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Misgendering a transgender woman using FORDISC 3.1: A case study

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1. Introduction

The Williams Institute estimates that there are at least 1.6 million people over the age of thirteen in the United States (U.S.) who identify as transgender (trans), including 1.3 million adults and 300,000 youth [1]. Trans individuals can be broadly classified as those who identify as a gender other than their assigned sex at birth and is typically understood as an umbrella term which encompasses a myriad of identities and expressions, including but not limited to: trans men and women, non-binary individuals, cross-dressers, genderqueer or gender-fluid people, demiboys, demigirls, and so on [2–6]. The complexity of gendered identities has led to distinct terms being used across academic discourse to refer to this community, such as transgender and gender non-conforming, transgender and gender diverse (TGD), transgender and gender expansive, and transgender and gender variant [7]. It is common for studies to also refer to individuals as their assigned sex at birth, using the acronyms AFAB and AMAB for those assigned female and male at birth, respectively [8]. Due to the fluidity of gendered language and identities, any combination of these terms may be seen throughout this and future works. Alternatively, cisgender refers to an individual whose gender identity aligns with their assigned sex. Unlike trans identities, cisgender is a fixed term that holds this definition consistently. The term sex is much more difficult to define as it has been used socially and by researchers in a myriad of ways that are poorly defined. We advocate for the deliberate use of the term "assigned sex at birth" or ASAB as it embraces the social aspect of defining sex in Western societies while also negating the biocolonialist [9] approach that sex is objectively binary.

While some TGD people express their gender within the binary, their very existence challenges the normalcy of the ASAB and gender binary, directly or indirectly advocating against *cis*-heteronormative structures. In return, society has ostracized and oppressed the trans community, leaving its members to suffer higher rates of addiction, suicidality, discrimination, medical mistreatment, violence, economic hardship, and involvement in survival-based sex work [9,10]. While many have explored the structural vulnerabilities that lead to poor physical and mental health outcomes in the trans community during life, it is not well known how these vulnerabilities present themselves in forensic methodologies involving the identification of TGD people. In fact, forensic research and methodologies have mostly ignored the trans community until recently. Thus, we present a case study involving the anthropological estimation of the ASAB of a trans woman referred to as “Patty.” Following our discussion on the use of a structural vulnerability framework when assessing remains from vulnerable communities, we provide an overview of morbidity in the trans community and how this likely causes them to be overrepresented in forensic casework. Finally, our case study investigates how FORDISC 3.1 classified Patty (i.e., male or female) based on her craniometric measurements. This will allow forensic anthropologists to interrogate current methods used for identification and to decipher how these methods may impact the identification of structurally vulnerable individuals.

1.1. Structural vulnerability

Socio-cultural, -political, and -economic hierarchies within society create structural vulnerabilities which place marginalized groups at risk within their community. Structural vulnerabilities are compounded by misogyny, homophobia, racism, ethnocentrism, and nationalism [11–14]. These may include but are not limited to: violence, financial struggles, difficulty accessing safe housing, isolation, poor health, and

Abbreviations: AFAB, Assigned female at birth; AMAB, Assigned male at birth; ASAB, Assigned sex at birth; TDG, Transgender and gender-diverse; Trans, Transgender.

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Table 1
Antemortem, perimortem, and postmortem risk factors of migrants at th U.S.-Mexico Border and the trans population as presented by Soler et al. [18] [1] and Michael et al. [20] [2].

	Migrant Population [1]	Trans Population[2]
Antemortem	Biological indicators of poverty and physical violence experienced in life and incorporated into the body	Social insecurity Economic insecurity Health disparities
Perimortem	Indicators of structural vulnerability that correlate with the recovery location of deceased migrants and the cause and manner of their deaths	Cause and manner of death Overrepresentation in forensic cases Bias and errors in initial reporting
Postmortem	Indicators of structural vulnerability in the unequal treatment of migrant bodies, including incomplete forensic investigation of their deaths, and the burdensome position of family members with a loved one who died while undocumented.	Analytical limitations Continued issues in reporting and documentation Family relationships

unemployment. Embracing a structural vulnerability framework "provides conceptual guidance for analyzing how intersectional structural oppression produces conditions in which stigmatized groups face threats to their health and survival" [13, p. 2].

Medical anthropology has used a structural vulnerability framework in regard to other cultural groups. For example, Holmes [15] conducted a participant observation study in an agricultural farmworker community in the state of Washington. Following one year with this community, they found that there is a rigid hierarchical structure which places undocumented Mexican migrants at the lowest tier, thus making them the most at-risk. There is an additional layer of a tiered system within the population of migrant workers; contract and hourly field workers are the lowest two tiers, followed by checkers, administrative assistants, supervisors, crop managers, and finally farm executives. The structural vulnerabilities faced by undocumented migrants within this community exposed them to a lower quality of life, with struggles in finding secure housing and poor overall health. These vulnerabilities are then compounded by the marginalization associated with race, ethnicity, and socioeconomic status. Quesada, Hart, and Bourgois [11] also applied the structural vulnerability framework to the migrant population within the U.S., also focusing on those who are laborers. They exhibit that Latin-a/o/x laborers are not only placed at an inferior position within the U.S., but also on a global scale, as they are exposed to financial insecurity, legal persecution, structural racism, and poor health.

