. The forms of violence that disproportionately impact forensic case decedents may translate to chronic stress that can become embodied (Krieger, 2005 [13, 14]; and ultimately lead to *weathering* [24,43,44]—accelerated aging—of bodies, body systems, skeletons, and dentition in ways that are visible postmortem (Walkup et al., in review). As these embodied violences may increase an individual's risk of disease susceptibility [45–47], identifying their postmortem impacts may contribute to an understanding of a decedent's premature death and even influence future measures to prevent such deaths. Postmortem evidence of lived experiences of marginalization may also inform interpretations of circumstances of death, highlighting inequitable housing conditions, socially structured poverty, and other preventable risk factors that put people "in harm's way" [48]:531). Additionally, since postmortem biomarkers of lived marginalization can span not only soft tissue but also skeletal and dental traits, they can reflect various periods of an individual's life and subsequently capture different lived experiences, expanding the limited timescale typically observable in death investigation. The SVP approach also contributes to a better understanding of how aspects of identity, and related marginalization and vulnerability, can interplay and become physically embodied, enabling researchers to move beyond historically essentialized or deterministic understandings of groups of people and associated outcomes [49] and toward more equitable and productive solutions (Winburn et al., this issue). Thus, regardless of a decedent's cause and manner of death, noting postmortem biomarkers of structural vulnerability may be vital to a faithful accounting of both their lives and their deaths.

Therefore, we emphasize the importance of recording multiple skeletal and dental biomarkers (Table 1), along with relevant soft-tissue traits and contextual data from scenes, material evidence, and circumstances of death. In the following section, we discuss how this SVP can be applied to the current medicolegal death investigation system.

4. Forensic anthropology and the SVP

Forensic anthropologists are experts in human skeletal and dental variation, skeletal trauma, and forensic taphonomy who frequently consult for MEs to inform determinations of cause of death, manner of death, and personal identity. The discipline uses established methods that meet the Daubert [50] standard—including general acceptability, established standards controlling the technique's operation and accuracy, a known or potentially known rate of error, and the testability of the procedure—to estimate aspects of the biological profile (i.e., age, population, sex, stature) in an attempt to narrow the pool of possible matching missing persons. Forensic anthropologists also include more subjective descriptions of pathological conditions, trauma, and taphonomic traits to assist with the interpretation of the circumstances surrounding death and deposition. For over a decade, forensic anthropologists have been using indicators of embodied stress to inform these analyses [51]. For example, forensic anthropologists working near the U.S.-Mexico border utilize an investigative model that assesses a set

Table 1
Examples of Structural Vulnerability Profile[a] biomarkers and their visibility.
+ indicates the biomarker is observable at this level; - indicates it is not observable; and
+/- indicates it is sometimes observable depending on variables such as preservation, image quality, etc.
* indicates the expertise of an anthropologist is required.
** indicates the expertise of a pathologist is required.

Biomarker	Levels of Visibility			
	Fully Fleshed	CT Scans	X-Rays	Skeletal
Porotic lesions of the skull (porotic hyperostosis, cribra orbitalia)	–	+*	+*	+*
Craniofacial fluctuating asymmetry	–	+*	+/−*	+*
Oral Health (Overall)	+/−	+	+	+
Caries	+/−	+	+	+
Abscesses	+/−	+	+	+
Antemortem tooth loss	+/−	+	+	+
Calculus	+/−	+/−	+/−	+
Enamel defects	+/−	+/−	+/−	+
Dental treatment (veneers, braces, bridges, etc.)	+/−	+	+	+
Post-cranial porotic lesions (e.g., scurvy)	–	+*	–	+*
Thoracic and lumbar vertebral neural canal size	–	+/−	–	+
Severe/untreated manageable chronic skeletal conditions	+/−*	+*	+*	+*
Isolated, improperly set fractures	+	+	+	+
Repetitive fractures or injuries	+	+	+	+
Evidence of medical treatment (e.g., joint replacement, remediated cranial fracture)	+	+	+	+
Evidence of gender-affirming surgeries	+	+	+/−	+/−
Early onset of age-related pathological conditions (e.g., osteoarthritis)	+/−**	+*	+*	+*
Early age-at-death	+	+	+	+
Overall nourishment/body condition	+**	+**	+/−	–

[a] Most SVP traits in this and the following table come from Table 1 in Winburn et al. (this issue), with the exception of "thoracic and lumbar vertebral neural canal size" and "overall nourishment/body condition".

of identification criteria including geographic context of recovery, personal effects, and cultural material (e.g., clothing type, prayer cards), along with dental pathological conditions linked with chronic stress, in order to estimate the likelihood that a decedent died during migration to the U.S [37,51]. These contextual clues, combined with the traditional biological profile, are used to more effectively identify presumed migrant decedents.

