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Forensic sexual assault examination and genital injury: is skin color a source of health disparity?⋆

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Abstract

Purpose—The study objectives were to (1) estimate the frequency, prevalence, type, and location of anogenital injury in black and white women after consensual sex and (2) investigate the role of skin color in the detection of injury during the forensic sexual assault examination.

Methods—A cross-sectional descriptive design was used with 120 healthy volunteers who underwent a well-controlled forensic examination after consensual sexual intercourse.

Results—Fifty-five percent of the sample had at least 1 anogenital injury after consensual intercourse; percentages significantly differed between white (68%) and black (43%) participants ($P = .02$). Race/ethnicity was a significant predictor of injury prevalence and frequency in the external genitalia but not in the internal genitalia or anus. However, skin color variables—lightness/darkness–, redness/greenness–, and yellowness/blueness–confounded the original relationship between race/ethnicity and injury occurrence and frequency in the external genitalia, and 1 skin color variable—redness/greenness —was significantly associated with injury occurrence and frequency in the internal genitalia.

⋆The study was designed and data were collected when the principal investigator (Marilyn Sommers) was a faculty member at the University of Cincinnati. Previous presentation: Injury prevalence preliminary data on a sub-sample and a review of injury detection methods were presented at a podium presentation at the State of the Science Congress in Washington, DC, in October, 2004 and at the Midwest Nursing Research Society, Cincinnati, OH in April, 2005. The difference in skin color and the relationship to methods of injury detection at various anatomic locations were presented at a podium presentation at the Midwest Nursing Research Society, Cincinnati, OH, in April, 2005. Comparisons of injury prevalence across injury detection techniques were presented at State of the Science Congress in Washington, DC, in October, 2006 and Scientific Meeting on the Health Implications of Violence against Women, University of Kentucky in June, 2006. Final study findings have not been presented.

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Conclusions—Although differences exist in anogenital injury frequency and prevalence between black and white women, such differences can be more fully explained by variations in skin color rather than race/ethnicity. Clinical recommendations and criminal justice implications are discussed.

1. Introduction

Of the estimated 6.8 million rapes and physical assaults in the United States each year, 2.6 million result in physical injury and almost 800000 result in the survivor receiving health care [1,2]. Emergency management of sexual assault survivors has 2 primary components: (1) assessment/treatment of injuries and (2) evidence collection. Physical injuries may need treatment so that they heal without adverse consequences. Genital injuries also have a forensic significance in that they are linked to the outcome of criminal justice proceedings [3–5].

The prevalence of genital injury resulting from sexual assault has been found to vary by examination type, ranging from 5% on direct visualization [6] to 87% with colposcopic technique [7]. Investigators have attempted to understand the relevance of sexual assault-related genital injury, as compared with injury resulting from consensual sexual intercourse. They have found a genital injury prevalence ranging from 10% to 73% after consensual sexual intercourse [8–16]. Although investigators have studied genital injury prevalence and location [3,6–8,17–27], few have considered a comprehensive assessment of anogenital injury pattern (frequency, prevalence, location, severity, and type of injury [9,28]), and none have investigated the role of skin color in injury detection.

1.1. Importance

Although examiners are using technologies such as digital imaging to enhance forensic evidence collection, they have not capitalized on the data available in digital images. Digital image analysis (DIA) has the potential not only to increase the accuracy of injury identification and documentation but also improve injury detection across the continuum of skin color. The authors of the national protocol for the forensic sexual assault examination note that it may be difficult to see injury in people with “dark skin,” but they provide no empirical evidence for this statement [29]. In addition, they do not offer techniques to resolve the issue of injury identification when injury is difficult to visualize, nor do they offer a definition of skin color, skin lightness, or skin darkness. Indeed, if individuals with dark skin are less likely than those with light skin to have injuries identified, documented, and treated after sexual assault, a health disparity exists. People with dark skin may not have their injuries treated and will be at a disadvantage throughout the criminal justice system if injury is not detected.

