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Title: Factors associated with trace evidence analyses and DNA findings among police reported cases of rape

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Keywords: Sex offenses; crime victims; medico-legal aspects; clinical forensic medicine; biological forensic samples; spermatozoa; DNA detection

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Abstract: Objective: The aim of this study was to examine the association between victim, suspect and assault characteristics and 1) forensic analysis of trace evidence, 2) detection of spermatozoa and 3) DNA match in police-reported cases of rape/attempted rape. In addition, we explored whether DNA findings were associated with legal outcome.

Methods: We conducted a retrospective, descriptive study based on police-reported rapes and attempted rapes of women  $\geq 16$  years of age in Sør-Trøndelag Police District throughout 1997 - 2010. Police data were merged with information from the Sexual Assault Centre (SAC) at St. Olavs University Hospital, Trondheim, Norway. We used binary and multivariable logistic regression for the comparisons.

Results: We identified 324 victims (mean age 24 years). The police requested analysis in 135 (45%) of the 299 collected victim samples. The police decision to analyze was after adjustment associated with the victim being employed or under education, and a public venue, but not with interval from assault to sampling. Spermatozoa were detected in 79 (61%) of the analyzed cases, of which 71 were collected from victims within 24h. Interval from assault being  $< 24$ h and reporting a penetrative assault remained associated with the findings of spermatozoa after adjustments. Forensic analyses of trace evidence collected from victim, suspect and/or venue disclosed matching DNA profiles in 57 (40%) of a total of 143 analyzed cases. Matching DNA profiles were associated with suspect being known to the victim and with the venue being private. A higher proportion of cases with a DNA match were prosecuted in court: 20 of the 29 cases prosecuted. However, despite a DNA match 35 cases were anyway dismissed because of insufficient evidence.

Conclusions: Although many of the associations in our study were expected, it is still important to report the actual numbers to gain insight into the importance of a DNA match in legal proceedings. A substantial proportion of cases with DNA match was dismissed because of insufficient evidence. To strengthen the justice response to sexual

assault, it is essential to generate knowledge about the role of medico-legal evidence in such cases, and there are obviously other non-medical factors influencing the legal decisions.

### **Acknowledgements**

Thanks to Berit Marianne Bjelkåsen at the Unit of Applied Clinical Research at the Norwegian University of Science and Technology who has kindly provided the web-based registration form and converted it to an SPSS-file. Thanks to the newly deceased Senior Researcher and Psychologist Jim Aage Nøttestad for securing basic research funding making this project possible and for comments which were always inspiring and cheerful. Thanks to the students Katharina Frydendal Pedersen, Karen Løhre, and Anna Hjorth-Hansen who participated in the registration of the hospital data, and to the students Amalie Steinsbekk, Amanda Rygvold, Ingvild Johansen, and Eirik Alberto Brattheim for reading and recording the police data.

## Cover letter

Trondheim, Norway, December 23, 2016

For the submitted manuscript:

### **Factors associated with trace evidence analyses and DNA findings among police reported cases of rape**

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## **Study relevance**

Low threshold, specialized sexual assault centres (SACs) should provide acute medical care to victims of sexual assaults and disclose medico-legal findings important for both the woman's health and legal interests. The forensic medical examination can provide crucial evidence in the investigation and prosecution of a rape. Even if forensic evidence has been collected by medical staff, it is up to the police investigators to request it to be analyzed. Two Nordic studies report that trace evidence is analyzed by the forensic laboratory only in 51 – 57% of the cases.

Nowadays, the police tend to request more analyses, but still much trace evidence remains unclaimed at the SAC. Little is known about how the police select cases to be submitted for analysis. Previous research indicates that the police are considering contextual factors in their decision.

Research focusing on medico-legal evidence in sexual assault is scarce. Studies published so far from SACs or police case series mostly focus on sociodemographic data, assault characteristics, relationship between victim and perpetrator, and injuries. Only a few rape case series worldwide report the results of forensic analyses, like spermatozoa/seminal fluid and matching DNA profiles and even rarer are medical studies describing in detail factors associated with these miscellaneous forensic genetic findings. The aim of this study was therefore to examine whether certain victim, suspect and assault characteristics were associated with 1) police requesting forensic analysis of trace evidence, 2) detection of spermatozoa and 3) DNA match in police-reported cases of rape/attempted rape. In addition, we explored whether DNA findings were associated with legal outcome.

We present a 14 years' case series of police-reported rapes and attempted rapes on women  $\geq 16$  years of age in one Norwegian police district using merged data police files and from hospital SAC records. We identified 324 victims with mean age 24 years police-reporting their sexual assault and having medical records at the SAC.

## **Highlights of the findings**

- Police requested analysis in 135 of the 299 collected victim cases
- Spermatozoa detected in 79 of analyzed victim cases, 71 of these within 24h
- Victim/suspect/venue trace evidence disclosed matching DNA profiles in 57/143 cases
- Matching DNA profiles were associated with known suspect and a private venue
- A higher proportion of cases with a DNA match were prosecuted in court

## **Why the journal *Forensic Science International*?**

We submit this article to *Forensic Science International* as the journal aims at publishing original research papers on forensic and medico-legal issues, including research regarding sexual assault and rape.

The study is about trace evidence analysis, and includes information regarding samples collected from both victim, suspect and/or venue of spermatozoa, epithelial and blood cells, and matching DNA profiles.

Even if retrospective, this 14 years' case series reporting from police-reported rapes should be of interest for several fields, including different health care personnel performing sexual assault examination after rape, family medicine and general practice, clinical and forensic gynaecology, forensic genetics, as well as for the police and the prosecuting authority dealing with sexual assault and rape. In addition, the results may be valuable to policy-makers operating in the field of public health and/or justice.

### **Related papers, thesis and abstracts published or submitted for publication**

The following related publications have been published:

#### *Papers*

- Hagemann CT. et al. "Impact of medico-legal findings on charge filing in cases of rape in adult women" published in *Acta Obstetrica et Gynecologica Scandinavica*<sup>1</sup>

#### *Master and Ph.D. Theses*

- Forr C. "Factors associated with trace evidence analysis and DNA findings among police reported cases of rape". Graduate thesis in Medicine, Norwegian University of Science and Technology; 2016<sup>2</sup>
- Haraldseide TM. "A comparison of intimate partner assailants and non-partner assailants among police reported rapes and attempted rapes in the Sør-Trøndelag police district" Graduate thesis in the clinical psychology program. Norwegian University of science and technology; 2015<sup>3</sup>
- Hagemann CT. "Medical findings and legal outcome among postpubertal women attending the Sexual Assault Centre at St. Olavs Hospital, Trondheim, Norway. A record-based study from 1997–2010". Ph.D thesis at the Norwegian University of Science and Technology; 2014<sup>4</sup>

#### *Abstracts*

- Forr C, Schei B, Stene LE, Hagemann C. "Factors associated with trace evidence analysis and DNA findings in police-reported cases of rape" presented orally at the 5th International Conference on the Survivors of Rape; September 29 - October 1, 2016; Stockholm, Sweden<sup>5</sup>
- Hagemann C, Forr C, Stene LE, Ormstad K, Myhre AK, Nøttestad JA, Schei B. «Norwegian police-reported rapes against adult females: Changes in characteristics in two time periods" presented orally at the 5th International Conference on the Survivors of Rape; September 29 - October 1, 2016; Stockholm, Sweden<sup>6</sup>

### **Figure and one table in the Main Manuscript**

In the main manuscript, one figure and one table are included. The two remaining tables are submitted in a separate document, named Table.

In addition to the main manuscript and the Table, the Title page, the Highlights, the Acknowledgments are submitted in separate files, together with this Cover letter.

### **Submission declaration**

The authors declare that the material presented has not been published previously and is not under any simultaneous consideration for publication elsewhere, except in the form of abstracts of preliminary results (and guidelines) that have been presented in an oral

conference session. If accepted, the manuscript will not be published elsewhere in any language.

All authors have approved the submitted version of the article. The responsible authorities where the work is carried out have also approved publication.

The authors vouch for the accuracy of the manuscript.

### **Individual contribution to Authorship**

CF is the main author. She made substantial contributions to data collection and registration of the forensic genetic laboratory data from police files, data analyses, interpretation of data, and to the drafting and revision of the manuscript. BS was the initiator of the study. CH has been the main supervisor for CF who has been working with this manuscript as part of her master thesis in medicine at the NTNU. KO contributed to the discussions of project plan, participation in manuscript preparation and revision. LS contributed to data collection and registration of the forensic genetic laboratory data, data analyses, and interpretation of data from the first project period (1997 – 2003) and to the drafting and revision of this manuscript. In total, all authors have contributed to study design, interpretation of the data and to the drafting and revision of the manuscript.

### **Ethical approval**

The SAC data collection study was approved by the Regional Committee for Medical and Health Research Ethics, Central Norway (REK-Midt), Approval Number 2010/1941.

The police data collection studies (1997 – 2003 and 2003 – 2010) were approved by the REK-Midt, Approval numbers 092/04 and 2011/276 respectively.

For the approval of collection of the police data (1997 – 2003), additional permission was obtained from the Norwegian Director General of Public Prosecutions, and the Norwegian Data Protection Authority provided a license so that the study could be performed with an exception from the principle of informed consent. In addition, the study was approved by the Data Protection Officer at the Norwegian Social Science Data Services.

### **Conflict of interest**

None of the authors have any conflict of interest by publishing this article.

### **Funding**

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## **The role of the funding sources**

The funding sources have no involvement in the study design, data collection, data analysis and interpretation, in writing of manuscript or the decision to submit, except for approving the initial and revised study protocols.

## **Patients' consent**

This is a retrospective, descriptive study with information collected from patients' hospital records. The study was approved by the Regional Committee for Medical and Health Research Ethics. According to instructions from the committee, all patients eligible for inclusion received a letter of information about the study with instructions on how to withdraw their information. Those not wanting their medical records used in the study were excluded. (The so-called "passive consent" was approved for this study.)