Building on this work, forensic, bioarchaeological, and medical anthropologists have explicitly called for the incorporation of a structural vulnerability framework in forensic analyses and reporting (e.g., Refs. [1,21]. Anthropologists at the University of West Florida have termed this the Structural Vulnerability Profile or "SVP"—a phrase both inspired by the Structural Vulnerability Assessment Tool ("SVAT") of medical anthropology [52] and chosen to contrast with the traditional *biological* profile and its implicit biological determinism (Winburn et al., this issue). Like the SVAT implemented in clinical medicine to foreground questions about social variables (e.g., housing security, food access), the SVP foregrounds the social and structural determinants that pattern skeletal and dental health, disease, and overall variation. These skeletal and dental biomarkers of stress can be contextualized within the biosocial environment to better understand the non-uniform distribution of risk across populations leading to selection bias in who ends up in the medicolegal system and why. As this special issue highlights, forensic anthropologists worldwide are galvanizing around the importance of a structural vulnerability framework for their research and practice.

Despite this move toward an SVP within the discipline, and even though forensic anthropologists have the scope in training to record information about a decedent's lived experiences, standard praxis in forensic anthropology dictates that the only data recorded and reported are those relevant to generating traditional biological profiles, making identifications, and interpreting circumstances of death and deposition. Centralized data repositories exist (e.g., the University of Tennessee's Forensic Databank), but these largely focus on data relevant to estimating adult age, sex, and population affinity. When additional information is recorded for a decedent, it is highly dependent on the situation, and because there is currently no standard or centralized mechanism to aggregate these data, this information can remain 'hidden' in notes. Further, discussions of the SVP and related approaches have as-yet been confined to academic conferences, edited volumes, and peer-reviewed journal publications (e.g., Refs. [38,53]. Thus, structural vulnerability perspectives have generally been incompletely incorporated into death investigation.

It is here that we see great potential. Whether realized or not, many medicolegal practitioners already collect data relevant to establishing whether a decedent experienced structural vulnerability. The primary purpose of the forensic autopsy examination and death investigation is often to establish cause and manner of death, and to record potential forensic evidence for use in the criminal justice system (e.g., descriptive analysis of gunshot wounds). However, important contextual information surrounding the decedent's death is also recorded, including incidental findings relevant to the decedents' families (e.g., congenital anomalies, other illnesses), non-lethal trauma, personal effects, and patterns of physical appearance.

As described in the hypothetical vignettes that preface our article (see Box 1), death investigators collect scene data relevant to interpreting a decedent's socioeconomic precarity or housing insecurity; pathologists make cause-of-death determinations that are definitively patterned by structural inequity (e.g., opioid use, fetal and infant mortality); and forensic anthropologists observe biomarkers indicating lack of access to medical care, dental care, or non-injurious labor. Yet, there is currently no standard mechanism in place for them to report this information, unless it is directly relevant to determining a decedent's identity or cause or manner of death. We propose that annual ME office reports provide a preexisting mechanism for data sharing that forensic anthropologists and other medicolegal professionals can contribute to.

5. Building on existing infrastructure: practical recommendations for implementation and reporting the SVP in the MEO context

Documentation of pathological conditions and anomalies in forensic anthropology is typically reserved to those that could contribute to identification. In their article in the current special issue, Winburn and colleagues lay out a framework for forensic anthropologists to record skeletally and dentally observable biomarkers relevant to interpreting whether a decedent experienced structural vulnerability. In expanding the SVP to the broader MEO context, we recognize that not every office has a forensic anthropologist. However, we propose that not every skeletal and dental biomarker proposed by Winburn et al. (this issue) requires one. In Table 1, we outline each of the proposed biomarkers in the Structural Vulnerability Profile and their potential levels of visibility, including whether they require the expertise of an anthropologist or a pathologist, and whether they are visible on fleshed decedents, skeletonized decedents, or in CT or radiographic images.