Beatrice and Soler [16] were amongst the first to explore how structural vulnerabilities may be embodied in the skeleton. Though they did not directly apply a structural vulnerability framework, the authors examined how the effects of being from a vulnerable population may impact the skeleton. When comparing a sample of remains from unidentified migrants found at the U.S.-Mexico border and non-immigrant U.S. citizens, Beatrice and Soler [16] found that migrants exhibited higher rates of porotic hyperostosis and enamel hypoplasia. Porotic hyperostosis is a paleopathological condition – most often thought to derive from anemia – that results in porous lesions on the ectocranium; enamel hypoplasia is a condition that affects the formation of tooth enamel, resulting in horizontal grooves, pits, or absent enamel [17]. These conditions suggest that the individual may have suffered from prolonged malnutrition and/or other primary pathological conditions (i.e., rickets, parasitic infections) during the juvenile growth and development period, leading to an increased risk of morbidity and premature death (e.g., social determinants of health) [14]. The authors suggest that the identification of these conditions in the skeleton may indicate, at least in Pima County, Arizona, that the remains belong to an undocumented migrant. This argument has its weaknesses, namely because porotic hyperostosis and enamel hypoplasia are not exclusively present in this population. However, these results do indicate that physiological stress resulting from structural vulnerability may be embodied in the skeleton.

Table 2
Challenges in identifying structurally vulnerable groups as outlined by Soler et al. [18] and Michael et al. [20].

Cases may take extra work and a longer time to make a positive identification
Antemortem data may not be easily available to forensic analysts
Public outreach is integral; NamUs or Facebook may be the only avenue for making an identification
Open collaboration with new partners is required
Positive identifications may only be confirmed by consulate or family members
Medicolegal professionals need time to build trust with family and friend

During their American Academy of Forensic Sciences (AAFS) 2020 presentation, Soler and colleagues [18] outlined antemortem, perimortem, and postmortem indicators of structural vulnerability within the skeleton and how they specifically relate to the migrant population at the U.S.-Mexico border (Table 1). Additionally, they noted the complications that may arise when a decedent lived as a member of a structurally vulnerable group, such as those within the migrant population (Table 2). A recent publication by Winburn, Wolf, and Marten [19] recommends establishing and employing a Structural Vulnerability Profile (SVP) alongside the biological profile in forensic anthropology casework and research. Noting the importance of understanding embodied stress in both immigrant and non-immigrant populations, the authors advocate for the use of an SVP which includes a list of biomarkers that are evidence of structural vulnerability in the skeleton: dental pathological conditions, enamel defects, craniofacial asymmetry, porotic lesions, active skeletal infections, severe/untreated manageable chronic skeletal conditions, isolated and/or improperly set fractures, repetitive fractures or injuries, evidence of surgical interventions, evidence of gender-affirming surgeries, early onset of age-related pathological conditions, and premature death [19, p. 100289]. Many of these examples suggest a lack of access to healthcare and other resources. Yet some examples, such as evidence of surgery, also exhibit the social support offered by the decedent's community indicating they were worthy of care. While it is true that undergoing surgery is not necessarily indicative of a strong support system, those who undergo surgery do require some form of community care, funding, or resources to endure and recover from their procedure(s).

Structural vulnerability was first applied to trans decedents by Michael and colleagues [20] in their AAFS 2021 presentation. Adapting the framework presented at AAFS 2020 [18], Michael and colleagues [20] outlined specific risk factors associated with the trans population during the antemortem, perimortem, and postmortem periods (Table 1) and noted that identifying members of the TGD population is associated with the same challenges as identifying individuals who were migrants at the U.S.-Mexico border (Table 2). They also provide strategies for harm reduction which should be incorporated into all forensic analyses for the benefit of not only trans people, but all decedents belonging to vulnerable groups. This presentation was groundbreaking for the forensic anthropology community. It was the first to highlight a structurally vulnerable population that has long been overlooked not only in forensic anthropology, but also in the medicolegal system as a whole. By outlining specific harm reduction strategies to be implemented, these researchers were also the first to advocate for active allyship between forensic anthropologists and the trans community.

Anti-trans structural vulnerability is codified through statutes in the U.S. legal system. In 2021, 130 bills targeting trans people were introduced into 33 state legislatures; 13 of these were enacted into law in 8 different states [7,21]. Even with increased representation of trans people in the media and holding government positions, this heinous trend continued into 2022. For example, Florida's 'Don't Say Gay' bill (HR 1557) passed, which prohibits discussion of all LGBTQ + related topics for students in kindergarten through third grade, amongst other

restrictions [22]. More than 100 other pieces of transphobic legislation were introduced in 35 state legislatures in 2022 [23]. These were often uniquely targeted at trans children, with many legislative acts focusing on trans students playing sports (i.e, HF 2416) [24], bathroom usage in schools (i.e., AL HB 332) [25], mandatory reporting of the LGTBQ + identity of students (i.e., HB 570) [26], and banning minors from seeking gender-affirming care even with a parent's or guardian's consent (i.e., the Texas Department of Family and Protective Services directive which classifies gender-affirming medical care as "child abuse" under state law) [27]. As of February 2023, the Human Rights Campaign (HRC) identified 340 anti-LGBTQ + laws at the state level in the U.S.; 150 of these specifically target trans people, becoming the highest record of anti-trans legislation tracked by the HRC in a single year [28]. While not all legal proposals are approved or remain in effect, they reflect the history of gendered bias within the U.S. which aims to stigmatize and erase trans identities, fueling the culture of hate, violence, and vulnerability surrounding their community [29,30].