## **Acknowledgements**

Thanks to Berit Marianne Bjelkåsen at the Unit of Applied Clinical Research at the Norwegian University of Science and Technology who has kindly provided the web-based registration form and converted it to an SPSS-file. Thanks to the newly deceased Senior Researcher and Psychologist Jim Aage Nøttestad for securing basic research funding making this project possible and for comments which were always inspiring and cheerful. Thanks to the students Katharina Frydendal Pedersen, Karen Løhre, and Anna Hjorth-Hansen who participated in the registration of the hospital data, and to the students Amalie Steinsbekk, Amanda Rygvold, Ingvild Johansen, and Eirik Alberto Brattheim for reading and recording the police data.

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4. Hagemann CT. Medical findings and legal outcome among postpubertal women attending the Sexual Assault Centre at St. Olavs Hospital, Trondheim, Norway. A record-based study from 1997–2010. Norwegian University of Science and Technology, 2014.
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6. Hagemann C, Forr C, Stene LE, et al. Norwegian police-reported rapes against adult females: Changes in characteristics in two time periods. 5th International Conference on the Survivors of Rape. Stockholm, Sweden: the Emergency Center for Rape Victims at Stockholm South General Hospital, 2016.

# **Factors associated with trace evidence analyses and DNA findings among police reported cases of rape**

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## Highlights

- Police requested analysis in 135 of the 299 collected victim cases
- Spermatozoa detected in 79 of analyzed victim cases, 71 of these within 24h
- Victim/suspect/venue trace evidence disclosed matching DNA profiles in 57/143 cases
- Matching DNA profiles were associated with known suspect and a private venue
- A higher proportion of cases with a DNA match were prosecuted in court

## Abstract

**Objective** The aim of this study was to examine the association between victim, suspect and assault characteristics and 1) forensic analysis of trace evidence, 2) detection of spermatozoa and 3) DNA match in police-reported cases of rape/attempted rape. In addition, we explored whether DNA findings were associated with legal outcome.

**Methods** We conducted a retrospective, descriptive study based on police-reported rapes and attempted rapes of women  $\geq 16$  years of age in Sør-Trøndelag Police District throughout 1997 – 2010. Police data were merged with information from the Sexual Assault Centre (SAC) at St.Olavs University Hospital, Trondheim, Norway. We used binary and multivariable logistic regression for the comparisons.

**Results** We identified 324 victims (mean age 24 years). The police requested analysis in 135 (45%) of the 299 collected victim samples. The police decision to analyze was after adjustment associated with the victim being employed or under education, and a public venue, but not with interval from assault to sampling. Spermatozoa were detected in 79 (61%) of the analyzed cases, of which 71 were collected from victims within 24h. Interval from assault being  $< 24$ h and reporting a penetrative assault remained associated with the findings of spermatozoa after adjustments. Forensic analyses of trace evidence collected from victim, suspect and/or venue disclosed matching DNA profiles in 57 (40%) of a total of 143 analyzed cases. Matching DNA profiles were associated with suspect being known to the victim and with the venue being private. A higher proportion of cases with a DNA match were prosecuted in court: 20 of the 29 cases prosecuted. However, despite a DNA match 35 cases were anyway dismissed because of insufficient evidence.

**Conclusions** Although many of the associations in our study were expected, it is still important to report the actual numbers to gain insight into the importance of a DNA match in legal proceedings. A substantial proportion of cases with DNA match was dismissed because of insufficient evidence. To strengthen the justice response to sexual assault, it is essential to generate knowledge about the role of medico-legal evidence in such cases, and there are obviously other non-medical factors influencing the legal decisions.

**Keywords:** Sex offenses, crime victims, medico-legal aspects, clinical forensic medicine, biological forensic samples, spermatozoa, DNA detection

## Introduction

Sexual assault is a prevalent, underreported and underprosecuted crime (1, 2). According to population-based surveys on self-reported rapes, only one in ten rapes is reported to either police or health care (3, 4). Among rape victims reporting to the police, 50 – 70% had also been attending a sexual assault center (SAC) after rape and vice versa (4-6). Despite increasing numbers of police-reported rapes, the number of cases proceeding to prosecution is low and almost constant (7), resulting in a decreasing proportion taken to court.

A SAC provides acute medical care to victims of sexual assaults and documents medico-legal findings important for both the woman's health and legal interests. The forensic medical examination can provide crucial evidence in the investigation and prosecution of a rape (8, 9). Studies from all over the world report that biological trace evidence is collected by medical staff in 54 – 91% of the cases (4, 6, 10-12).

Traditionally, the analyses of trace evidence in police-reported rapes have been seen as a resource-demanding and not always a prioritized investigative step (13), hampering the use of available forensic evidence in the investigation and prosecution of the cases (8, 11, 14, 15). Even if forensic evidence has been collected by medical staff, it is up to the police to request it to be analyzed. Two Nordic studies report that trace evidence is analyzed by the forensic laboratory only in 51 – 57% of the cases (4, 6). Nowadays, the police tend to request more analyses, but still much trace evidence remains unclaimed at the SAC (6). Little is known about how the police select cases to be submitted for analysis. Previous research indicates that the police are considering contextual factors in their decision (14-16).

Studies consistently report that a low percentage of the trace evidence analyses are positive in rape cases (17). The analysis of spermatozoa gains further importance in a sexual assault case with the increased availability and progressive advances in DNA-profiling techniques (1, 9). Today, the increased use of DNA-registers enhances the potential to detect and interpret DNA evidence. From September 1, 2008, the Norwegian DNA-register may be used in investigation and prosecution of criminal cases (18). Hence, more analyses are expected to be performed (6). Even when the perpetrator is not identified, the DNA profiles obtained from cases of rape are included in the DNA register. This may be of crucial importance in future investigations, as it may identify offenders in previously unsolved crimes (19).

Research focusing on medico-legal evidence in sexual assault is scarce. Studies published so far from SACs or police case series mostly focus on sociodemographic data, assault characteristics,

relationship between victim and perpetrator and injuries. Only a few rape case series worldwide report the results of forensic analyses, like spermatozoa/semens and matching DNA profiles (4, 6, 10, 12) and even rarer are medical studies describing in detail factors associated with these miscellaneous forensic genetic findings. An earlier study from the same police district (20), showed that the only medico-legal finding significantly associated with charge filing was the analysis of the collected trace evidence. Surprisingly, no more analyses were performed when the assailant had a more distant relationship to the victim. However, the results are difficult to interpret due to the small sample size. From our clinical experience working at a SAC and cooperating closely with the police, a public venue more often seems to be associated with stranger rape. Hence, in such cases, we hypothesize that the police could be more interested in trace evidence analysis to identify a potentially unknown suspect. This is in contrast to a given private setting, where we hypothesize that it would more likely be a known suspect and the suspect claiming the sexual actions were consensual. In such situations, the trace evidence analysis could give minimal extra information to the police or legal authorities. The aim of this study thus was to examine whether certain victim, suspect and assault characteristics were associated with 1) police requesting forensic analysis of trace evidence, 2) detection of spermatozoa and 3) DNA match in police-reported cases of rape/attempted rape. In addition, we explored whether DNA findings were associated with legal outcome.

## Material and Methods

### Design and sample

We conducted a retrospective descriptive study based on police-reported cases of rape and attempted rape of women  $\geq 16$  years of age in the Sør-Trøndelag Police District between January 1, 1997 and December 31, 2010. Cases were selected based on the former Norwegian Penal Code applicable until September 2015 (21). According to this law (Chapter 19, Section 192), rape was defined as in the following abbreviated version: penetration of penis/finger/foreign object in vagina/anus, penis in mouth, masturbation, and coercion by means of violence, threats, or during impaired consciousness (6, 21). Altogether 697 cases were reported during the study period. Cases were excluded according to Figure 1. Details of the procedure are described elsewhere (5, 20, 22-24).

### Data collection and variables

Clinical, forensic, and laboratory information was extracted from the victims' hospital SAC records and the police files. Detection of spermatozoa and a DNA match between victim and

suspect were based on laboratory reports from the Institute of Forensic medicine, Oslo, Norway, available in the police records.

Victim characteristics were collected from SAC medical records and included age, ethnic origin, occupational status and vulnerability factors, as well as voluntary alcohol intake. Victim origin was classified as Western if stated as Western Europe, North America or Oceania, else classified as Non-Western. Definition of vulnerability factors included, according to priority, physical or cognitive disability, mental health problems or substance abuse and/or prior history of sexual assault. Self-reported alcohol intake in relation to the assault was categorized into none,  $< 5$ , or  $\geq 5$  units of alcohol. The latter category included being clinically intoxicated. Data regarding interval from assault to medical examination/sampling were also collected from the SAC.

Suspect- and assault characteristics, as well as investigational and legal outcome data were collected from police records. Information given by the victim was used in case of an unidentified suspect and from SAC records in case of missing information in the police files. Suspect characteristics included sex, age and (assumed) origin, the latter classified as for victims.

The victim/suspect relationship was dichotomized into known and stranger. The suspect was defined as being known to the victim if he was a current or previous partner/husband/boyfriend, family member, acquaintance or casual acquaintance (known  $< 24$ h). If the victim had never seen the suspect before he was categorized as a stranger. The type of sexual assault was defined as penetrative or non-penetrative. Penetration included both penile and foreign object penetration of anal, vaginal and oral orifices. Penetration by a finger and sexual acts like forced masturbation, attempted penetration and touching up/fondling, were defined as no penetration. Physical violence was dichotomized into yes and no, the latter including verbal threats. The venue was defined as private, which included the victim's, suspect's or other person's residence, or public, which included any public indoor or outdoor location or a vehicle.

Investigational data included information on whether the police had interrogated the suspect and/or witnesses, whether they had inspected the venue, as well as information regarding admittance of sexual contact or rape/attempted rape. According to the Norwegian Administration of Justice Act, legal outcome was categorized into four main categories: charges filed (i.e., the case taken to court or prosecuted); insufficient evidence; no suspect identified; and no crime/accusation withdrawn.

The results of trace evidence analyses were categorized as match, no match and other. Identical DNA profiles recovered from an evidence sample and from reference swabs collected from the victim or the suspect was termed a DNA match.