1.2. Goals of this investigation

A proxy population of women after consensual sexual intercourse was used to answer questions about selected aspects of anogenital injury pattern and to determine whether skin color has important implications for the results of the forensic examination. For this phase of our work, the study aims focused on females who self-identified as black (black/African American/non-Hispanic) or white (white/non-His-panic). The specific aims of the study were to (1) estimate the frequency, prevalence, type, and location of injury to the female genitalia and/or anus after consensual sex using visual inspection, a contrast medium (toluidine blue), and colposcopy technique with DIA; (2) evaluate whether injury frequency, prevalence, type, and location of injury vary by race/ethnicity; and (3) evaluate whether differences in injury frequency, prevalence, type, and location of injury between racial/ethnic groups will be accounted for by biometric quantification of skin color.

2. Methods

2.1. Study design, sample, and setting

A cross-sectional, descriptive design was used for the study with a sample of 120 women 21 years or older. Participants were healthy, English-speaking, community volunteers who self-identified as black or white. Exclusion criteria included injury to the genitalia treated by a health practitioner in the last month, pregnancy, hysterectomy, menses at the time of examination, treatment for an abnormal pap smear or sexually transmitted infection in the past 6 months, or history of gynecologic cancer. Participants also were excluded if they had previous abnormal colposcopic examination and/or required cervical surgical procedures. Participants were recruited from an urban health sciences center and its environs by flyers and word of mouth. Interested candidates were screened by phone to determine whether or not they met inclusion/exclusion criteria. All examinations were completed in a digital imaging laboratory at the health sciences center.

2.2. Sampling procedures and selection of participants

Obtaining a probability sample was not feasible, given the nature of the present study. We desired, however, to obtain a sample representative of sexual assault survivors in terms of race/ethnicity, age, and the time interval between intercourse and examination. Data from a large sexual assault survivor registry (N = 761) housed in a Midwestern US regional medical center were used to determine the distributions of race/ethnicity (black, white), age (21–24, 25–34, 35–44, 45–54, 55–64, ≥65 years old), and time interval between sexual intercourse and examination (1–4, 5–8, 9–12, 13–16, 17–20, 21–24 hours). The proportions of survivors in each category were used to guide the number and age of black and white participants that we enrolled, as well as the randomly assigned time intervals between consensual sexual intercourse and the examination. A maximum 24-hour time interval for the examinations was chosen to reduce the effect of injury healing.

2.3. Procedures

Two female nurse sexual assault forensic examiners who had each completed more than 250 forensic examinations including colposcopy and had training by a physician expert, performed all the examinations. Each examiner completed at least 2 sessions with a paid model, and a digital imaging expert before study initiation and was evaluated every 6 months by the physician-expert for examination consistency. Examiners used the ***T***ears, ***E***cchymoses, ***A***brasions, ***R***edness, and ***S***welling (TEARS) classification [9] with the following definitions for injury: *tears* were defined as any breaks in tissue integrity including fissures, cracks, lacerations, cuts, gashes or rips; *ecchymoses* were defined as skin or mucous membrane bruising; *abrasions* were defined as excoriations caused by the removal of the epidermal layer and with a defined edge; *redness* was defined as skin or mucous membrane that is abnormally inflamed due to irritation or injury without a defined edge or border; and *swelling* was defined as edematous tissues. Examiners were not informed that skin color was a variable in the study to reduce their bias.

The study was approved by the affiliated university's institutional review board. Research assistants reviewed the consent document with the participants, after which all participants provided written informed consent. Participants were screened between December 1, 2002, and February 28, 2005, and all examinations were completed by June 30, 2005. Participants who qualified for the study were scheduled for a face-to-face interview, scheduled for an examination, and requested to have consensual sexual intercourse with a male partner at an assigned interval before the examination. The type of consensual sexual encounter was not specified, other than to request that the partners have sexual intercourse.

At a follow-up appointment, self-reported data were collected about the consensual sexual encounter to control for variability among the participants. These data included descriptors of sexual behavior during intercourse, use of lubricants and birth control, length of the encounter, partner penile size, and use of sexual enhancements and/or alcohol and drugs. Participants then underwent a standard forensic sexual assault examination by a trained sexual assault nurse examiner with the research assistant present to assist. A pregnancy test and test for sexually transmitted infections were performed on all participants.