1.2. Morbidity of trans people and their prevalence in forensic casework

Structural vulnerability can lead to increased morbidity and mortality, indicating that members of structurally vulnerable groups will comprise a large proportion of forensic cases. However, data on trans mortality within the U.S. has historically not been well documented. Prior to the *Matthew Shepard and James Byrd, Jr. Hate Crimes Prevention Act* of 2009, 18 U.S.C. §249 [31], the U.S. government was not required to track hate crime statistics; this act was the first of its kind and required that the FBI begin tracking data on hate crimes involving juveniles. U.S. law enforcement was not required to track hate crime data involving all ages until 2013 [32]. In 2016, gender identity and sexual orientation were added to the National Crime Victimization Survey (NCVS), an annual survey of U.S. households where individuals are interviewed about their personal experiences with criminal victimization, specifically those related to an aspect of their identity (i.e., race, religion, gender) [33,34]. A statistical report from the U.S. Department of Justice Bureau of Justice Statistics indicates that hate crimes in general are on the rise, including those with victims of gender-based discrimination. Nearly 1,000 respondents to the NCVS between 2013 and 2019 reported being the victims of a hate crime due to their gender identity [35]. However, it can be assumed that there is an underreporting bias within this sample, as many trans individuals likely did not respond to the NCVS over the years due to inaccessibility to the internet or a telephone, fear of reporting to law enforcement, or fear of retaliation from their assailant. Additionally, this information focuses on the experiences of those who are still living, excluding the deceased. There are no national or federally funded databases that track death statistics for the TGD community. Even the National Missing and Unidentified Persons System (NamUs) does not include any indicators for gender expression or variant gender identities within their system, meaning this information may not be added to a person's NamUs case, or these details may be overlooked because gender indicators are not considered necessary or routine information to report. Local medicolegal offices and databases typically follow suit, rarely reporting evidence of gender-affirming surgery or personal effects in their databases and reporting only assigned sex. To mitigate the downfalls of data aggregated by governmental organizations, independent researchers and grassroot organizations have begun tracking death statistics for the TGD community.

The HRC and the Transgender Day of Remembrance (TDOR) have begun collecting data on known trans victims of homicide and premature death. Homicides of more than 200 trans individuals in the U.S. have been recorded by the HRC since 2013, with 2021 being the deadliest year (n = 50) on record [36–39]. Data from TDOR mimics these patterns, with more than 5,000 premature trans deaths recorded worldwide, 83.4% (n = 4210) of which resulted from interpersonal violence. The year 2021 was the second deadliest year (n = 446) on record for TDOR, with 2020 having the most trans deaths (n = 463). In 2022, TDOR recorded 387 premature trans deaths worldwide and the HRC recorded at least six homicides within the U.S. [38,40]. TDOR has recorded at least 140 global deaths of trans individuals in the year 2023, with an extrapolated estimate of 323 deaths for the year. Brazil remains the country with the most trans deaths on record (n = 1870), followed by the U.S. (n = 796) and Mexico (n = 651)[1] [40]. Over the last several years, trans homicides have been recorded in at least 30 states and 100 cities across the U.S. Approximately 4 out of every 5 homicide victims have been trans women of color, with most being Black or Latina/o/x [38,41]. Most recently, the news outlet Insider has compiled a database of 175 trans people killed in the U.S. and Puerto Rico over five years (2017–2021) [42]. Their analysis found that only three of these cases were legally charged as hate crimes, with 61 cases remaining unsolved today. Similar to others, Insider [42] found that communities of color were disproportionately affected, with 85% of the victims being people of color, two-thirds of whom were Black trans women. Crimes against these individuals were less likely to be solved than crimes against those who were White. These numbers likely underrepresent the actual number of trans homicide victims across the country as these individuals are often misgendered by police, forensic analysts, media reports, and even family members [37–39,43]. The HRC reported that between the years of 2017 and 2018 alone, at least 74% of known trans homicide victims were initially misgendered in reports regarding their deaths [44].

Physical and sexual assault, bullying, harassment, discrimination, and family rejection have all been found to correlate with suicidal thoughts and attempts amongst trans individuals, though statistics vary on the true prevalence of suicidality [43,45–47]. A study by Nemoto, Bödeker and Iwamoto [48] found that 32% of trans people under the age of 25 within the city of San Francisco, California had a history of at least one suicide attempt; they also suggest that approximately 64% of trans individuals overall will attempt suicide. These values are much higher than the overall rate of suicide attempts in the U.S., which is 0.5% of the population [49]. As of 2018, the HRC estimated that the rate of suicide attempts amongst trans youth and adults is nine times higher than the national average [36]. A more recent study by Narang and colleagues [50] suggests that the overall range of suicide attempts amongst trans people is less well known, with the suggested rate falling somewhere between 30 and 81%, or 60 to 162 times higher than the general population. It is likely that this range is so large due to the lack of cohesive data on this topic. Despite the uncertainty surrounding the true rates of suicidal thoughts, attempts, and deaths within the trans community, the many forms of violence experienced throughout the lives of trans individuals contribute to staggering estimates. For example, many TGD individuals who consider or attempt suicide had previously sought aid from treatment programs which failed in helping them, often due to discrimination, ill-informed healthcare providers, and/or financial inaccessibility for treatment. It is likely that the remains of many of these individuals were investigated by a forensic practitioner.