In cases with more than one suspect, information regarding the most active suspect was used. In case of discrepancy between police and medical record information, police files were regarded as gold standard.

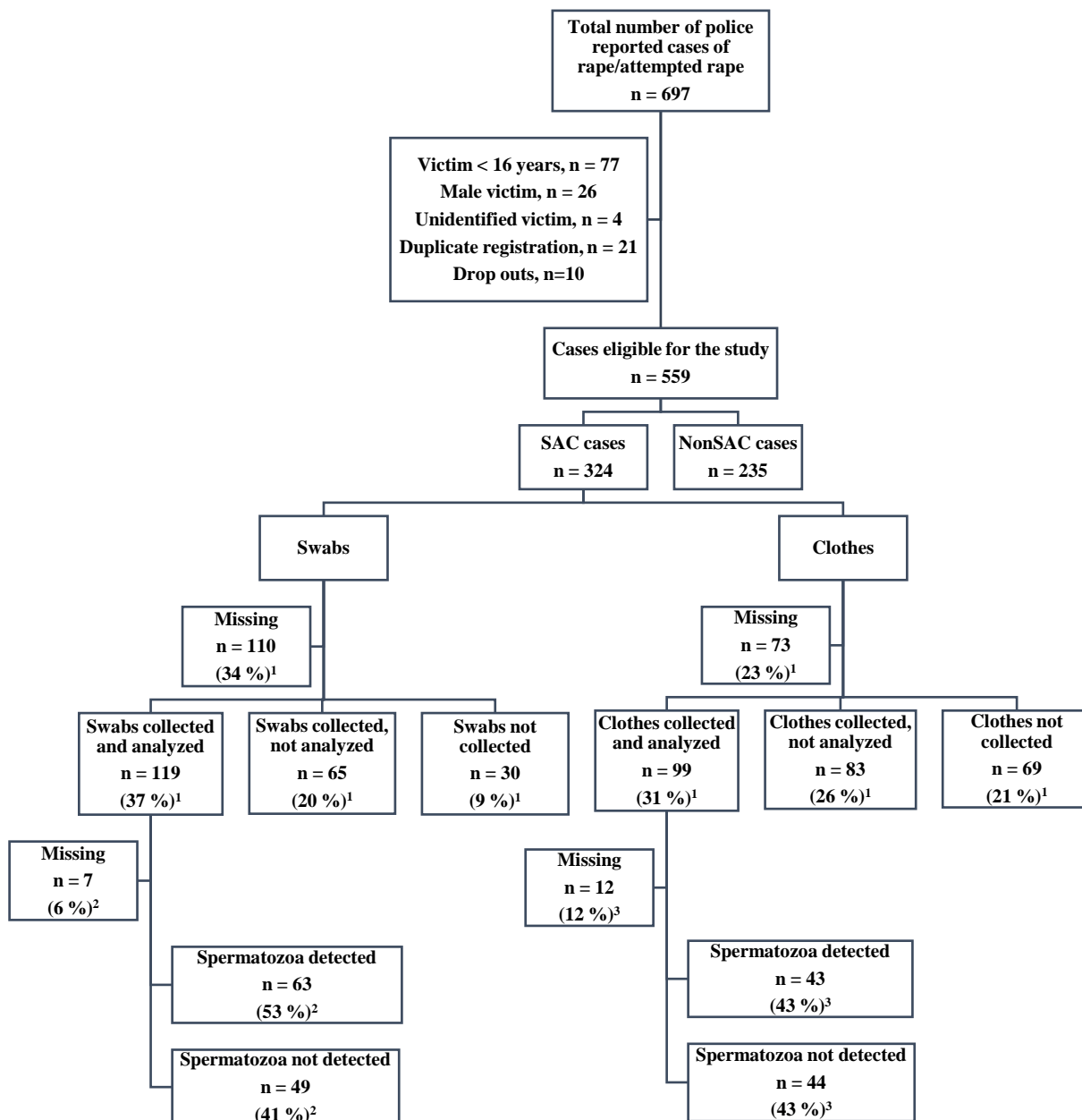
## Study approval

The study was approved by the Regional Committee for Medical and Health Research Ethics (REK-Midt) and the Norwegian Director General of Public Prosecutions (through the Advisory Board on Secrecy and Reserch).

## Statistical analyses

Associations between the independent categorical variables and the outcome variables were analyzed using Pearson's  $\chi^2$  test, and for dichotomous outcomes binary and multivariable logistic regression without stepwise selection were applied. For the outcome "analysis of swabs and/or clothes collected from victim", we adjusted for victim age, interval from assault to sampling, victim/suspect relationship, type of sexual assault (penetration vs. no penetration), and inspection of the venue (as an indicator of the quality of the police investigation). Due to statistical power considerations, we had to limit the number of freedom degrees to three and four for the outcomes "detection of spermatozoa on analyzed swabs and/or clothes collected from victim" and "detection of DNA match versus no match", respectively. Statistical significance was assumed when  $p < 0.05$ . Missing data were calculated but excluded when statistical tests were performed. Data analyses were performed using IBM SPSS Statistics for Windows, version 22.0.





**Figure 1** Flow chart of included and excluded police-reported cases of rape and attempted rape for the period 1997 – 2010 in the Sør-Trøndelag police district. Presentation of trace evidence analyses and detection of spermatozoa on swabs and clothes collected from the victim.<sup>1,2,3</sup>

<sup>1</sup> Percent of the 324 police-reported cases of rape/attempted rape with available medical information

<sup>2</sup> Percent of the 119 cases of analyzed swabs collected from the victim

<sup>3</sup> Percent of the 99 cases of analyzed clothes collected from the victim

## Results

Descriptive information regarding victim characteristics among the 324 police-reported cases with medical record at the SAC is summarized in Table 1. The mean age was 24.2 (SD = 8.4), ranging from 16 to 59 years old. Based on self-reported data, 245 (76%) of the victims had been drinking alcohol in relation to the assault, of whom 169 (52%) had ingested five units or more. The suspected perpetrators were all men, with a mean age of 29.4 (SD = 9.6), ranging from 14 to 58 years old.

**Table 1** Victim background characteristics, N=324

Characteristics	n (%)
Ethnicity	
Western	210 (65)
Non-Western	11 (3)
Missing	103 (32)
Occupational status	
Employed/under education	219 (68)
Unemployed	77 (24)
Missing	28 (8)
Vulnerability	
No	122 (38)
Physically or mentally disabled	32 (10)
Prior/current psychiatric history or drug abuse	131 (40)
Prior physical or sexual assault	38 (12)
Missing	1 (0)
Voluntary alcohol intake	
No intake	44 (14)
< 5 units	76 (24)
≥ 5 units	169 (52)
Missing	35 (10)

Among the 324 police-reported cases with available medical information, trace evidence in terms of swabs and/or clothes were collected from the victim in 299 cases (92%): Both swabs and clothes in 242 cases, only swabs in 46 cases, and only clothes in 11 cases. The police opted to submit the collected trace evidence for analysis in 135 cases (45%): Swabs and clothes were analyzed in 83 cases, only swabs in 36 cases, and only clothes in 16 cases. For further descriptions, see Figure 1.

Table 2 (left columns) presents crude and adjusted OR with corresponding 95% CI of victim, suspect and assault characteristics related to the police decision to request analysis. The police decision to analyze was after adjustment associated with the victim being employed or under education; and a public venue. Among the analyzed cases 111 samples (83%) were collected from victims <24h after the assault, however, after adjustment interval from assault to sampling was not associated with the police decision to analyze the trace evidence

Table 2 (right columns) describe victim, suspect and assault characteristics related to the finding of spermatozoa at the forensic laboratory. Trace evidence analyses could be evaluated in 129 of the 135 cases (96%). Spermatozoa were detected in altogether 79 cases (61%); i.e. on both swabs and clothes in 27 cases, only on swabs in 36 cases and only on clothes in 16 cases. Among the analyzed 98 penetrative rapes, 64 cases (65%) were spermatozoa positive, and reporting a penetrative assault was associated with the finding of spermatozoa also after adjustment. Even if the police more often requested analysis when the venue was a public place, there was no significant association between place of assault and sperm detection. Among the analyzed 111 samples collected within 24h after the rape/attempted rape, 71 (64%) were positive for spermatozoa, whereas eight (35%) of the 23 analyzed samples collected after 24h were positive for spermatozoa. Interval from assault being < 24h remained associated with the findings of spermatozoa after adjustments.

Among the available trace evidence samples collected from the victim and/or the suspect and/or the venue, 143 cases were sent for analysis at the FMI. The results are presented in Table 3 . DNA extracted from swabs and/or clothes from the victim matched the suspect's DNA profile in 41 cases and vice versa in 11 cases. Material collected from the venue matched the suspect's and the victim's DNA profile in 5 cases. Regarding the 50 cases with no DNA match 29 cases were coded as "no DNA match detected" and in 21 cases DNA extracted from swabs and/or clothes from the victim mismatched the suspect's DNA profile. Cases classified as "other" regarding DNA match included: no reference (n=20); too small amounts of DNA to allow a conclusive DNA typing (n=13); missing information regarding the results of the DNA typing; no suspect;

and no tested material (the latter three each n=1).

Among the 57 cases with a DNA match between victim and suspect, in 51 cases (89%) the trace evidence had been collected at the SAC or by the police within 24h after the assault, however there was no significant association with matching DNA and interval from assault. After adjustment, there was a significantly higher proportion of DNA matches if the suspect was known to the victim. The suspect was known to the victim in 52 (91%) of the 57 cases with matching DNA profiles. When comparing DNA match to “no match”, after adjustment, there was a significant association between a DNA match and a private venue. Among the cases disclosing matching DNA profiles 42 (74%) reported a private venue. Interrogation of the suspect and the suspect admitting sexual contact, were after adjustment associated with a DNA match. Among the 29 cases prosecuted in court 20 cases had a matching DNA result, and after adjustment, having a DNA match was associated with prosecution. However, despite a DNA match 35 cases were anyway dismissed because of insufficient evidence

## Discussion

We found that trace evidence, in terms of swabs and clothes, was collected from the victim in 92% and analyzed in 45% of the cases. In comparison, prior studies from the Nordic countries, South Africa and Canada report that biological trace evidence is collected by medical staff in 54 – 91% of the cases (4, 6, 10-12), and that trace evidence is analyzed by forensic laboratories in 51 – 57% (4, 6). There is a considerable attrition and selection of cases from victim attendance through forensic medical examination, trace evidence collection and further analysis which may considerably influence the legal process (10).