2.4. Methods of measurement

Examinations consisted of visual inspection, colposcopy with digital image capture, and toluidine blue contrast application. For the colposcopy portion of the examination, a Cooper Surgical Leisegang (Lake Forest, CA) colposcope system was used. For the contrast media portion, toluidine blue contrast was applied using a 1% aqueous solution of the contrast medium to the external genitalia and anus and then removed with cotton balls moistened in water-based lubricant. Twenty-six standardized digital images of the skin, external genitalia, and internal genitalia were captured. The standard procedure for all participants included 4 images that were captured after toluidine blue application. With the first group of 55 participants, the camera interface from the colposcope was used, and with the second group of 65 participants, a Hitachi (Tokyo, Japan) KP-D20A high-quality, 1-megapixel color video camera with internal color balance and sensitivity controls was used. Except for an increase in resolution in the second group of images, there were no differences in the imaging protocol between the 2 groups, and analysis of the images from both groups was identical.

As injury prevalence and frequency varied across these examination techniques, results were assessed separately by technique and then combined in order to obtain a total estimate of injury prevalence and frequency for each injury type within each anogenital region. Anogenital injury frequency was defined as the number of injuries counted by the examiner during each aspect of the examination: visual inspection, colposcopy, and toluidine blue application. Injury prevalence was the proportion of participants with an occurrence of injury as calculated from injury frequency, and injury type was determined by the TEARS classification [9]. Anogenital injury location was the anatomical site of injury: external genitalia (labia majora, labia minora, periurethral area, perineum, posterior fourchette, and fossa navicularis), internal genitalia (hymen, vagina, cervix), and anus (anus, rectum).

Measures of skin color were obtained during DIA, which included captured images of the vulvar epidermis or untanned skin of the buttocks (skin color), external genital mucosa at the posterior fourchette (mucous membrane color), and internal genital mucosa at the vaginal wall (vaginal color). Skin color was measured using colorimetric analyses, based on the International Commission on Illumination (or Commission Internationale de l'Eclairage) system of colorimetry [30]. The International Commission on Illumination 1976 (L*a*b*) color space (a geometric model that represents color in terms of intensity values [31]) was used as the model for skin color analysis because it represents colors relative to a white reference point and is used in scientific skin color measurement [30,32–34]. Color values in this model are lightness/darkness (L*), redness/greenness (a*), and yellowness/blueness (b*) [33]. Value L* extends from 0 (black) to 100 (white). Although there are no specific numerical limits for a* and b*, a positive value of a* is red and a negative value is green; a positive value of b* is yellow and a negative value is blue [32].

Biometric measures of skin color were obtained by 2 trained technicians using the colorimetry functions within Adobe PhotoShop CS2 (San Jose, CA) with procedures that are standard for DIA of skin color [35–39]. Each technician recorded at least 9 measurements of L*, a*, and b* values for each tissue location (vulvar or buttocks epidermis, genital mucosa, and vaginal wall) for each participant. Digital image analysis software resulted in values that could be transformed, through either scaling or shifting, into standard L*, a*, and b* values. Two-way, mixed-effects, intra-class correlation coefficients (ICCs) [40] were computed to evaluate the intrarater and interrater reliability of the color measurements for each tissue location. Measurements were averaged (1) within technicians after establishment of acceptable intra-rater agreement (ICC ≥ .90) and (2) between technicians after establishment of acceptable interrater agreement (ICC ≥ .90) to yield a single value for each skin color and tissue type.

2.5. Sample size analysis, data management, and primary data analysis

A sample size analysis [41] indicated that 120 participants were necessary to achieve at least 80% power to detect (α = .05) (1) as small as a 5% change in the odds of injury occurrence associated with a 10-U change in L* color values and (2) as small as a 5% increase in the number of observed injuries (frequency) associated with a 10-U change in L* color values. L* color values were selected as they are the most analogous to white and black skin color, and their values are constrained to fall between 0 and 100, whereas a* and b* values are boundless. All data were double-entered, and all discrepancies were rectified by consultation with the primary author. All statistical analyses were conducted using either the *R* statistical environment (Vienna, Austria) [42] or StatXact-5 (Cambridge, MA) [43].