Given the heightened violence and levels of mortality facing the trans population, it is likely that trans decedents are overrepresented in forensic casework. To examine this prevalence, Tallman, Kincer, and Plemons [51] conducted a survey targeting Anthropology section members of the AAFS, to which approximately 26% responded. Of those who completed the survey, 28.9% reported working with trans decedents in casework, though most were unfamiliar with evidence indicative of gender-affirming care. Additionally, the nonprofit organization Trans Doe Task Force, with its associated LGBT + Accountability for Missing and Murdered Persons (LAMMP) database, has identified more than 100 cold cases across the U.S. which likely involve trans decedents. These cases have largely been identified based on social transition and personal effects, including reported pronouns, social

[1] All data reported from the Transgender Day of Remembrance website [40] were collected on June 7, 2023.

Table 3
History of Facial Feminization Surgery (FFS) procedures undergone by Patty.

Procedure	Year	Description
Primary Rhinoplasty	2002	Alters the size and shape of the nose, including the nasal bones.
Secondary Rhinoplasty	2003	Alters the size and shape of the nose, including the nasal bones; alters areas of concern from previous rhinoplasty procedure.
Tertiary Rhinoplasty	2009	Alters the size and shape of the nose, including the nasal bones; alters areas of concern from previous rhinoplasty procedures. Tertiary is used for the third or more corrective rhinoplasty.
Sliding Genioplasty	2010	Reshapes and realigns the chin region.
Tracheal Shave	2010	Reduction of the thyroid cartilage (i.e., Adam's Apple).
Gonial Angle Reduction	2010	Reshapes the width and flare of the gonial angle of the mandible, generally reducing the broadness of the overall jaw.
Upper Lip Reduction (Lip Lift)	2010	Reduces and lifts the upper lip.
Orbital Rim Shaving	2010	Shaving, filing, and/or general reconstruction of the orbit.
Browlift	2010	Raises eyebrows to a desired position on the face.
Forehead Contouring Type 3	2010	Reduces the overall size of the glabella region on the frontal bone by removing a section of bone, reducing the bossing, and replacing the bone.
Hairline Lowering	2010	Moves the hairline and associated soft tissue forward on the face.
Cheekbone Reduction	2014	Shaving and contouring of the zygomatic bones to reduce the width of the face.
Cheekbone Reconstruction	2018	Shaving and contouring of the zygomatic bones to reduce the width of the face; alters areas of concerns from previous procedure(s).

media presence, tattoos, and gendered social indicators (i.e., feminine versus masculine clothing) [51–53]. It is clear that there is a large number of trans decedents represented in forensic casework, and many researchers have proposed that these values underrepresent the actual prevalence of trans decedents due again to constraints in data collection.

1.3. Case study

Patty is a 38-year-old, European trans woman living in the U.S. She was AMAB and socialized as such throughout her childhood and adolescence. As a child, family and medical professionals often referred to her as effeminate, expressing concern that she was not as masculine in her appearance and actions as cisgender boys her age. At age 11, an endocrinologist and andrologist began treating Patty with testosterone-based hormonal therapy to masculinize her physical appearance and attempt to cure her gender dysphoria. This treatment lasted until age 14. Patty began identifying as a trans woman at age 15, socially transitioning shortly after with changes in her appearance such as wearing longer hair, makeup, and feminine clothing. Her medical transition began at age 21 and she has since received various gender-affirming medical interventions, including facial feminization surgery (FFS) and estrogen-based hormone replacement therapy (HRT) with anti-androgens.

HRT is the use of estrogen- or testosterone-based medications to enhance and/or suppress physical characteristics most often associated with being AFAB or AMAB. Many trans people use HRT to help alter their physical characteristics to more closely align with their gender identity. Trans women and transfeminine people use estrogen-based HRT to promote a feminine appearance, which may be combined with anti-androgen therapy to suppress masculine traits. Over time, those using HRT can expect to see alterations in their gross physical appearance including a reduction of body hair, decreased muscle mass, increased BMI, and a redistribution of fat [54–57]. The gross effects of HRT on the skeleton are generally unknown beyond alterations in bone mineral density and metabolism, and even these results are often inconsistent. For example, Davidge-Pitts and Clarke [58] indicate that bone mineral density in the lumbar spine of trans women increases with estrogen-based HRT, yet Fighera and colleagues [59] found that there

Fig. 1. 3D-printed skull used to collect Patty's craniometrics. A) Anterior view; B) Inferior view; C) Lateral right view; D) Lateral left view.

was no significant difference in the bone mineral density between cisgender men and trans women at the femoral neck, total femur, or lumbar spine.