In our study spermatozoa were detected on swabs and/or clothes collected from the victim in 61% of the cases. Our finding is in line with a recent study from Costa Rica where spermatozoa were found in 59% of the samples (25). In two studies from Denmark and Finland respectively, spermatozoa were detected only in 35% (4) and 46% (26). The high detection rate of spermatozoa in our study could be due to both swabs and clothing being available, improved quality of evidence collection and/or increased sensitivity of modern laboratory techniques (2, 27).

We found that the police’s decision to request analysis of trace evidence material was associated with a public venue of the assault. The association was still valid after adjusting for among other factors victim/suspect relationship. Thus, our hypothesis of an association between public venue

and decision to analyze trace evidence was confirmed; however, it could not be fully explained by the relationship between victim and suspect. In contrast, there was a significantly higher proportion of matching DNA profiles in cases with a private venue. Only 15 (26%) of the 58 assaults reported from public venues had DNA match and could be due to a lack of reference but also too small amounts of DNA to allow for a conclusion.

Spermatozoa were detected in as many as 64% of the cases when the interval from assault to sampling was < 24h. This indicates that early attendance augments sperm detection, but our findings show that more than a third of the samples collected after 24h also were positive for spermatozoa. For both health personnel and police cooperating with SACs it is important to be aware of that identifiable spermatozoa may be recovered from the genital tract of fertile women for up to 7 days and almost “forever” on dried clothing (2, 9, 28, 29), implying that evidence may be lost if the SAC receives victims only up to 72h post-assault. Detection of spermatozoa could prove a sexual contact, but more importantly, makes it possible to identify the suspect through DNA-profiling.

Our analyses indicate that unemployed victims got their evidence less often sent by the police for forensic analysis; however, there were no association to victim vulnerability. Previous studies have indicated that the police consider victim and assault characteristics when deciding whether to request an analysis (14, 15). A US study suggested that the decision to submit forensic material for analysis depended on the status of the suspect in the crime investigation, i.e. no suspect identified or suspect adjudicated without forensic evidence testing, and the perceived quality of available evidence (16). This selection may result in a loss of medical evidence, especially in cases where the suspect denies sexual contact (6). However, studies have shown that the offender seldom denies sexual contact with the victim in cases where trace evidence collection already has been performed (4, 10). Encouraging victims reporting a rape to accept a potentially unpleasant forensic and “invasive” gynecological examination might still be worthwhile, considering that it also provides an opportunity to detect and treat potential sexually transmitted diseases and genital injuries, and should be offered in a safe and unprejudiced setting, as e.g. in a SAC. Failure of health care or police in offering at least a partial examination results in a lost opportunity for important trace evidence collection from the victim. Obviously, later on in the investigative process, in cases where the crucial issue is the question of consensuality, forensic analyses may not add relevant information (22), and a match does not necessarily lead to conviction (10). In a South African study, the presence of a DNA report was not associated with conviction. However, there were more acquittals among cases where the

DNA profile did not match that of the suspect. This may suggest that DNA is inconsequential if the criminal justice system for other reasons establishes “reasonable doubt” (10).

A DNA match between victim and suspect was detected in 40% of our cases, with the largest group of cases being swabs and/or clothes from the victim matching the suspect’s DNA profile from the reference test. In two other Nordic studies a DNA match between victim and suspect was found in 14% (4) and 16% (6) of the cases, respectively, and the latter study showed no association with conviction. In our study, a DNA match was detected in a higher proportion of cases when the police had interrogated the suspect, which may reflect that the police are putting more effort on different levels into those cases more likely to proceed. Among the cases prosecuted as many as 20 (69%) of the 29 cases had a DNA match. However, despite a DNA match altogether 35 (61%) of the 57 cases were dismissed due to insufficient evidence. The increased discrepancy between the number of reported rape cases and those proceeding to prosecution may reflect an increase in police-reported cases that are more challenging to the legal system. Matching DNA in adolescent and adult rape cases could be essential, but is seldom sufficient evidence for the case to proceed to court; other evidentiary factors in the case may be too vague or ambiguous.

In our study, among the cases DNA tested and classified as “other” regarding DNA match, 20 cases had no reference. This means that a DNA profile of an unknown male was detected and the police forwarded the results for registration in the Norwegian DNA register. As a result, putative future crimes committed by the same subjects may later identify the suspects from some of the rape cases included in this study. Our material was updated until November 2012, and possible later identification of a suspect will therefore not be captured in the results presented above. This illustrates that trace evidence collected at the SAC may contribute to registration of DNA profiles which may be of importance years later if this person commits any future crime.

The possible DNA match is difficult to interpret as a predictor for conviction, because its influence is reduced by 1) missing evidence collection, 2) collected evidence not being sent for laboratory analysis, and 3) missing reference samples from the suspect. Studies from both high and low/middle income countries report that DNA analysis was not yet the standard during the study period (27, 30), partly explaining why non-medical variables have shown such a strong influence on case outcome (31, 32). With the consistent availability of high-quality medico-legal examination and laboratory techniques, DNA analyses may gain more importance in determining case outcome than what the literature has traditionally found (1). Both an American and an Australian study have concluded that DNA evidence significantly increases the likelihood of

legal case progression (1, 33). A more in-depth or qualitative study may assess the impact of vulnerability factors and data other than DNA match important for a case to proceed.

Few studies have been able to combine victim and assault characteristics, medico-legal examination, crime investigation and DNA results (6), as well as to assess the impact of forensic evidence. Reported results are inconsistent. Most previous studies have focused on the impact of injuries on legal outcome; some report a significant association (34) while others have found no such association (32, 35, 36). No studies have shown an association between sperm detection or DNA match and conviction (32, 34-36).

This study has several limitations. Firstly, it is important to emphasize that this is a study of police-reported cases of rape/attempted rape. It is unknown whether a crime actually has been committed. Secondly, the results only pertain to victims of rape/attempted rape who report both to the police and present to the SAC in a Nordic setting. Thirdly, the nature of a retrospectively designed study means that information has not been systematically collected in a research context using standardized case report forms. The reliability of the data is influenced by both the accuracy of the victims' and the suspects' self-reported descriptions, as well as the police officers' and the physicians' reports. Finally, some variables have a rather small effect size, which may make it difficult to determine significant associations. Missing data may also bias the results. Additionally, it should be pointed out that since this is a cross sectional study, and even if we use multivariable approach with confounders included in the statistical models, statistical associations do not imply causal inferences. It is difficult to ascertain the direct effects of medico-legal findings on police and court decisions. For further methodological limitations see (22) and (5).

Despite the above-mentioned limitations, the exploration of this rather large study sample based on files from the police, SAC, and Institute of Forensic Medicine, has contributed to filling a gap of knowledge on the impact of trace evidence analyses and DNA matching in the investigation of rape cases in a Norwegian police district. It is a strength of our study that we have merged information from three data sources and utilized available technologies for DNA-profiling, enabling us to present our DNA findings and associated factors. Furthermore, the long follow-up interval allows for monitoring final legal conclusions.

## Conclusions

Medico-legal examination and collection of trace evidence are important tools in the investigation and prosecution of rape cases. In our cases with DNA match between victim and

suspect, a higher proportion of cases was taken to court. Nevertheless, DNA evidence will always be considered in the scope of other evidence. Our study has provided descriptive data regarding trace evidence analyses and identified potential factors influencing forensic analyses and DNA findings. To strengthen the justice response to sexual assault, it is essential to generate knowledge about the role of medico-legal evidence in such cases, and there are obviously other non-medical factors influencing the legal decisions.



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## Abstract

**Objective** The aim of this study was to examine ~~whether the relation~~ association between victim, suspect and assault characteristics ~~were associated with~~ and 1) forensic analysis of trace evidence, 2) detection of spermatozoa and 3) DNA match in police-reported cases of rape/attempted rape. In addition, we explored whether DNA findings were associated with legal outcome.

**Methods** We conducted a retrospective, descriptive study based on police-reported rapes and attempted rapes of women  $\geq 16$  years of age in Sør-Trøndelag Police District throughout 1997 – 2010. Police data were merged with information from the Sexual Assault Centre (SAC) at St.Olavs University Hospital, Trondheim, Norway. We used binary and multivariable logistic regression for the comparisons.

**Results** We identified 324 victims (mean age 24 years). The police requested analysis in 135 (45%) of the 299 collected victim samples. The police decision to analyze was after adjustment associated with the victim being employed or under education, and a public venue, but not with interval from assault to sampling. Overall, swabs and/or clothes were collected from victims  $< 24$ h from the assault in 111 (83%) of the 135 analyzed cases compared to 117 (73%) of the 164 cases not analyzed ( $p=0.033$ ). Spermatozoa were detected in 79 (61%) of the analyzed cases, of which 71 were collected from victims within 24h. Interval from assault being  $< 24$ h and reporting a penetrative assault remained associated with the findings of spermatozoa after adjustments. ( $p=0.003$ ). Forensic analyses of trace evidence collected from victim, suspect and/or venue disclosed matching DNA profiles in 57 (40%) of a total of 143 (40%) analyzed cases, of which in 51 cases the trace evidence had been collected at the SAC or by the police within 24h after the assault ( $p=0.164$ ). Matching DNA profiles were associated with suspect being known to the victim (52 cases,  $p=0.013$ ), and with the venue being private (42 cases,  $p=0.013$ ). A higher proportion of cases with a DNA match were prosecuted in court: (20 of the 29 cases prosecuted) ( $p<0.001$ ). However, despite a DNA match 35 cases were anyway dismissed because of insufficient evidence.