For each anogenital region (external genitalia, internal genitalia, and anus), multiple logistic and negative binomial regression models were computed to test the specific aim that skin color, instead of race/ethnicity, would be associated with the detection of injury occurrence (presence or absence) and frequency (count), respectively. Because of the sparseness of injury occurrence and frequency (ie, many zero values) within specific injury types (ie, TEARS), the primary outcome variables were respecified as occurrence and frequency of any injury type. Model fitting began with univariable analyses of each outcome regressed on potential covariates—age (year intervals mirroring the previously mentioned sampling strata), race/ethnic identity (black, white), time between consensual intercourse and examination (hourly intervals mirroring the previously mentioned sampling strata), duration of foreplay (minutes), duration of penetration (minutes), contraception use (none, condom, etc), self-reported penis size (1-to-10 scale), and self-reported degree of vaginal lubrication at time of intercourse (1-to-10 scale). Covariates with significant relationships with the outcomes of at least $P < .20$ were retained in multivariable main-effects models. Individual covariates were removed from the main effects models if the likelihood ratio test indicated nonsignificant change in model fit after their removal. An α of .10 was used as the criteria to retain and adjust for covariates that approached statistical significance. However, regardless of statistical significance, race/ethnicity, age, and time interval were retained. After the best-fitting initial models were determined, L*, a*, and b* color values were added to determine if they would confound the relationship between race/ethnicity and each outcome. For injury count outcomes, negative binomial, rather than Poisson, regression models were estimated as the variances significantly exceeded their means (ie, overdispersion) as assessed through likelihood ratio tests (87.12, $P < .01$; 40.81, $P < .01$ for external and internal genitalia models, respectively) [44]. Diagnostic evaluation of the final models indicated no statistical problems with influential data or colinearity.

3. Results

3.1. Characteristics of study participants

From a sample of 253 individuals who were screened, 132 met study inclusion criteria and were enrolled. Four participants did not return for the examination. Data for 8 additional participants were excluded from the study because of pilot testing of instrumentation (n = 2), pregnancy (n = 3), and unusable digital images because of an error in equipment use (n = 3). Thus, interview and examination data for 120 participants remained for statistical analysis. The demographic characteristics of the study sample, stratified by race/ethnicity, are summarized in Table 1.

3.2. Main results

Descriptive statistics for injury prevalence and frequency by injury type, anogenital region, and race/ethnicity are presented in Table 2. The percentage of participants with at least 1 injury (TEARS) after consensual sex identified by the three examination techniques is presented in Table 3. Eight women (5 white, 3 black), were observed to have an anogenital injury by using toluidine blue contrast medium when no injury had been detected with visual inspection or colposcopy. Although 55% of the total sample was observed to have at least one anogenital injury of any type after consensual intercourse, the percentages significantly differed for white (68%) and black (43%) participants (P = .02). However, when the presence of anogenital injury was analyzed within each anogenital region, the significant discrepancy between white and black participants was only evident for the external genitalia (P = .003) and not for the internal genitalia (P = .20) or anus (P = .99).

Color measurements from the epidermis, but not from the vaginal wall or genital mucosa, were found to be significantly related to genital injury prevalence and frequency and were included in the analyses. Agreement both within and between technicians on color values measured from the epidermis was acceptably high (ICCs = .99 for L*, a*, and b* values) to warrant averaging. Independent-samples permutation tests indicated that L* and a* skin color values significantly differed between white (L*: M = 75.31, SD, 6.42; a*: M = 19.86, SD, 6.35) and black (L*: M = 51.90, SD, 12.09; a*: M = 17.72, SD, 5.44) participants, whereas b* values did not (white: M = 20.73, SD, 8.86; black: M = 20.18, SD, 9.27).

Results of multiple logistic regression indicated that race/ethnicity was significantly associated with injury occurrence in the external genitalia (see Table 4). Specifically, a 3-fold increase in the odds of injury detection was observed for white as compared to black females (adjusted odds ratio [AOR], 3.15; 95% CI, 1.38–7.44; P = .0073). In addition, the odds of external genitalia injury among women who used a method of birth control other than a condom were 2 1/2 times greater than among women who used no birth control (AOR, 2.52; 95% CI, 0.93–7.36; P = .0772), approaching statistical significance. However, no covariates, including race/ethnicity, were significantly associated with internal genitalia or anal injury occurrence (results for latter are not presented). When skin L*, a*, and b* values were added to the logistic regression models, higher L* (lightness) and lower b* (less yellowness) values were found to be significantly associated with increased occurrence of external genitalia injury. In addition, after adding color values to the model, the effect of birth control method was no longer significantly associated with injury prevalence. Lower skin a* (less redness) values were associated with an increased odds of internal genital injury occurrence. The effect of race/ethnicity became nonsignificant after adding skin color values to the model predicting occurrence of external genitalia injury, indicating the spurious nature of the relationship between race/ethnicity and injury prevalence.