We make recommendations for minimum recording standards in Table 2. Pathological conditions and anomalies should be described using standardized terminology, and differential diagnosis should be used to analyze skeletal and dental conditions [54,55]. Other biomarkers can be recorded through minor adjustments to already standard practices in forensic anthropology. For instance, craniometric data could be collected with a 3D digitizer and coordinate data saved for later analysis of cranial fluctuating asymmetry. Another, "overall nourishment/condition of the body" is adopted from ME practices and only observable in fleshed remains or images of fleshed remains. There are significant considerations for how skeletal data should be analyzed, particularly in interpreting what "health" and "stress" mean and how skeletal biomarkers should be interpreted [56]. These considerations are discussed in depth by Gruenthal-Rankin and colleagues (this issue). We argue that without integrating the practice of recording this data into standard forensic anthropological or pathological praxis, interpretations cannot be made.

Structural vulnerability approaches have been increasingly implemented in clinical practice to enable clinicians and public health specialists to recognize social determinants of health and related adverse health outcomes [57]. Described briefly above, the Structural Vulnerability Assessment Tool, or SVAT, is one such approach [52]. The SVAT was designed to be implemented in clinical care as a checklist, enabling the capture of data that highlights the local and broader hierarchies of power relationships involved in affecting patient health [52]. Here, we have adapted the language used in the SVAT in Kaiser Permanente's publicly available Systemic Review of Social Risk Screening Tools to make it both applicable to medicolegal death investigation and comparable across fields (Table 3) [58].

The medicolegal SVAT proposed in Table 3 sets up each data section with a simple, overarching question (bold text), with sub-questions that can also be answered if the data collector has additional information. In Table 3, the "categories" column includes the main domains assessed by clinical and public health practitioners. The "assessments" column provides prompts for data collection. The "data" column provides minimum recommendations for each prompt. Intake forms that include both yes/no/unknown checkboxes and space for more descriptive information could be beneficial for simplifying recording and later data processing. We anticipate that the life history data for the medicolegal SVAT would most likely be collected by medicolegal death investigators or coroners, depending on jurisdiction. These personnel already complete detailed social/contextual histories for certain types of deaths (e.g., infant deaths using the CDC Sudden Infant Death Investigation Reporting Form), so they would be well poised to extend that level of detail to all deaths using the SVAT. However, if any of the SVAT data are documented in the medical records (e.g., in patients seen by Social Services), the medical examiner accessing those records could also add data to the SVAT.

Table 2
Recommendations for minimum recorded data related to the SVP biomarkers.

Biomarker	Recorded Data
Porotic lesions of the skull (porotic hyperostosis, cribra orbitalia)	Present/Absent Active/Healed
Craniofacial fluctuating asymmetry	Digitize 3D cranial landmarks at minimum
Oral Health (Overall)	Condition (good, fair, poor) Teeth = present, some antemortem tooth loss, advanced antemortem tooth loss, edentulous
Caries	Present/Absent Location
Abscesses	Present/Absent Location
Antemortem tooth loss	Present/Absent Location
Calculus	Present/Absent Location
Enamel defects	Present/Absent Frequency
Medical treatment (veneers, braces, bridges, etc.)	Present/Absent Location Type
Post-cranial porotic lesions (e.g., scurvy)	Present/Absent Location Active/Healed Differential diagnosis of condition
Thoracic and lumbar vertebral neural canal size	Vertebra location Maximum anteroposterior and transverse diameters of the vertebral neural canal space
Severe/untreated manageable chronic skeletal conditions (e.g., rheumatoid arthritis)	Present/Absent Location Active/Healed Differential diagnosis of condition
Isolated, improperly set fractures	Present/Absent Location Active/Healed Related conditions (e.g., pseudoarthrosis, malunion)
Repetitive fractures or injuries	Present/Absent Location Active/Healed Related conditions (e.g., pseudoarthrosis, malunion)
Evidence of medical treatment (e.g., joint replacement, remediated cranial fracture)	Present/Absent Location Type
Evidence of gender-affirming surgeries	Present/Absent Location Type
Early onset of age-related pathological conditions (e.g., osteoarthritis)	Present/Absent Location Type
Early age-at-death	Known or estimated age-at-death
Overall nourishment/body condition	Description, e.g., adequately nourished, obese, cachectic, muscular Body mass index could be calculated from height and weight