**Conclusions** Although Tthe police were more likely to request analyses and spermatozoa were more often detected when the interval from assault to victim sampling was  $< 24$  h, most of the non-analyzed samples had been collected within 24h. Our findings indicate that the reason why samples are not analyzed is usually other than time before sampling. Detection of a DNA match between victim and suspect were associated with the suspect being known to the victim and a private venue of the assault. Although many of the associations in our study were expected, it is

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still important to report the actual numbers to gain insight into the importance of a DNA match in legal proceedings. A higher proportion of cases with a DNA match were prosecuted in court. A substantial proportion of cases with DNA match was dismissed because of insufficient evidence. To strengthen the justice response to sexual assault, it is essential to generate knowledge about the role of medico-legal evidence in such cases, and there are obviously other non-medical factors influencing the legal decisions.

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**Keywords:** Sex offenses, crime victims, medico-legal aspects, clinical forensic medicine, biological forensic samples, spermatozoa, DNA detection

## Introduction

Sexual assault is a prevalent, underreported and underprosecuted crime (1, 2). According to population-based surveys on self-reported rapes, only one in ten rapes is reported to either police or health care (3, 4). Among rape victims reporting to the police, 50 – 70% had also been attending a sexual assault center (SAC) after rape. ~~Victims who first address themselves to a SAC, between 50 – 70 % also report to the police and vice versa.~~ (4-6). Despite increasing numbers of police-reported rapes, the number of cases proceeding to prosecution is low and almost constant (7), resulting in a decreasing proportion taken to court.:

A SAC provides acute medical care to victims of sexual assaults and documents ~~discloses~~ medico-legal findings important for both the woman's health and legal interests. The forensic medical examination can provide crucial evidence in the investigation and prosecution of a rape (8, 9). Studies from all over the world report that biological trace evidence is collected by medical staff in 54 – 91% of the cases (4, 6, 10-12).

Traditionally, the analyses of trace evidence in police-reported rapes have been seen as a resource-demanding and not always a prioritized investigative step (13), hampering the use of available forensic evidence ~~to be used~~ in the investigation and prosecution of the cases (8, 11, 14, 15). Even if forensic evidence has been collected by medical staff, it is up to the police to request it to be analyzed. Two Nordic studies report that trace evidence is analyzed by the forensic laboratory only in 51 – 57% of the cases (4, 6). Nowadays, the police tend to request more analyses, but still much trace evidence remains unclaimed at the SAC (6). Little is known about how the police select cases to be submitted for analysis. Previous research indicates that the police are considering contextual factors in their decision (14-16).

Studies consistently report that a low percentage of the trace evidence analyses are positive in rape cases (17). The analysis of spermatozoa gains further importance in a sexual assault case with the increased availability and progressive advances in DNA-profiling techniques (1, 9). Today, the increased use of DNA-registers enhances the potential to detect and interpret DNA evidence. From September 1, 2008, ~~;~~ the Norwegian DNA-register may be used in investigation and prosecution of criminal cases (18). Hence, more analyses are expected to be performed (6). Even when the perpetrator is not identified, the DNA profile ~~samples~~ obtained from ~~in~~ cases of rape ~~;~~ the profile is ~~can be~~ included in the DNA register ~~err~~. This may be of crucial importance in future investigations, as ~~a match can be obtained, hence it may making it possible to~~ identify offenders in previously unsolved crimes (19).

Research focusing on medico-legal evidence in sexual assault is scarce. Studies published so far from SACs or police case series mostly focus on sociodemographic data, assault characteristics, relationship between victim and perpetrator and injuries. Only a few rape case series worldwide report the results of forensic analyses, like spermatozoa/semens and matching DNA profiles (4, 6, 10, 12) and even rarer are medical studies describing in detail factors associated with these miscellaneous forensic genetic findings. An earlier study from the same police district (20), showed that the only medico-legal finding significantly associated with charge filing was the analysis of the collected trace evidence. Surprisingly, no more analyses were performed when the assailant had a more distant relationship to the victim. However, the results are difficult to interpret due to the small sample size. From our clinical experience working at a SAC and cooperating closely with the police, a public venue more often seems to be associated with stranger rape. Hence, in such cases, we hypothesize that the police could be more interested in trace evidence analysis to identify a potentially unknown suspect. This is in contrast to a given private setting, where we hypothesize that it would more likely be a known suspect and the suspect claiming the sexual actions were consensual. In such situations, the trace evidence analysis could give minimal extra information to the police or legal authorities.

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The aim of this study thus was to examine whether certain victim, suspect and assault characteristics were associated with 1) police requesting forensic analysis of trace evidence, 2) detection of spermatozoa and 3) DNA match in police-reported cases of rape/attempted rape. In addition, we explored whether DNA findings were associated with legal outcome.

## Material and Methods

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### Design and sample

We conducted a retrospective descriptive study based on police-reported cases of rape and attempted rape of women  $\geq 16$  years of age in the Sør-Trøndelag Police District between January 1, 1997 and December 31, 2010. Cases were selected based on the former Norwegian Penal Code applicable until September 2015-(21). According to this law (Chapter 19, Section 192), rape was defined as in the following abbreviated version: penetration of penis/finger/foreign object in vagina/anus, penis in mouth, masturbation, and coercion by means of violence, threats, or during impaired consciousness (6, 21). Altogether 697 cases were reported during the study period. Cases were excluded according to Figure 1. Details of the procedure are described elsewhere (5, 20, 22-24).

## Data collection and variables

Clinical, forensic, and laboratory information was extracted from the victims' hospital SAC records and the police files. Detection of spermatozoa and a DNA match between victim and suspect were based on laboratory reports from the Institute of Forensic medicine, Oslo, Norway, available in the police records.

Victim characteristics were collected from SAC medical records and included age, ethnic origin, occupational status and vulnerability factors, as well as voluntary alcohol intake. Victim origin was classified as Western if stated as Western Europe, North America or Oceania, else classified as Non-Western. Definition of vulnerability factors included, according to priority, physical or cognitive disability, mental health problems or substance abuse and/or prior history of sexual assault. Self-reported alcohol intake in relation to the assault was categorized into none, < 5, or  $\geq 5$  units of alcohol. The latter category included being clinically intoxicated. Data regarding interval from assault to medical examination/sampling were also collected from the SAC.

Suspect- and assault characteristics, as well as investigational and legal outcome data were collected from police records. Information given by the victim was used in case of an unidentified suspect and from SAC records in case of missing information in the police files. Suspect characteristics included sex, age and (assumed) origin, the latter classified as for victims.

The victim/suspect relationship was dichotomized into known and stranger. The suspect was defined as being known to the victim if he was a current or previous partner/husband/boyfriend, family member, acquaintance or casual acquaintance (known < 24 h<sup>24h</sup>). If the victim had never seen the suspect before he was categorized as a stranger. The type of sexual assault was defined as penetrative or non-penetrative. Penetration included both penile and foreign object penetration of anal, vaginal and oral orifices. Penetration by a finger and sexual acts like forced masturbation, attempted penetration and touching up/fondling, were defined as no penetration. Physical violence was dichotomized into yes and no, the latter including verbal threats. The venue was defined as private, which included the victim's, suspect's or other person's residence, or public, which included any public indoor or outdoor location or a vehicle.

Investigational data included information on whether the police had interrogated the suspect and/or witnesses, whether they had inspected the venue, as well as information regarding admittance of sexual contact or rape/attempted rape. According to the Norwegian Administration of Justice Act, legal outcome was categorized into four main categories: charges filed (i.e., the case taken to court or prosecuted); insufficient evidence; no suspect identified; and no crime/accusation withdrawn.

The results of trace evidence analyses were categorized as match, no match and other. Identical DNA profiles recovered from an evidence sample and from reference swabs collected from the victim or the suspect was termed a DNA match.

In cases with more than one suspect, information regarding the most active suspect was used. In case of discrepancy between police and medical record information, police files were regarded as gold standard.

### Study approval

The study was approved by the Regional Committee for Medical and Health Research Ethics (REK-Midt) and the Norwegian Director General of Public Prosecutions (through the Advisory Board on Secrecy and Reserch).

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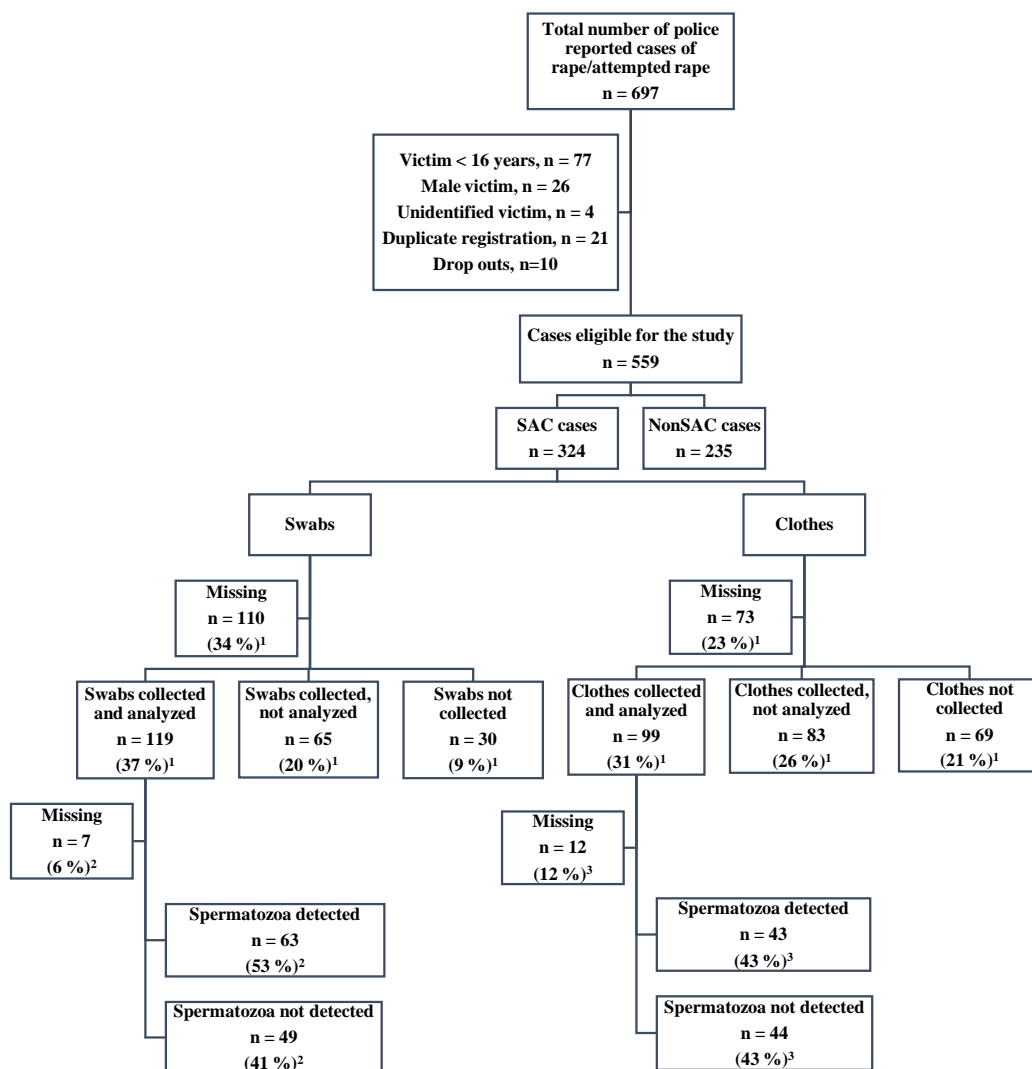
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### Statistical analyses