Before adding color variables to the negative binomial regression models, race/ethnic identity and contraception use were significantly associated with injury frequency, whereas hours between intercourse and examination approached significance (see Table 4). Nearly 3 times the number of injuries to the external genitalia were identified in white as compared with black women (adjusted rate ratio [ARR], 2.94; 95% CI, 1.52–5.80; P = .0012). In addition, compared with women who used no birth control (28%), women who used birth control methods other than a condom (59%; 13% had used a condom) had more than double the number of external genital injuries (ARR, 2.51; 95% CI, 1.09–6.07; P = .0350). The negative effect for hours since intercourse indicated a decline in the number of observed injuries in the internal genitalia as the time between intercourse and examination increased. No demographic or intercourse-

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related injuries were significantly associated with internal genitalia or anal injury frequency. After adding skin color variables, race/ethnicity was no longer a significant predictor of external genitalia injury, again illustrating that the key relationship is between skin color and injury, rather than race/ethnicity and injury. After adding skin color, the relationships for contraceptive use and hours between intercourse and examination remained approximately the same. Higher skin L*, lower b*, and higher a* values were significantly associated with an increased rate of external genital injury. However, higher skin a* values were associated with a decreased injury frequency in the internal genitalia.

An additional set of logistic and negative binomial regression analyses were conducted to determine whether redness and swelling injury subtypes accounted for the differential occurrence and rate of anogenital injury between white and black women as a function of lighter skin in white women. Therefore, in this set of analyses, injury prevalence and frequency were defined only by tears, ecchymoses, and abrasions (ie, excluding injuries classified as redness or swelling). With the exception of 2 findings, results of these analyses were virtually identical to our previous results that suggested the relationship between race/ethnicity, and anogenital injury was confounded by skin color values. First, contraceptive use (specifically, none vs other methods) remained a significant predictor of external genital injury in both the logistic and negative binomial models after adding skin color values. Second, although skin L* values remained a significant predictor of injury to the external genitalia, skin a* and b* color values were no longer significantly associated.

4. Discussion

In a consensual sexual intercourse sample, differences existed in injury prevalence and frequency in black and white females. More importantly, these differences were explained more fully by variations in skin color than by race/ethnicity. We suggest that our findings are likely a result of problems with injury detection on dark skin. This finding is novel and important with respect both to clinical assessment and the decisions made within the criminal justice process. If replicated, it indicates that females with dark skin will not be as likely as females with light skin to have their injuries identified, documented, and treated. In addition, given the importance placed on the presence of injury throughout the criminal justice process, legal proceedings may be less likely initiated for women with dark skin.

The issue of skin color is a socially charged, relatively unexplored factor in injury science. Race/ethnicity have previously been used as a proxy for skin color, but the continuum of skin color clearly overlaps across races and ethnicities. For instance, in both our own sample and in previously reported research [45], blacks had mean L* values lower than whites, but blacks had a broader range of L* values as compared to whites (eg, from the present study: SD for blacks, 12.09, and SD for whites, 6.42).

Little research before this report is available that explores differences in injury prevalence across the continuum of skin color. A careful reading of several reports of anogenital injury prevalence demonstrates that racial/ethnic differences may be present with regard to skin injury. Investigators have found differences in genital injury after vaginal births, with whites more likely than blacks to have third and fourth degree perineal lacerations and tears [46,47]. Authors of published series of sexual assault cases also have found racial differences. In a retrospective review of medical records, Cartwright [48] found that white women of all ages had almost twice as frequent anogenital injuries as black women. Coker et al [49] found that among male sexual assault survivors, their race (being white) was significantly associated with traumatic physical injury when adjusting for other correlates (AOR, 1.6; 95% CI, 1.1–2.4), but among women, injury was not significantly associated with race/ethnicity (AOR, 1.1; 95% CI, 0.9–1.3). From a community sample of sexual assault survivors, Sommers et al [50] found a significant association between race (black vs white) and genital injury (AOR, 4.30; 95% CI, 1.09–25.98; *P* = .03), indicating that the odds for genital injury among whites was more than four times greater than blacks. Thus, differences in injury prevalence between races/ethnicities have been reported, but few investigators have discussed them, and only one mentioned skin color as a factor in injury assessment [50].