FFS refers to the group of cranio-maxillofacial procedures which aim to reduce and feminize the overall size and shape of the face [60]. Trans women often seek FFS to sculpt their faces in a way that will be perceived as naturally feminine by the general public. FFS includes a number of soft and hard tissue alterations which may be done individually or in tandem with one another. The procedures which alter the morphology of the skull specifically include those which change the contour of the forehead, nose, zygomatic arches, chin, and jaw angle [61]. Patty underwent a number of these procedures between 2002 and 2018 (Table 3).

In 2021, Patty approached the University of Nevada, Las Vegas (UNLV) Forensic Anthropology and Bioarchaeology Laboratory (FAB Lab) to discuss the identification of trans people in forensic anthropology. She was curious about the commonly used methods for ASAB estimation, and ultimately questioned how she and others in the trans community would be identified in the instance of their death. Following our discussion, Patty was particularly interested in FORDISC and questioned whether her gender-affirming care was *enough* to classify her as a woman using craniometrics. To investigate this, Patty had a 3D replica of her skull (Fig. 1) printed using a computed tomography (CT) scan from 2019.

The use of CT scans to replicate skeletal material has been broadly accepted because they better reflect skeletal measurements than 2D radiographs and have shown minimal metric and morphological differences to physical bone [60,62,63]. The use of 3D-printed models is an emerging resource in forensic anthropology, with recent years seeing the first-ever literature published on the reliability of these models by Carew and colleagues [64]. According to their study that tested the accuracy of six models of 3D printers, 3D replicas have a mean difference to physical bone of only 0.2–1.2 mm on average, with all differences in the cranium being within 1.0 mm. Additionally, as outlined by Carew and Errickson [65], there are many different applications of 3D-printed models in forensic science, including crime scene reconstruction, ballistic reconstruction, pattern and impression evidence, forensic archaeology sites, forensic medicine, forensic anthropology, forensic taphonomy, forensic odontology, facial reconstruction, and forensic engineering. Carew, French, and Morgan [66] have proposed that 3D tools with applications to the criminal justice system be included in their own field, "3D forensic science (3DFS)". Franklin and Marks [67] discuss that 3D scans and prints may be warranted to preserve skeletal evidence when destructive sampling, such as DNA extraction, from bone if necessary. 3D-printed specimens are also crucial to building modern forensic datasets with replicas that can be utilized for research and teaching purposes.

In the only other forensic anthropology study of trans women and FORDISC, Schall, Rogers, and Deschamps-Braly [60] analyzed the pre- and post-operative craniometrics of eleven trans women who underwent FFS. Using virtual 3D models built from CT scans, seventeen measurements were taken from all samples and further divided into those affected and not affected by FFS for comparative analysis; each set of measurements was put into FORDISC 3.1. Their results classified all preoperative scans from trans women as males; this was unsurprising, yet highlighted the potential to misgender trans people who have not undergone surgery and/or when relying on ASAB classification alone. Post-operative measurements also overwhelmingly classified the individuals as male. Only one individual was classified as a female post-operatively, and this occurred when only FFS-impacted measurements were included; when all available measurements were used, FORDISC classified this individual as a male. Both of these classifications included results with low posterior probabilities and typicalities, increasing the risk that this individual would have fallen into the ambiguous ASAB category in a forensic anthropology report. These results emphasize that even those who have undergone gender-affirming surgeries are at risk of being misiclassified or unidentified using FORDISC software. It is likely that trans people of color are at an increased risk of being mis- or unidentified by FORDISC because their comparative groups/sample sizes within the Forensic Anthropology Data Bank (FDB) are far smaller than for White individuals.

As a child, Patty underwent psychological and medical conversion therapy in an attempt to masculinize her appearance and even her personality. Conversion therapy is the practice of attempting to change an individual's sexual orientation or gender identity through forced means; it is a pseudoscientific practice that has no positive health or identity outcomes. Many juxtapose conversion therapy with torture as it may include isolation, confinement, forced medication usage, deprivation of resources, and elongated pain and suffering [68]. The overall psychological and physical health impacts of conversion therapy are not well documented [69]. During her conversion therapy, Patty was coerced to take testosterone; her doctors convinced her that these hormonal medications would cure her gender dysphoria, something she soon learned was not at all truthful. Though she recalls seeing her physical body change from these medications, the anatomical and physiological effects of the medications on her body, particularly her skeleton, were not well documented. Due to the highly unethical nature of Patty's care as a child, there are also no known studies that discuss the effects of hormonal conversion therapy on the juvenile skeleton. This is unsurprising as research involving the medical coercion of children, particularly those in vulnerable groups (i.e., trans children), would violate bioethical guidelines such as the Nuremberg Code, the Declaration of Helsinki, and the U.S. Common Rule. Therefore, we do not know if Patty's unique medical history impacted her skeletal growth and development. Some studies [i.e., 70–73] have ethically explored the effects of puberty blockers and gender-affirming HRT on the juvenile and adolescent skeleton. Though this literature is overall sparse, the studies that have been conducted suggest that HRT may have varying effects on the immature skeleton, including decreased bone turnover, increased apparent bone mineral density, decreased bone mass, and impacts on geometric bone development [70,71,73].