~~Bivariate a~~ssociations between the independent categorical variables and the outcome variables ~~1) analysis of trace evidence; 2) detection of spermatozoa; 3) DNA match~~ were analyzed using Pearson's  $\chi^2$  test, and for dichotomous outcomes binary and multivariable logistic regression without stepwise selection were applied. For the outcome "analysis of swabs and/or clothes collected from victim", we adjusted for victim age, interval from assault to sampling, victim/suspect relationship, type of sexual assault (penetration vs. no penetration), and inspection of the venue (as an indicator of the quality of the police investigation). Due to statistical power considerations, we had to limit the number of freedom degrees to three and four for the outcomes "detection of spermatozoa on analyzed swabs and/or clothes collected from victim" and "detection of DNA match versus no match", respectively. ~~Fischer's Exact Test or Exact unconditional test was used as appropriate.~~ Statistical significance was assumed when  $p < 0.05$ . Missing data were calculated but excluded when statistical tests were performed. Data analyses were performed using IBM SPSS Statistics for ~~w~~Windows, version 22.0.

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**Figure 1** Flow chart of included and excluded police-reported cases of rape and attempted rape for the period 1997 – 2010 in the Sør-Trøndelag police district. Presentation of trace evidence analyses and detection of spermatozoa on swabs and clothes collected from the victim.<sup>1,2,3</sup>

<sup>1</sup> Percent of the 324 police-reported cases of rape/attempted rape with available medical information

<sup>2</sup> Percent of the 119 cases of analyzed swabs collected from the victim

<sup>3</sup> Percent of the 99 cases of analyzed clothes collected from the victim

## Results

Descriptive information regarding victim characteristics among the 324 police-reported cases with medical record at the SAC is summarized in Table 1. The mean age was 24.2 (SD = 8.4), ranging from 16 to 59 years old. Based on self-reported data, 245 (76%) of the victims had been drinking alcohol in relation to the assault, of whom 169 (52%) had ingested five units or more. The suspected perpetrators were all men, with a mean age of 29.4 (SD = 9.6), ranging from 14 to 58 years old.

**Table 1** Victim background characteristics, N=324

Characteristics	n (%)
Ethnicity	
Western	210 (65)
Non-Western	11 (3)
Missing	103 (32)
Occupational status	
Employed/under education	219 (68)
Unemployed	77 (24)
Missing	28 (8)
Vulnerability	
No	122 (38)
Physically or mentally disabled	32 (10)
Prior/current psychiatric history or drug abuse	131 (40)
Prior physical or sexual assault	38 (12)
Missing	1 (0)
Voluntary alcohol intake	
No intake	44 (14)
< 5 units	76 (24)
≥ 5 units	169 (52)
Missing	35 (10)

Among the 324 police-reported cases with available medical information, trace evidence in terms of swabs and/or clothes were collected from the victim in 299 cases (92%): Both swabs and clothes in 242 cases, only swabs in 46 cases, and only clothes in 11 cases. The police opted to ~~send-submit~~ the collected trace evidence for analysis in 135 cases (45%): Swabs and clothes were analyzed in 83 cases, only swabs in 36 cases, and only clothes in 16 cases. For further descriptions, see Figure 1.

~~Table 2 (left columns) presents crude and adjusted OR with corresponding 95% CI of vVictim, suspect and assault characteristics related to the police decision to request analysis are described in the left double columns of Table 2. The police decision to analyze trace evidence was after adjustment associated with the victim being employed or under education; and a public venue ( $p = 0.006$ ), with 57 of the 101 (56%) of the cases being analyzed. Among the analyzed cases 111 samples (83%) were collected from victims <24h24h after the assault, however, after adjustment interval from assault to sampling was not associated with the police decision to analyze the trace evidence ( $p = 0.033$ ).~~

Table 2 ~~mid(right -columns)~~ describe victim, suspect and assault characteristics related to the finding of spermatozoa at the forensic laboratory. Trace evidence analyses could be evaluated in 129 of the 135 cases (96%). Spermatozoa were detected in altogether 79 cases (61%); i.e. on both swabs and clothes in 27 cases, only on swabs in 36 cases and only on clothes in 16 cases.

~~Among the analyzed 98 penetrative rapes, 64 cases (65%) were spermatozoa positive, and reporting a penetrative assault was associated with the finding of spermatozoa also after adjustment. Even if the police more often requested analysis when the venue was a public place, there was no significant association between place of assault and sperm detection. Among the analyzed 11105 samples collected within 24 h24h after the rape/attempted rape, 71 (64%) were positive for spermatozoa, whereas eight (35%) of the 23 analyzed samples collected after 24 h24h were positive for spermatozoa. Interval from assault being < 24h remained associated with the findings of spermatozoa after adjustments. ) ( $p = 0.003$ ). Among the analyzed 95 penetrative rapes, 64 cases were spermatozoa positive ( $p = 0.006$ ). Although not statistically significant, there was a trend towards more evidence of spermatozoa in cases with a private venue ( $p = 0.082$ ), where spermatozoa were detected in 51 of the 75 analyzed cases.~~

Among the available trace evidence samples collected from the victim and/or the suspect and/or the venue, 143 cases were sent for analysis at the FMI. The results are presented in Table ~~32 right triple columns~~. DNA extracted from swabs and/or clothes from the victim matched the suspect's DNA profile in 410 cases and vice versa in 11 cases. Material collected from the venue

matched the suspect's and the victim's DNA profile in 5 cases. ~~In one case abortion material matched the suspect's DNA profile.~~ Regarding the 50 cases with no DNA match 29 cases were coded as "no DNA match detected" and in 21 cases DNA extracted from swabs and/or clothes from the victim mismatched the suspect's DNA profile. Cases classified as "other" regarding DNA match included: no reference (n=20); too small amounts of DNA to allow a conclusive DNA typing (n=13); missing information regarding the results of the DNA typing; no suspect; and no tested material (the latter three each n=1).

Among the 57 cases with a DNA match between victim and suspect, in 51 cases (89%) the trace evidence had been collected at the SAC or by the police within 24h after the assault ( $p=0.164$ ), ~~however there was no significant association with matching DNA and interval from assault. After adjustment,~~ there was a significantly higher proportion of DNA matches if the suspect was known to the victim ( $p=0.013$ ) and in case of a private venue ( $p=0.013$ ). The suspect was known to the victim in 52 (91%) of the 57 cases with matching DNA profiles ( $p=0.013$ ). ~~When comparing DNA match to "no match", after adjustment, there was a significant association between a DNA match and a private venue.~~ Among the cases disclosing matching DNA profiles 42 (74%) reported a private venue ( $p=0.013$ ).

~~As shown in Table 3, i~~Interrogation of the suspect ( $p < 0.001$ ), ~~inspection of the venue ( $p = 0.013$ ),~~ and the suspect admitting sexual contact ( $p = 0.003$ ), were ~~after adjustment~~ associated with a DNA match. ~~Among the 29 cases prosecuted in court 20 cases had a matching DNA result, and after adjustment, having a DNA match was associated with prosecution. However, despite a DNA match 35 cases were anyway dismissed because of insufficient evidence. A higher proportion of cases with a DNA match (20/29) were prosecuted in court ( $p < 0.001$ ).~~

## Discussion

We found that trace evidence, in terms of swabs and clothes, was collected from the victim in 92% and analyzed in 45% of the cases. In comparison, prior studies from the Nordic countries, South Africa and Canada report that biological trace evidence is collected by medical staff in 54 – 91% of the cases (4, 6, 10-12), and that trace evidence is analyzed by forensic laboratories in 51 – 57% (4, 6). There is a considerable attrition and selection of cases from victim attendance through forensic medical examination, trace evidence collection and further analysis which may considerably influence the legal process (10).

In our study spermatozoa were detected on swabs and/or clothes collected from the victim in 61% of the cases. Our finding is in line with a recent study from Costa Rica where spermatozoa were found in 59% of the samples (25). In two studies from Denmark and Finland respectively, spermatozoa were detected only in 35% (4) and 46% (26). The high detection rate of spermatozoa in our study could be due to both swabs and clothing being available, improved quality of evidence collection and/or increased sensitivity of modern laboratory techniques (2, 27).