We suspect that differences in injury prevalence occur because of difficulties with injury detection in dark skin. An alternative but less likely explanation is that differences in injury prevalence result from differences in the innate properties of the skin based on skin color. This alternative explanation would be based on a theory that dark skin is in some way more elastic, or less likely to be injured, than light skin. Curiously, in spite of well-developed science in the area of skin mechanics [51–56], no investigators report differences in skin elasticity among racial/ethnic groups. Investigators have studied skin elasticity in fair/white subjects with regard to their healed wounds [54] and erythema [55] and have studied the mechanobiologic features of scars in individuals with dark skin [56], but no comparisons of skin elasticity based on constitutive (untanned) skin color differences were found in the scientific literature. Because there is no reason to suspect innate differences in skin elasticity based on the science available to us at this time, we suggest that the differences we found in injury prevalence between races/ethnicities are due to problems with injury detection and not differences in skin elasticity related to skin color.

4.1. Criminal justice implications

Our reported injury prevalence (55% overall) falls within estimates of the reported injury prevalence after consensual sexual intercourse [8,14,15]. Some investigators have previously found an injury prevalence as high as 61% to 73% after consensual intercourse [13,16]. From a criminal justice perspective, the importance of the proof of injury prevalence is relevant for 2 primary reasons. First, during the last 10 years, the annual National Crime Victimization Survey repeatedly has reported that black women have higher rape/sexual assault rates compared to white women [57]. Second, national victimization surveys, including the National Crime Victimization Survey, reported that a reason for a substantial proportion of women not reporting their sexual victimization to the police is the “lack of proof” that an incident happened [57,58].

Forensic documentation of anogenital injuries influences decision making throughout the criminal justice process, especially at pivotal gate-keeping stages. For example, in 2 studies, McGregor et al [4,59] reported that the presence of moderate or severe injury (AOR, 3.33; 95% CI, 1.06–10.42; $P < .0001$) was significantly associated with the filing of charges after sexual assault and specifically, moderate injury (eg, genitalia lacerations, abrasions) was significantly related to the filling of charges (AOR, 4.00; 95% CI, 1.63–9.84). Rambow et al [5] found evidence that the presence of trauma was significantly related to the successful prosecution of sexual assault cases ($\chi^2 = 7.85$, $df = 1$, $P < .01$), and Gray-Eurom et al [3] found that the presence of trauma (OR 1.92; 95% CI, 1.08–3.43) was significantly associated with a guilty conviction in sexual assault cases. Penttilä and Karhumen [60] provided data that demonstrated the association between presence of severe injuries and the defendant being sentenced to prison that approached significance.

Evidence of anogenital injury is a part of a constellation of evidentiary factors of alleged rape (eg, DNA results, presence of a weapon) used by the complainant, law enforcement, attorneys, jury, and judge to make decisions. Further research into the biometric quantification of skin color may improve the validly and reliability of the identification and documentation of anogenital injury, thus affecting the quality of forensic evidence proffered and decisions made throughout the criminal justice process. Forensic evidence based on such improved measurement techniques could be used to corroborate other physical evidence and the victim’s testimony, influence more objective decision making, and ultimately contribute to enhancing the quality of justice for sexual assault victims of *all* skin color, regardless of their race/ethnicity.

4.2. Limitations

Several limitations exist. The sample for the study was composed of community volunteers who underwent a forensic examination after consensual sexual intercourse; thus, there may be biases associated with participant self-selection. Although these findings may not be generalizable to the nonconsensual sexual intercourse population, they did replicate findings of health disparities related to race/ethnicity from a retrospective study of sexual assault survivors [50]. Several variables, such as length of the sexual encounter, degree of lubrication, and penile size, may suffer from measurement error as they are self-report. Two other limitations are important when considering the internal and external validity of the study findings. First, the TEARS classification, although in standard use in clinical practice, has not undergone extensive testing for interobserver reliability. Second, 2 individuals performed all the examinations, and their findings may not be generalizable to other examiners.

Injury prevalence was calculated based on injury identification by 3 methods: visual inspection, colposcopic magnification, and toluidine blue staining. Although these 3 methods are considered state-of-the-art, human error may have led to injury misidentification: injuries may be missed or areas that are identified as injury may be pigment differences or structural changes.