We acknowledge that all SVAT information will not be readily available for each case; however, attempting to gather as much information as possible would be beneficial. By adapting and mirroring the SVATs already in place in clinical practice, the data collected in medicolegal death investigations can be more easily utilized by and translatable to adjacent fields and practitioners. Additionally, collecting data in this way might help to mitigate potential ethical considerations with how the SVP is implemented in medicolegal casework. For instance, practitioners may be more comfortable collecting and analyzing diverse data that highlights various aspects of an individual's life rather than categorizing decedents as "vulnerable" or "not vulnerable."

As critiqued in Ref. [59]; the Winburn et al. (this issue) call to operationalize the SVP focuses on biomarkers, not recovery context. However, these authors' preliminary work developing structural vulnerability frameworks for forensic science [1] explicitly highlights the importance of material culture, depositional context, and other scene evidence—as well as the protocols necessary to ensure their systematic collection and documentation—to accurate interpretations of decedents' experiences of life and death. We wish to amplify that sentiment here. In addition to the biological traits visible in fleshed and skeletonized decedents, contextual data from scene recoveries can indeed be relevant to an interpretation of a decedent's lived experiences of marginalization (sensu [1,59]. In our third opening vignette of the unhoused decedent (see Box 1), the death investigator immediately speculated about the individual's housing precarity—a conclusion almost certainly contributing to their death due to exposure. In the vignette of the deceased infant, the family's poverty, potentially structured by the economic inequity of U.S. society [60], likely played a role. We argue that these contextual data, along with the life-history data captured in Table 3, can be as powerful as biological data in reporting mortality trends within a structural vulnerability framework.

Forensic scientists can compile SVP data at various levels, including individual reports/casework notes beyond the immediate needs of the forensic report (as forensic pathologists do), or by expanding pre-existing databases of unknowns, or compiling data into end-of-year reports similar to MEO annual mortality reports. This information could potentially be directly added to the annual ME reports in cases where practitioners work in the ME setting; or for forensic anthropologists in academic settings that consult with medical examiner offices, this could be aggregated into an office database until centralized systems are in place to enable data sharing. We recognize that there is variability in death investigation nationally, let alone internationally, and that many jurisdictions have limited means (e.g., staffing shortages, financial limitations) to implement procedures that require specialized training and technology. However, some of the recommended biomarkers (e.g., overall oral health and body condition) are easy to assess and routinely documented in the autopsy report. These data could easily be compiled into the annual reporting.

Basic contextual information and demographic information could be used to summarize and better understand the relationships between demographics and biomarkers, and locality of death for decedents with specific biomarkers could be visualized in map form, similar to how drug-related cases are mapped in the 2018 annual report from Office of State Medical Examiner, KY Justice and Public Safety Cabinet (see Figure 9 in Ref. [5]; https://justice.ky.gov/Departments- Agencies/me/Documents/Old%20Site/2018%20ME%20Annual%20Report.pdf). We are not asking forensic practitioners to complete research on top of their other responsibilities. However, the unified and concerted effort to compile SVP relevant data alongside the work already being completed would allow for future assessments of questions, such as: Is a subset of the population more likely to have certain biomarkers than others? Is this subset more likely to experience a particular cause or manner of death? Does this happen in a particular locality? Do we more often see certain biomarkers co-occurring than others? And above all, how can we address these patterned disparities in morbidity and mortality to achieve greater equity?

We anticipate that critiques of this approach may reference the specter of objectivity—in essence, that the level of social engagement inherent in this work will undermine our scientific distance from the cases we analyze. Yet, decades of research in multiple scientific disciplines—including the forensic sciences— indicate that this long-held ideal of scientific objectivity never existed (e.g., Refs. [61–76]). Rather, the pervasiveness of implicit bias and the theory-laden nature of scientific data render the myth of objectivity obsolete ([77]:100196). This does not, however, mean that forensic science is bad science, or that it constitutes a purely subjective endeavor [78]. Rather, it suggests that a mitigated objectivity approach is warranted [79]. Mitigated objectivity acknowledges the subjectivities and implicit biases inherent in scientific analyses with the explicit goal of constraining them. As applied to the forensic sciences, mitigated objectivity uses strong

Table 3
The medicolegal SVAT: Recommendations for minimum recorded data related to the decedent's life history.