2. Materials and methods

The second author, who is a board-certified forensic anthropologist in the U.S. (D-ABFA), used the 3D-printed replica of Patty's skull to complete a craniometric assessment following the guidelines established by Langley et al. [74] and Jantz and Ousley [75]. Measurements were taken using a GPM Sliding Caliper (Martin type) and Mitutoyo Digital Spreading Caliper (500-196-30). The replica was printed at a local printing shop that utilized an Original Prusa i3 MK3S+ 3D printer with polylactic acid (PLA) filament; the total print time was 65 h. PrusaSlicer v2.5.0 was used to prepare the 3D model for printing.

Twenty-seven measurements were ultimately taken and input into FORDISC version 3.1.322 [76]. FORDISC is a well-known and long-used linear discriminant function (LDF) analysis software program that may be used to estimate an individual's ASAB, stature, and/or population affinity [76]. To do this, measurements for an unknown variable (i.e., ASAB) are compared to a population of measurements from those with known assigned sex to estimate how similar the unknown individual's measurements are to those from known populations. The 3D skull was printed with the cranium and mandible attached; thus, measurements

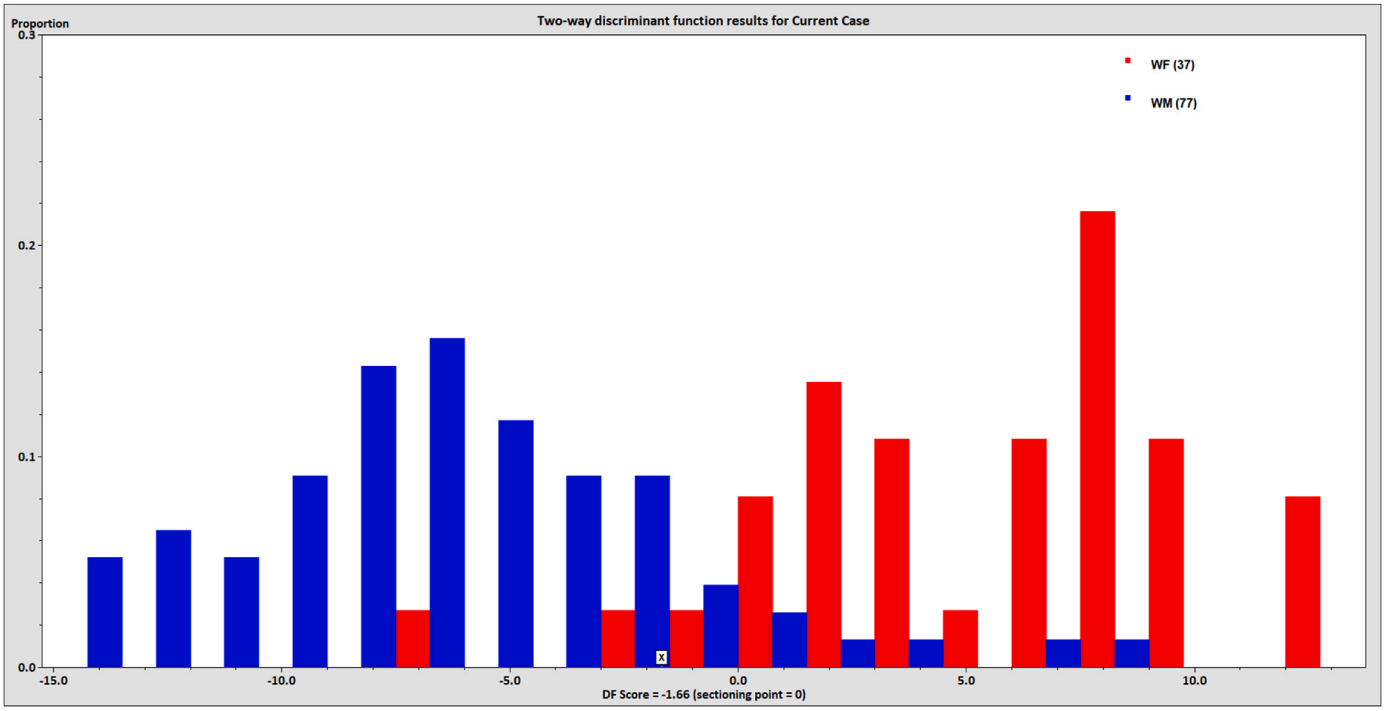

Fig. 2. Histogram of default settings. "X" demarcates case/unknown.

MLN, XRH, and MAN were excluded because the mandibulometer cannot be used accurately when the mandible is not isolated. Measurements MAL, ASB, ZMB, DKB, and MDH were also excluded due to an inability to complete the measurement, most frequently because sutures were difficult to identify due to their fine surface details, such as at dacryon [cf [77]]. Measurements GNI, GOG, GOL, OBB, OBH, EKB, and ZYB were impacted by previous FFS but were still included in the measurements input into FORDISC.

Since Patty was born in Europe and descends from European populations, her craniometrics were compared only against "White[2] Males" and "White Females" within the FDB. This simulates a scenario in which a decedent's population affinity has already been estimated with confidence and, for the purposes of this study, it allows us to control for population and only tests one variable (i.e., ASAB). For two groups (e.g., White Males and White Females), FORDISC uses LDF methods, which produces an LDF score for each group as well as a sectioning point [75]. The one outlier was removed and the analysis rerun. There were 37 White females and 77 White males within the FDB used for this comparison, utilizing all 27 measurements. A histogram was generated within FORDISC to display the distribution and sectioning point of the samples and unknown individual placement. No shape transformation was necessary, as size is the most useful data when classifying males and females of the same group (i.e., "White").