4.3. Clinical recommendations and summary

Skin color plays a significant role in the assessment of anogenital injury and may be a source of health disparity. The novel findings from this study have clinical ramifications for those performing the forensic sexual assault examination. Practitioners need to increase their vigilance when examining individuals with dark skin to ensure that all injuries are identified, treated, and documented. Protocols should include a contrast medium of some sort to increase injury detection, but a need exists for development of alternatives to toluidine blue, a dark blue dye that adheres to abraded skin but does not provide much contrast to dark skin, that will allow for injury identification across all skin colors.

Our results also suggest that quantified measures of skin color are better predictors of injury occurrence and frequency than racial/ethnic identification. Further work is needed with refined biometric procedures and DIA to replicate this work. Measurement techniques then need to be modified for *real world* use so that they can easily incorporated into the standard forensic sexual assault examination in the clinical setting. The technology and imaging procedures used during the forensic examination may need to vary depending on the sexual assault survivor's skin color. We suggest that disparities in injury detection may be a major contributor to the differences in anogenital injury prevalence and frequency in females with light and dark skin after consensual and perhaps non-consensual sexual intercourse. We suggest further that only improved clinical forensic sexual assault examination techniques that are appropriate for survivors across the entire continuum of skin color have the potential to reduce health disparities.

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Table 1

Demographic and sexual intercourse-related characteristics

Characteristic	**Black**	**White**	**Total Sample**
	(n = 63)	**(n = 57)**	**(n = 120)**
Age, mean (SD) (y)	33.3 (9.7)	31.7 (8.1)	32.5 (9.0)
Marital status* (no. [%])			
Single	40 (63.5)	26 (45.6)	66 (55.0)
Married	22 (34.9)	30 (52.6)	52 (43.3)
Other	1 (1.6)	1 (1.8)	2 (1.7)
Frequency of sexual intercourse* (no. [%])			
<1/mo	1 (1.6)	0 (0.0)	1 (0.8)
1/mo	2 (3.2)	4 (7.0)	6 (5.0)
>1/mo	11 (17.5)	5 (8.8)	16 (13.3)
1–2/wk	22 (34.9)	31 (54.4)	53 (44.2)
3–5/wk	27 (42.9)	14 (24.6)	41 (34.2)
1/d	0 (0.0)	3 (5.3)	3 (2.5)
Last sexual intercourse (mean [SD]) (h)	8.0 (6.3)	8.5 (6.5)	8.2 (6.3)
Penis size (mean ([SD]) (1 [very small] to 10 [very large])	6.4 (1.8)	6.5 (1.4)	6.4 (1.6)
Lubrication* (mean [SD]) (1 [dry] to 10 [very lubricated])	7.5 (2.3)	5.9 (2.2)	6.7 (2.4)
Penetration* (mean [SD]) (min)	19.3 (16.8)	12.9 (8.4)	16.2 (13.8)

*Significant differences ($P < .05$) between black and white subgroup means or proportions after independent-samples *t* or χ^2 tests.

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Table 2

Injury occurrence (prevalence) and frequency by anogenital region, injury type, and race/ethnicity for consensual intercourse participants

Anogenital region	Measure	Race/ethnicity	Tears	Ecchymoses	Abrasions	Redness	Swelling
External Genitalia	Prevalence	Total	31 (26%)	0 (0%)	17 (14%)	11 (9%)	0 (0%)
		Black	11 (18%)	0 (0%)	4 (6%)	1 (2%)	0 (0%)
		White	20 (35%)	0 (0%)	13 (23%)	10 (18%)	0 (0%)
	Frequency	Total	59	0	22	17	0
		Black	19	0	4	2	0
		White	40	0	18	15	0
Internal genitalia	Prevalence	Total	3 (3%)	10 (8%)	5 (4%)	16 (13%)	0 (0%)
		Black	1 (2%)	6 (10%)	2 (3%)	6 (10%)	0 (0%)
		White	2 (4%)	4 (7%)	3 (5%)	10 (18%)	0 (0%)
	Frequency	Total	6	12	5	18	0
		Black	1	8	2	6	0
		White	5	4	3	12	0
Anus	Prevalence	Total	5 (4%)	0 (0%)	1 (1%)	5 (4%)	1 (1%)
		Black	4 (6%)	0 (0%)	0 (0%)	2 (3%)	0 (0%)
		White	1 (2%)	0 (0%)	1 (2%)	3 (5%)	1 (2%)
	Frequency	Total	11	0	1	5	1
		Black	9	0	0	2	0
		White	2	0	1	3	1

Prevalence values represent n and (%) of participants with at least one injury and frequency values represent total injury count by anogenital region and injury type for total sample (N = 120) and within each racial/ethnic group (white, n = 57; black, n = 63).