We found that the police's decision to request analysis of trace evidence material was associated with a public venue of the assault. The association was still valid after adjusting for among other factors victim/suspect relationship. Thus, our hypothesis of an association between public venue and decision to analyze trace evidence was confirmed; however, it could not be fully explained by the relationship between victim and suspect. In contrast, ~~spermatozoa were more often detected in case of a private venue. In addition,~~ there was a significantly higher proportion of matching DNA profiles in cases with a private venue. ~~The police requested more analyses and detected~~ Only 15 (26%) of the 58 assaults reported from public venues had DNA match and could be due to a lack of reference but also too small amounts of DNA to allow for a conclusion.

Spermatozoa were detected in as many as 68.4% of the cases when the interval from assault to sampling was < 24h. This indicates that early attendance augments spermatozoal detection, but our findings show that more than a third of the samples collected after 24h also were positive for spermatozoa. In addition, when there is a longer interval from assault to sampling, there may be less remaining evidence. However, it For both health personnel and police cooperating with SACs it is important to remember to be aware of that identifiable spermatozoa may be recovered from the genital tract of fertile women for up to 7 days and almost “forever” on dried clothing (2, 9, 28, 29), implying that evidence may be lost if the SAC receives victims only up to 72-h post-assault. Detection of spermatozoa could prove a sexual contact, but more importantly, makes it possible to identify the suspect through DNA-profiling.

Our analyses indicate that unemployed victims got their evidence less often sent by the police for forensic analysis; however, there were no association to victim vulnerability. Previous studies have indicated that the police consider victim and assault characteristics when deciding whether to request an analysis (14, 15). A US study suggested that the decision to submit forensic material for analysis depended on the status of the suspect in the crime investigation, i.e. no suspect identified or suspect adjudicated without forensic evidence testing, and the perceived quality of available evidence (16). This selection may result in a loss of medical evidence,

especially in cases where the suspect denies sexual contact (6). However, studies have shown that the offender seldom denies sexual contact with the victim in cases where trace evidence collection already has been performed (4, 10). Encouraging victims reporting a rape to accept a potentially ~~unpleasant~~ ~~traumatizing~~ forensic and “invasive” gynecological examination might still be worthwhile, considering that it also provides an opportunity to detect and treat potential sexually transmitted diseases and genital injuries, and should be offered in a safe and unprejudiced setting, as e.g. in a SAC. Failure of health care or police in offering at least a partial examination results in a lost opportunity for important trace evidence collection from the victim. Obviously, later on in the investigative process, in cases where the crucial issue is the question of consensuality, forensic analyses may not add relevant information (22), and a match does not necessarily lead to conviction (10). In a South African study, the presence of a DNA report was not associated with conviction. However, there were more acquittals among cases where the DNA profile did not match that of the suspect. This may suggest that DNA is inconsequential if the criminal justice system for other reasons establishes “reasonable doubt” (10).

~~In our study, among the cases DNA tested and classified as “other” regarding DNA match, 20 cases had no reference. In these cases the police forwarded the results for registration in the Norwegian DNA register. This illustrates that trace evidence collected at the SAC could contribute to registration of DNA profiles which may be of importance years later if this person commits any future crime.~~

A DNA match between victim and suspect was detected in 40% of our cases, with the largest group of cases being swabs and/or clothes from the victim matching the suspect’s DNA profile from the reference test ~~(70%)~~. In two other Nordic studies a DNA match between victim and suspect was found in 14% (4) and 16% (6) of the cases, respectively, and the latter study showed no association with conviction. In our study, a DNA match was detected in a higher proportion of cases when the police had interrogated the suspect, which may reflect that the police are putting more effort on different levels into those cases more likely to proceed.~~In our study,~~ aAmong the cases prosecuted as many as 20 (69%) of the 29 ~~(69%)~~ cases had a DNA match. However, despite a DNA match altogether 35 (61%) of the 57 cases ~~(61%)~~ were dismissed due to insufficient evidence. The increased discrepancy between the number of reported rape cases and those proceeding to prosecution may reflect an increase in police-reported cases that are more challenging to the legal system. Matching DNA in adolescent and adult rape cases could be essential, but is seldom sufficient evidence for the case to proceed to court; ~~hence,~~ other evidentiary factors in the case may be too vague or ambiguous.

In our study, among the cases DNA tested and classified as “other” regarding DNA match, 20 cases had no reference. This means that a DNA profile of an unknown male was detected and the police forwarded the results for registration in the Norwegian DNA register. As a result, putative future crimes committed by the same subjects may later identify the suspects from some of the rape cases included in this study. Our material was updated until November 2012, and possible later identification of a suspect will therefore not be captured in the results presented above. This illustrates that trace evidence collected at the SAC may contribute to registration of DNA profiles which may be of importance years later if this person commits any future crime.

The possible DNA match is difficult to interpret as a predictor for conviction, because its influence is reduced by 1) missing evidence collection, 2) collected evidence not being sent for laboratory analysis, and 3) missing reference samples from the suspect. Studies from both high and low/middle income countries report that DNA analysis was not yet the standard during the study period (27, 30), partly explaining why non-medical variables have shown such a strong influence on case outcome (31, 32). With the consistent availability of high-quality medico-legal examination and laboratory techniques, DNA analyses may gain more importance in determining case outcome than what the literature has traditionally found (1). Both an American and an Australian study have concluded that DNA evidence significantly increases the likelihood of legal case progression (1, 33). A more in-depth or qualitative study may assess the impact of vulnerability factors and data other than DNA match important for a case to proceed.

Few studies have been able to combine victim and assault characteristics, medico-legal examination, crime investigation and DNA results (6), as well as to assess the impact of forensic evidence. Reported results are inconsistent. Most previous studies have focused on the impact of injuries on legal outcome; some report a significant association (34) while others have found no such association (32, 35, 36). No studies have shown an association between sperm detection or DNA match and conviction (32, 34-36).

This study has several limitations. Firstly, it is important to emphasize that this is a study of police-reported cases of rape/attempted rape. It is unknown whether a crime actually has ~~taken place~~been committed. Secondly, the results only pertain to victims of rape/attempted rape who report both to the police and present to the SAC in a Nordic setting. Thirdly, the nature of a retrospectively designed study means that information has not been systematically collected in a research context using standardized case report forms. The reliability of the data is influenced by both the accuracy of the victims' and the suspects' self-reported descriptions, as well as the police officers' and the physicians' reports. Finally, some variables have a rather small effect

size, which may make it difficult to determine significant associations. Missing data may also bias the results. Additionally, it should be pointed out that since this is a cross sectional study, and even if we use multivariable approach with confounders included in the statistical models, statistical associations does not imply a causal relationship inferences. It is difficult to ascertain the direct effects of medico-legal findings on police and court decisions. For further methodological limitations see (22) and (5).

Despite the above-mentioned limitations, the exploration of this rather large study sample based on files from the police, SAC, and Institute of Forensic Medicine, has contributed to filling a gap of knowledge on the impact of trace evidence analyses and DNA matching in the investigation of rape cases in a Norwegian police district. It is a strength of our study that we have merged information from three data sources and utilized available technologies for DNA-profiling, enabling us to present our DNA findings and associated factors. Furthermore, the long follow-up interval allows for monitoring final legal conclusions.

## Conclusions

Medico-legal examination and collection of trace evidence are important tools in the investigation and prosecution of rape cases. In our cases with DNA match between victim and suspect, a higher proportion of cases ~~were~~ was taken to court. Nevertheless, DNA evidence ~~should~~ will always be considered in the scope of other evidence. Our study has provided descriptive data regarding trace evidence analyses and identified potential factors influencing forensic analyses and DNA findings. ~~The results may improve the quality of the health and police systems, enabling forensic evidence collection and analysis as well as DNA profiling to fulfill its potential.~~ To strengthen the justice response to sexual assault, it is essential to generate knowledge about the role of medico-legal evidence in such cases, and there are obviously other non-medical factors influencing the legal decisions.

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Table 2 Victim-, suspect- and assault characteristics by analysis and detection of spermatozoa on swabs and/or clothes collected from the victim, in police-reported cases of rape