The UNLV Institutional Review Board determined this project to be an excluded activity as it does not meet the definition of "research with human subjects" according to federal regulations, and thus no review was required by the IRB.

[2] Terms such as "White" are socially constructed labels which have historically been used to subjugate those who are Black, Indigenous, and People of Color (BIPOC). When discussing FORDISC and our case study results, we use the term "White" as defined by the FDB: Euro-American and European-born individuals from across the U.S. who were born after the year 1930. We otherwise recognize the racist and oppressive history of race/ancestry/population affinity analysis and stress the limitations of using FORDISC to estimate a decedent's ancestral group or geographic origin, with particular caution extended when working with decedents belonging to BIPOC communities.

3. Results

The LDF scores were 7.171 for White Females and −7.171 for White Males, with a sectioning point of 0. The unknown individual LDF score was −1.663, placing them closest to White Males (Fig. 2). According to the classification matrix on how well the measurements discriminate reference samples, 91.9% of White Females and 92.2% of White Males were correctly classified using these 27 measurements with an overall cross-validation of 92.1%. The individual was classified as a White Male with a posterior probability of 0.841 (Fig. 3). The generally low typicality probabilities suggest that the unknown would be atypical for either reference group (TypF = 0.049; TypChi = 0.000; TypR = 0.064). Due to two of the three typicalities falling below the 0.05 threshold, the hypothesis that this unknown individual's skull belongs to one of these two groups should be rejected.

4. Discussion and conclusion

Estimating ASAB has long been a critical component of the biological profile built by forensic anthropologists. Estimating a decedent's ASAB can presumably eliminate half of the pool of potential identification matches. This presumption is called into question due to the mere existence of TGD people who fall outside of the traditional binary of male *or* female. The case study presented here provides insight into the limitations of forensic methods in identifying TGD individuals. Following a standard craniometric assessment of Patty's 3D-printed skull, FORDISC results suggested that the skull belonged to a "White Male'' despite Patty being a trans woman with extensive gender-affirming care in her medical history. If this skull had been from a decedent in a forensic investigation and craniometrics alone were favored or relied on, her ASAB would have been classified as ambiguous or unknown, again risking her being unidentified. Our findings reflect those of the only other forensic anthropology study of this kind, the aforementioned study by Schall, Rogers, and Deschamps-Braley [60]. Ultimately, their study and ours indicate that trans women are at risk of being misclassified as males by FORDISC. Trans women are not the first group vulnerable to such misclassification. In a study by Dudzik and Jantz [78], it was confirmed

FORDISC 3.1.322 Analysis of Current Case
(FD3CaseFile.adt)
Excluded from samples: ID = F0806
Using cranial data file version 1.24

DFA results using 27 measurements:

AUB	BBH	BNL	BPL	CDL	EKB	FOB	FOL	FRC	GNI
GOG	GOL	HMF	MAB	NLB	NLH	OBB	OBH	OCC	PAC
TMF	UFBR	UFHT	WFB	WRB	XCB	ZYB			

Measurement Checks, Group Means, Discriminant Function Coefficients, Relative Weights

Current Case	Chk	WF 37	WM 77	DF Weights	Rel Grp Imp %	Rel Case Imp %
AUB	**135** **+++**	116.0	123.2	0.295	6.8	9.0
BBH	138	133.6	142.5	-0.320	9.2	0.2
BNL	99	98.9	106.3	-0.138	3.3	4.4
BPL	93	91.8	98.6	-0.053	1.2	1.0
CDL	**130** **+++**	109.5	116.9	-0.063	1.5	2.1
EKB	**105** **+++**	92.2	97.2	-0.360	5.8	5.3
FOB	31	29.4	31.5	0.108	0.7	0.2
FOL	36	34.6	37.6	-0.643	6.2	0.2
FRC	115 +	108.8	114.6	0.174	3.3	3.5
GNI	31	29.0	32.4	0.146	1.6	0.2
GOG	100 +	90.3	98.4	-0.125	3.3	4.9
GOL	181	177.2	187.6	-0.046	1.6	0.8
HMF	31 +	27.4	30.7	-0.759	8.2	5.0
MAB	65 +	57.8	61.5	0.075	0.9	0.6
NLB	25 +	22.3	23.9	0.055	0.3	0.1
NLH	52	48.4	52.6	-0.271	3.7	2.0
OBB	43 ++	39.1	40.6	0.622	2.9	0.8
OBH	**40** **++++**	32.9	33.4	0.301	0.4	0.0
OCC	105 +	96.6	100.4	0.014	0.2	0.1
PAC	111 -	113.0	118.9	0.048	0.9	1.0
TMF	16 ++	10.6	11.9	0.031	0.1	0.0
UFBR	111 ++	99.2	105.3	0.276	5.4	6.1
UFHT	74 +	65.4	70.9	0.089	1.6	1.6
WFB	104 ++	93.2	96.8	0.123	1.4	1.0
WRB	28 -	28.4	31.8	-0.202	2.3	1.4
XCB	**157** **+++**	134.4	141.3	-0.119	2.6	3.3
ZYB	134 +	119.7	129.7	-0.749	24.4	45.2
	Constant			143.320		
	Scores	7.171 (Group means)	-7.171	-1.663 (Case)		