Table 3

Occurrence (prevalence) of at least 1 injury after sexual intercourse by examination technique, anogenital region, and race/ethnicity

Anogenital region	**Race/ethnicity**	**Examination technique**			
		Visual	**Colposcopy**	**Toluidine blue**	**Combined**
All	Black	23 (37%)	22 (35%)	19 (30%)	27 (43%)
	White	33 (58%)	33 (58%)	28 (49%)	39 (68%)
	All	56 (47%)	55 (46%)	47 (39%)	66 (55%)
External genitalia	Black	12 (19%)	11 (18%)	15 (24%)	15 (24%)
	White	24 (42%)	23 (40%)	27 (47%)	32 (56%)
	All	36 (30%)	34 (28%)	42 (35%)	47 (39%)
Internal genitalia	Black	11 (18%)	10 (16%)	2 (3%)	12 (19%)
	White	16 (28%)	16 (28%)	3 (5%)	16 (28%)
	All	27 (23%)	26 (22%)	5 (4%)	28 (23%)
Anus	Black	4 (6%)	5 (8%)	4 (6%)	6 (10%)
	White	3 (5%)	3 (5%)	4 (7%)	5 (9%)
	All	7 (6%)	8 (7%)	8 (7%)	11 (9%)

Values represent number of cases with at least 1 injury and (%) for total sample (N = 120) and within each racial/ethnic group (white, n = 57; black, n = 63).

Table 4

Analysis of injury occurrence (prevalence) via logistic regression and injury frequency via negative binomial regression by anogenital region before (models 1) and after (models 2) adding skin color values (N = 120)

Anogenital region	Model	Predictor	Logistic			Negative binomial		
			AOR	95% CI	*P*	ARR	95% CI	*P*
External genitalia	1	Race/ethnicity	3.15	1.38–7.44	.0073	2.94	1.52–5.80	.0012
		Age	0.91	0.60–1.35	.6474	1.02	0.74–1.42	.8795
		Hours since intercourse	0.89	0.68–1.15	.3813	0.84	0.68–1.03	.0996
		No contraceptive vs condom	1.42	0.33–5.89	.6302	2.24	0.75–6.86	.8795
		No contraceptive vs other Method	2.52	0.93–7.36	.0772	2.51	1.09–6.07	.0350
	2	Race/ethnicity	1.14	0.31–4.18	.8422	1.01	0.38–2.69	.9885
		Age	1.00	0.65–1.51	.9975	1.03	0.76–1.40	.8193
		Hours since intercourse	0.86	0.64–1.14	.3119	0.83	0.67–1.01	.0641
		No contraceptive vs condom	1.22	0.26–5.51	.7990	1.67	0.56–5.09	.3709
		No contraceptive vs other method	2.42	0.82–7.68	.1166	2.62	1.14–6.50	.0275
		Skin L* value	1.06	1.01–1.11	.0192	1.04	1.00–1.08	.0364
		Skin b* value	0.94	0.89–0.99	.0268	0.94	0.89–0.99	.0067
		Skin a* value				1.10	1.02–1.19	.0148
Internal genitalia	1	Race/ethnicity	1.37	0.55–3.46	.5052	1.64	0.76–3.59	.2047
		Age	0.97	0.63–1.46	.8804	1.03	0.70–1.50	.8534
		Hours since intercourse	0.97	0.73–1.28	.8468	0.97	0.76–1.24	.8171
	2	Race/ethnicity	2.30	0.85–6.54	.1073	2.10	0.99–4.57	.0508
		Age	1.14	0.72–1.77	.5746	1.11	0.77–1.58	.5642
		Hours since intercourse	1.04	0.75–1.41	.8301	1.01	0.78–1.27	.9747
		Skin a* value	0.80	0.71–0.89	.0002	0.89	0.82–0.95	.0010

ARR, adjusted rate ratio. Model 1 does not include skin color variables as predictors. Model 2 includes skin color variables as predictors.