Categories	Assessments	Data
Housing Security	**Did they have a safe, stable place to sleep and store their possessions?**	**Y/N/Unknown**
	What was the zip code of their primary residence?	Zip code
	How long did they live or stay there?	# weeks, months, years
	Was the residence clean, quiet, and protected?	Y/N/U
	Was the residence overcrowded?	Y/N/U
	(For children) Was there a safe, age-appropriate sleeping space?	Y/N/U
Financial Security	**Did they make enough money to live comfortably?**	**Y/N/Unknown**
	How did they make money? Did they have a hard time doing this work?	Y/N/U
	Did they receive any forms of government assistance?	Occupation title
	Did they depend on anyone else for income?	Y/N/U
	Were they unable to pay for medical care or prescriptions?	Y/N/U
		Y/N/U
Risk Environments	**Were the places where they spent their time each day safe and healthy?**	**Y/N/Unknown**
	Were they exposed to violence (one-time incident or regularly)?	Y/N/U
	Were they exposed to regular drug use and criminal activity?	Type and duration
	Did they themselves use alcohol or substances?	Y/N/U
	Were they exposed to any toxins or chemicals in their day-to-day environment?	Type and duration
	Did they experience partner violence (i.e., physical, financial, emotional)?	Y/N/U
		Type and duration
		Y/N/U
		Type and duration
		Y/N/U
		Type and duration
Food Access	**Did they have adequate nutrition and access to healthy food?**	**Y/N/Unknown**
Social Network	**Did they have a supportive community (i.e., friends, family, or other people)?**	**Y/N/Unknown**
	Did they have a primary care provider/other health professional?	Y/N/U
Legal Status	**Did they encounter legal problems?**	**Y/N/Unknown**
	Were they ever arrested and/or incarcerated?	Y/N/U
	Were they undocumented or in fear of deportation?	Y/N/U
Education	**What level of education had they reached?**	**Y/N/Unknown**
	What language(s) could they read or write?	Y/N/U
Recovery Context	**Where was the decedent recovered?**	**Zip Code/GPS Coord.**
	Indoors or outdoors?	Indoors/Outdoors
	What was the nature of the scene (e.g., private residence, public space, clandestine grave)?	Describe
	Relevant contextual information (e.g., if a motor vehicle accident, was decedent a driver, pedestrian, biker, or passenger?)	Describe (and/or link with Investigation Narrative, Scene Report, etc.)
	Were personal effects or other materials present?	Y/N/U Describe (and/or link with list of property, etc.)

methodological standards and effective quality-control measures in order to constrain practitioner subjectivity and enable the attainment of sound and defensible scientific conclusions [78]. Mitigated objectivity allows for an appreciation, and application, of rich theoretical frameworks that underlie data uniquely available in the medicolegal context and uniquely observable by forensic practitioners [77,78,80]. Importantly, this approach also allows forensic scientists to be socially responsible and civically engaged citizens who recognize that their expertise can be applied to solve problems faced by the communities they regularly work with (Clemmons and Winburn, 2022; [81]. Thus, sound scientific conclusions are not undermined when we systematically record skeletal biomarkers, just as they are not compromised when forensic pathologists record other health/disease information not directly related to cause and manner of death. On the contrary, as long as practitioners maintain case integrity (e.g., via reliable techniques and accepted methods, standards to constrain over-interpretation, bias-reduction methods like peer review and linear sequential unmasking), using skeletal stress biomarkers to inform medicolegal death investigation well aligns with the scientific approach of mitigated objectivity.

6. Conclusions

Though not explicitly done through an SVP lens, medical examiner offices already record information relevant to the social and structural determinants of health. For example, end-of-year reports often address mortality trends such as opioid overdoses and infant deaths. However, the likelihood of dying in these contexts is strongly correlated with poverty, racialized social experiences, and other experiences of social marginalization [22,23,25,27,82]. If this critical contextual information is missing from MEO reporting, it prevents a holistic analysis from being undertaken to assess how the violence continuum differentially impacts structurally vulnerable decedents both throughout their lives and at the time of their deaths.