Mahalanobis Distance = 14.341

+/- measurement deviates higher/lower than all group means; ++/-- deviates 1 to 2 STDEVs
+++/--- deviates two to three STDEVs; ++++/---- at least 3 STDEVs

Outliers detected in reference groups: 0

Natural Log of VCVM Determinant = 55.8002

Classification Matrix

From Group	Group Counts	Into Group (counts) WF	WM	Percent Correct
WF	37	34	3	91.9 %
WM	77	6	71	92.2 %
Total Correct:	105 / 114 (92.1 %) *** CROSS-VALIDATED ***			

Two Group Discriminant Function Results

Group	Classified into	Distance from	Probabilities Posterior	Typ F	Typ Chi	Typ R
WM	**WM**	57.9	0.841	**0.049**	0.000	0.064 (74/78)
WF		61.2	0.159	**0.036**	0.000	**0.026 (38/38)**

Fig. 3. FORDISC output of Patty's craniometrics, with outliers removed.

that “Hispanics” were frequently misclassified as “Japanese” within FORDISC 3.1 using the FDB modern samples. Additionally, in a study by Spradley and colleagues [79], postcranial metric estimation using the FDB "American White" reference sample did not estimate ASAB well for “Hispanics” due to this group being generally smaller than "American Whites".

With these results, we stress the adaptation of a biocultural profile in forensic anthropology. Using a biocultural approach, craniometrics alone will be insufficient for estimating the characteristics of an individual. Instead, they will be used as an ancillary tool to other biomarkers and sociocultural indicators (e.g., contextual evidence). For example, if following the SVP outlined by Winburn and colleagues [19], evidence of surgical interventions and gender-affirming surgeries would be noted on Patty’s skull. Recording and analyzing this evidence would broaden the anthropologist’s understanding of the individual both biomedically and socially, likely leading them to question the craniometric results from FORDISC. This is one step toward building a biocultural profile, as the SVP helps investigate if individuals were marginalized during life, providing further insight into their lived experiences. Following the SVP in Patty’s case likely would have helped the anthropologist deduce that she was trans, and the evidence of her FFS would likely have aided in her identification. Assigned sex and gender are conflated in most biological profiles, when in reality anthropological assessments typically correlate only with the individual’s ASAB. A biocultural profile will address these as separate aspects of a person’s identity, one that is biomedically assigned and the other that is culturally defined. This will again provide an all-encompassing analysis of the identity of the person and help to avoid misgendering and misidentification. Along with recording skeletal measurements, pathological conditions, development, and degeneration, a biocultural profile should include comments on sociocultural indicators of identity such as clothing, jewelry, tattoos, social media presence, personal effects, and statements regarding social identity from the decedent’s family, friends, and community.

The number of trans individuals seeking gender-affirming medical care, including FFS, is increasing in the U.S., meaning that forensic anthropologists cannot continue relying solely on anthropometric measurements to classify individuals into an ASAB category. Instead, forensic anthropologists must begin challenging antiquated perspectives of a rigid sex or gender binary. By placing the remains of all individuals into dichotomous ASAB categories, forensic anthropologists ignore the continuum on which skeletal features exist (i.e., human variation), devalue inclusive analyses, and misrepresent the lived experiences of decedents. Additionally, methods used by forensic anthropologists perpetuate culturally constructed “biological sex” as a fundamental aspect of an individual’s identity, centralizing colonialist perspectives and ignoring the multicultural realities in which we as anthropologists work [9]. Forensic anthropologists ought to build a decedent profile with a holistic view rather than a purely medicalized one. This will help anthropologists destigmatize gender non-conformity and recognize that cognitive biases creep into science whether we are aware of them or not. Biases have been reported in estimating the ASAB of cisgender decedents by researchers such as Weiss [80] and Nakhaeizadeh, Dror, and Morgan [81]; thus, we can assume that biases against trans decedents exist at least to the same extent, if not more drastically, in forensic anthropological settings. Additionally, many researchers tend to assume metric assessments are more objective than morphological ones, but as was shown by Hartley, Winburn, and Dror [82] this is not entirely true. Acknowledging the subjectivity that exists within an anthropological analysis of human remains lessens the harm that may be inflicted from medicalizing or pathologizing marginalized bodies.

Our results pose a critical question: What makes a trans woman *woman enough* to be identified correctly in death? The answer should not be deduced only from the observable, physical ramifications of extensive surgery or medical care, which are difficult to access and taxing on the body. It also should not be that an individual’s metrics must fall into anthropologically defined categories of male or female, as these conflate social constructs of masculinity and femininity with individual genetic and epigenetic variability. Rather, the answer is that anthropologists must work to adapt a holistic, biocultural approach to identifying human remains. By using a holistic lens, we can lessen the violence that we perpetuate toward marginalized groups in both life and death, and better identify marginalized individuals including trans women like Patty.

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CRediT authorship contribution statement

Taylor M. Flaherty: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. **Jennifer F. Byrnes:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Antonella Maddalena:** Conceptualization, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – review & editing.

Declaration of competing interest

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