Overdoses, for instance, are the leading cause of injury-related death in the United States, and the majority of these overdoses are related to opioids [41]. In northwest Florida, for example, fentanyl was the drug most commonly detected in forensic case decedents in the year 2022; it was even more common than alcohol [83]. Medical examiners in this region regularly and publicly speak about the opioid epidemic (e.g., in State of the MEO addresses; [83], and we assert that forensic scientists need to amplify this message globally. We can see this effort also occurring in Kentucky, which had the third highest drug overdose fatality rate in the nation in 2015, and where there are efforts to establish a comprehensive drug overdose fatality surveillance system based on ME mortality data (Hargrove et a., 2018b). While these efforts allow for the identification of important details, including which drugs were involved and basic demographic information, these efforts must also specify who is being impacted, and the social factors underlying the disproportionate impacts on structurally vulnerable people.

For our coauthors in Kentucky, it is important to recognize the biosocial context of the state and its residents, which are situated in Appalachia, a region with its own rich and complex history. For instance, communities with a predominately manual labor workforce have higher rates of work-related injuries which, in combination with other factors such as insufficient behavioral and public health services, can contribute to higher rates of opioid misuse and overdose in the region [84]. Appalachia is also unique from other areas of the country in that it has both industrial cities and rural areas, precarious winding roads which make car accidents more fatal, and isolated individuals residing in country hollers where emergency services are not as readily

accessible. These factors likely contribute to differences in demographics and lived experiences among decedents between these areas and those investigated by MEOs in metropolitan areas such as New York City or Houston. By incorporating a standard practice of recording biomarkers of structural vulnerability and contextual information, we can better address questions such as "who is falling ill, who is getting sicker, and who is dying?" to more effectively steer policies and efforts to prevent death.

In our hypothetical case of the infant who died due to positional asphyxia (see Box 1), the investigator already noted factors necessary to employ a structural vulnerability approach; including the crowded conditions of the apartment, the lack of a safe-sleep space, and the fact that the parents were smokers. Not only are these factors related, but they are also socially structured. As highlighted in Bartick and Tomori's [22] discussion on SUID, traditional preventive initiatives without an SSDH-informed perspective could actually be diverting efforts away from impactful interventions aimed at the root causes of unexplained infant death. Poverty, which is in part structured by racism and sexism, contributes to a family's likelihood of living in a crowded apartment; without space or money for a dedicated, safe-sleep space; with family members working multiple jobs, experiencing sleep deprivation, and potentially self medicating—all of which may increase a baby's risk of death. Public health efforts that only focus on teaching the public about behavioral causes for infant death miss the structural forces contributing to unsafe sleep conditions among vulnerable U.S. populations. In nations that have less race-based social inequity, and a smaller wealth gap, dedicated safe-sleep campaigns have led to significant decreases in infant mortality despite bed-sharing practices persisting. Meanwhile, despite the U.S. being a wealthy country, infant mortality rates have stayed disturbingly high, particularly for BIPOC infants [22]. Far from a problem of "individual choice" or "bad decisions," this pattern is socially structured. The information necessary to make connections like this are in part present in current medicolegal reporting practices; now we must highlight the real roots of the problem—social marginalization and structural vulnerability. This could then inform the way that Healthy Start or other service providers conduct their safe-sleep campaigning.

In our vignette concerning pedestrian deaths (see Box 1), motor vehicle accidents cluster in a neighborhood lacking the infrastructure to ensure pedestrian and cyclist safety. In their recent New York Times article, Badger and Parlapiano [85] report how investment in public works like sidewalks, lighting, and bike lanes have decreased pedestrian deaths in most nations. The U.S., however, represents a notable exception, as our infrastructure decisions have created, and perpetuate, a transportation system prioritizing speed rather than safety—a system where "motor vehicles are first, highways are first, and everything else is an afterthought" [85]. When such a system also exists in a sociocultural context of extreme andoften-racialized socioeconomic inequity, as it does in the U.S., people living in poverty die in motor vehicle accidents at disproportionately high numbers [86]. Lower-income people are more likely to live in neighborhoods where high-speed roads are common, and they are more likely to drive older and more dangerous vehicles, if they are able to afford a vehicle at all; they are also more likely to work in occupations that require commuting to a job site rather than working from home [86,87]. The lack of walkable communities means individuals without cars are forced to cross dangerous roads to access basic services like grocery stores [88,89]. These factors translate to lower-income, often BIPOC, individuals dying disproportionately because of transit-system decisions that are made at the level of City or State government [87]. If medical examiners would frame pedestrian and bicycle deaths in this way, they might influence City and State-level decisions about investment in public transit, bike lanes, sidewalks, lighting, and safer cars (sensu [90].

In our hypothetical vignette of the unhoused decedent (see Box 1), the investigator notes the individual's housing precarity but has no defined mechanism to report it. Just as many ME offices currently do for infant deaths, opioid deaths, and motor vehicle accidents, medical examiners could report annual statistics on deaths for which living unhoused was a contributing factor. This information could be coupled with the observed skeletal and dental biomarkers. Perhaps, as is the case in our hypothetical decedent, antemortem injuries and infections suggest that the individual was not able to readily access health care or dental care. Perhaps a few older dental fillings are observed alongside more recent antemortem tooth loss, suggesting they had access to dental care at some point in time, but were unable to access it more recently. Or perhaps there is a pattern that unhoused decedents are at a higher risk of having repeated injuries (e.g., fractures from falls). By reporting the numbers of unhoused people who are victims of everyday violence, Medical Examiner Offices can play public health and public outreach roles, educating the public about their communities in an effort to reduce deaths in a population that is often "unseen in plain sight" [1]:135).

In each of the death contexts explored above, concrete, realistic, and actionable changes could be affected by the presentation of medicolegal data within a structural vulnerability framework. Recording SVP biomarkers and contextual data is thus relevant not only for death investigation, but also potentially impactful for public health, public policy, medical anthropology, and the medical fields. Variations in the data collection and reporting process may occur due to the subjective nature of many of the observations throughout the death investigation process and different standards across the United States for what is considered relevant to stakeholders (e.g., the "cultural profile" implemented by forensic anthropologists at the PCOME). As highlighted before, this can be seen in the aspects of death investigation that deal with the physical remains of decedents, including autopsies and skeletal examinations. Following the scientific epistemology of mitigated objectivity [78,79], we argue that the SVP will serve to constrain some of that subjectivity—allowing for more consistency in recording and therefore more valuable data for analysis. The suggestions for data recording we provide in Table 1 through 3 were constructed with consideration for the needs of a broad range of stakeholders, including forensic practitioners and public health experts, so the data could be translatable to other fields.

Forensic practitioners are last responders, and as such, can sound the alarm to issues directly related to mortality in their communities. This is highlighted by the relevance of death investigation in public health issues such as the opioid epidemic, SUID, and more. There is an existing precedent for recording information through a structural vulnerability perspective, including the contextual situation surrounding a decedent's death and skeletal and dental biomarkers reflecting lived experiences which have already been recorded, albeit indirectly, by other forensic practitioners. Other fields, including social epidemiology and medical anthropology, also have a long history of viewing health and disease information through a structural vulnerability lens to better understand how biosocial factors work synergistically together to induce adverse gradients across the population, with burdens falling along preexisting lines of social inequality [30]. The WHO Commission on Social Determinants of Health emphasizes turning public health knowledge into political action to enact real change [34]. The annual mortality reports completed by medical examiner offices provide a blueprint for how mortality data are already compiled and made publicly available; we argue that further data outlined in this paper should be compiled and reported following this pre-existing framework to allow for future examinations into how death is socially structured and ultimately help minimize preventable suffering. Ultimately, this approach highlights the role of forensic pathologists and anthropologists as public health practitioners, charged with the responsibility of honoring the lessons learned from the deceased by serving the living public at large, in contrast with their often disproportionately emphasized role in the criminal justice system.

Let conversation cease. Let laughter flee. This is the place where death rejoices to help the living. –Giovanni Morgagni.

Credit author statement

Caroline L. Znachko: Conceptualization; Writing – original draft; Writing – review & editing. **Allysha Powanda Winburn**: Conceptualization; Writing – original draft (equal); Writing – review & editing (equal). **Meredith Frame**: Writing - original draft (supporting); Writing – review & editing (supporting). **Sarah Haines**: Writing - original draft (supporting);Writing – review & editing (supporting).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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