Characteristics	Analysis of swabs and/or clothes collected from victim, N=299					Detection of spermatozoa on analyzed swabs and/or clothes collected from victim, N=129				
	N	Analyzed n = 135 (45 %) n (%)	Not analyzed n = 164 (55 %) n (%)	Crude OR (95% CI)	Adjusted OR <sup>a</sup> (95% CI)	N	Spermatozoa positive n = 79 (61 %) n (%)	Spermatozoa negative n = 50 (39 %) n (%)	Crude OR (95% CI)	Adjusted OR <sup>b</sup> (95% CI)
Age	299					129				
16 – 24 years		87 (64)	118 (72)	Ref	Ref		50 (63)	35 (70)	Ref	Ref
≥ 25 years		48 (36)	46 (28)	1.4 (0.9 – 2.3)	1.4 (0.8 – 2.5)		29 (37)	15 (30)	1.4 (0.6 – 2.9)	1.5 (0.7 – 3.3)
Vulnerability factors present	298					128				
No		51 (38)	61 (37)	Ref	Ref		29 (37)	19 (39)	Ref	Ref
Yes		83 (62)	103 (63)	1.0 (0.6 – 1.5)	0.9 (0.5 – 1.4)		50 (63)	30 (61)	1.1 (0.5 – 2.3)	1.0 (0.5 – 2.3)
Occupation	273					117				
Employed/student		96 (78)	105 (70)	Ref	Ref		54 (78)	37 (77)	Ref	Ref
Unemployed		27 (22)	45 (30)	0.7 (0.4 – 1.1)	0.5 (0.3 – 1.0)		15 (22)	11 (23)	0.9 (0.4 – 2.3)	0.9 (0.3 – 2.3)
Suspect origin	271					118				
Western		81 (66)	111 (75)	Ref	Ref		46 (61)	30 (70)	Ref	Ref
Non-Western		42 (34)	37 (25)	1.6 (0.9 – 2.6)	1.6 (0.9 – 2.9)		29 (39)	13 (30)	1.5 (0.7 – 3.2)	1.2 (0.5 – 2.8)
Type of sexual assault	253					111				
No penetration		18 (16)	19 (14)	1.1 (0.6 – 2.3)	1.1 (0.5 – 2.3)		5 (7)	11 (26)	0.2 (0.1 – 0.7)	0.2 (0.1 – 0.8)
Penetration		98 (85)	118 (86)	Ref	Ref		64 (93)	31 (74)	Ref	Ref
Victim/suspect relationship	293					128				
Known		107 (80)	125 (79)	Ref	Ref		66 (84)	36 (74)	Ref	Ref
Stranger		27 (20)	34 (21)	0.9 (0.5 – 1.6)	1.1 (0.6 – 2.0)		13 (17)	13 (27)	0.5 (0.2 – 1.3)	0.5 (0.2 – 1.2)
Physical violence	252					110				
No/Verbal		25 (22)	22 (16)	1.5 (0.8 – 2.7)	1.5 (0.8 – 3.0)		12 (18)	12 (28)	0.6 (0.2 – 1.4)	0.5 (0.2 – 1.4)
Yes		90 (78)	115 (84)	Ref	Ref		55 (82)	31 (72)	Ref	Ref
Venue	295					128				
Private		77 (58)	117 (73)	Ref	Ref		51 (65)	24 (49)	Ref	Ref
Public		57 (43)	44 (27)	2.0 (1.2 – 3.2)	3.2 (1.7 – 6.2)		28 (35)	25 (51)	0.5 (0.3 – 1.1)	0.6 (0.3 – 1.2)
Time of day of assault	289					126				
7 a.m. – 8 p.m.		13 (10)	24 (15)	0.6 (0.3 – 1.2)	0.6 (0.3 – 1.2)		8 (10)	4 (9)	1.2 (0.3 – 4.3)	1.0 (0.3 – 3.7)
8 p.m. – 7 a.m.		119 (90)	133 (85)	Ref	Ref		71 (90)	43 (92)	Ref	Ref
Interval from assault to sampling	297					128				
< 24 h		111 (83)	118 (72)	1.8 (1.0 – 3.2)	1.8 (0.9 – 3.4)		71 (90)	34 (69)	3.9 (1.5 – 10.1)	3.6 (1.4 – 9.5)
> 24 h		23 (17)	45 (28)	Ref	Ref		8 (10)	15 (31)	Ref	Ref
Inspection of the venue	296					128				
No		45 (34)	64 (40)	0.8 (0.5 – 1.2)	0.8 (0.5 – 1.4)		23 (30)	21 (42)	0.6 (0.3 – 1.2)	0.7 (0.3 – 1.5)
Yes		89 (66)	98 (61)	Ref	Ref		55 (71)	29 (58)	Ref	Ref
Interrogation suspect	274					116				
No		28 (23)	35 (23)	1.0 (0.6 – 1.7)	1.3 (0.6 – 2.7)		18 (24)	9 (21)	1.2 (0.5 – 2.9)	1.1 (0.4 – 2.7)
Yes		94 (77)	117 (77)	Ref	Ref		56 (76)	33 (79)	Ref	Ref

<sup>a</sup> Adjusted for victim age, interval from assault to sampling, victim/suspect relationship, type of sexual assault (penetration), and inspection of the venue<sup>b</sup> Adjusted for victim age, interval from assault to sampling, and inspection of the venue

Table 3 Victim-, suspect- and assault characteristics by detection of a DNA match between the victim and the suspect, in police-reported cases of rape

Characteristics	Detection of a DNA match between victim and suspect, N=143					
	N	Match n = 57 (40 %) n (%)	No match n = 50 (35 %) n (%)	Other <sup>a</sup> n = 36 (25 %) n (%)	Match vs. no match	
					Crude OR (95% CI)	Adjusted <sup>b</sup> OR (95% CI)
Age	143					
16 – 24 years		40 (70)	31 (62)	25 (69)	Ref	Ref
≥ 25 years		17 (30)	19 (38)	11 (31)	0.7 (0.3 – 1.6)	0.7 (0.3 – 1.7)
Vulnerability factors	142					
No vulnerability factor		26 (46)	13 (27)	13 (36)	Ref	Ref
At least one vulnerability factor present		31 (54)	36 (74)	23 (64)	0.4 (0.2 – 1.0)	0.4 (0.2 – 1.0)
Suspect origin	132					
Western		37 (66)	34 (77)	20 (63)	Ref	Ref
Non-Western		19 (34)	10 (23)	12 (38)	1.7 (0.7 – 4.3)	2.0 (0.7 – 5.5)
Type of sexual assault	124					
No penetration		5 (10)	9 (21)	6 (19)	0.4 (0.1 – 1.3)	0.4 (0.1 – 1.6)
Penetration		45 (90)	33 (79)	26 (81)	Ref	Ref
Victim/suspect relationship	142					
Known		52 (91)	39 (80)	24 (67)	Ref	Ref
Stranger		5 (9)	10 (20)	12 (33)	0.4 (0.1 – 1.2)	0.2 (0.06 – 0.8)
Venue	142					
Private		42 (74)	23 (47)	19 (53)	Ref	Ref
Public		15 (26)	26 (53)	17 (47)	0.3 (0.1 – 0.7)	0.3 (0.1 – 0.8)
Interval from assault to sampling	142					
< 24 h		51 (91)	39 (78)	31 (86)	2.9 (0.9 – 9.0)	2.8 (0.8 – 9.7)
> 24 h		5 (9)	11 (22)	5 (14)	Ref	Ref
Interrogation suspect	130					
No		1 (2)	11 (25)	14 (48)	0.05 (0.007 – 0.4)	0.05 (0.005 – 0.5)
Yes		56 (98)	33 (75)	15 (52)	Ref	Ref
Inspection of the venue	142					
No		10 (18)	18 (37)	16 (44)	0.4 (0.2 – 0.9)	0.4 (0.2 – 1.1)
Yes		47 (83)	31 (63)	20 (56)	Ref	Ref
Admits sexual contact	100					
No		13 (24)	13 (42)	10 (71)	0.4 (0.2 – 1.1)	0.2 (0.07 – 0.7)
Yes		42 (76)	18 (58)	4 (29)	Ref	Ref
Legal outcome <sup>c</sup>	142					
Prosecuted in court		20 (35)	4 (8)	5 (14)	Ref	Ref
Insufficient evidence		35 (61)	27 (55)	10 (28)	0.3 (0.08 – 0.8)	0.3 (0.08 – 1.0)
No suspect identified		1 (2)	13 (27)	19 (53)		
No crime/complainant withdrawn		1 (2)	5 (10)	2 (6)		

<sup>a</sup>Cases classified as “other” regarding DNA match included: no reference (n=20); too small amounts of DNA to allow a conclusive DNA typing (n=13); missing information regarding the results of the DNA typing; no suspect; and no tested material (the latter three each n=1).<sup>b</sup>Adjusted for victim age, victim/suspect relationship, interval from assault to sampling, and inspection of the venue<sup>c</sup>Adjusted for victim age, interval from assault to sampling, and inspection of the venue

Table 3 Victim-, suspect- and assault characteristics by detection of a DNA match between the victim and the suspect, in police-reported cases of rape

Characteristics	Detection of a DNA match between victim and suspect, N=143							
	N	Match n = 57 (40 %) n (%)	No match n = 50 (35 %) n (%)	Other <sup>a</sup> n = 36 (25 %) n (%)	Match vs. no match		Match vs. other	
					Crude OR (95% CI)	Adjusted <sup>b</sup> OR (95% CI)	Crude OR (95% CI)	Adjusted <sup>c</sup> OR (95% CI)
Age	143							
16 – 24 years		40 (70)	31 (62)	25 (69)	Ref	Ref	Ref	Ref
≥ 25 years		17 (30)	19 (38)	11 (31)	0.7 (0.3 – 1.6)	0.7 (0.3 – 1.7)	1.0 (0.4 – 2.4)	0.9 (0.4 – 2.4)
Vulnerability factors	142							
No vulnerability factor		26 (46)	13 (27)	13 (36)	Ref	Ref	Ref	Ref
At least one vulnerability factor present		31 (54)	36 (74)	23 (64)	0.4 (0.2 – 1.0)	<b>0.4 (0.2 – 1.0)</b>	0.7 (0.3 – 1.6)	0.8 (0.3 – 2.0)
Occupation	132							
Employed/ <del>education</del> student		41 (77)	37 (79)	23 (72)	Ref	Ref	Ref	Ref
Unemployed		12 (23)	10 (21)	9 (28)	1.1 (0.4 – 2.8)	1.0 (0.3 – 3.0)	0.7 (0.3 – 2.0)	0.7 (0.2 – 2.1)
Suspect origin	132							
Western		37 (66)	34 (77)	20 (63)	Ref	Ref	Ref	Ref
Non-Western		19 (34)	10 (23)	12 (38)	1.7 (0.7 – 4.3)	2.0 (0.7 – 5.5)	0.9 (0.3 – 2.1)	1.0 (0.4 – 2.6)
Type of sexual assault	124							
No penetration		5 (10)	9 (21)	6 (19)	0.4 (0.1 – 1.3)	0.4 (0.1 – 1.6)	0.5 (0.1 – 1.7)	0.5 (0.1 – 2.1)
Penetration		45 (90)	33 (79)	26 (81)	Ref	Ref	Ref	Ref
Victim/suspect relationship	142							
Known		52 (91)	39 (80)	24 (67)	Ref	Ref	Ref	Ref
Stranger		5 (9)	10 (20)	12 (33)	0.4 (0.1 – 1.2)	<b>0.2 (0.06 – 0.8)</b>	<b>0.2 (0.06 – 0.6)</b>	<b>0.1 (0.04 – 0.5)</b>
Physical violence	122							
No/Verbal		11 (22)	8 (19)	5 (17)	1.2 (0.4 – 3.2)	1.1 (0.4 – 3.2)	1.3 (0.4 – 4.3)	1.6 (0.5 – 5.7)
Yes		40 (78)	34 (81)	24 (83)	Ref	Ref	Ref	Ref
Venue	142							
Private		42 (74)	23 (47)	19 (53)	Ref	Ref	Ref	Ref
Public		15 (26)	26 (53)	17 (47)	<b>0.3 (0.1 – 0.7)</b>	<b>0.3 (0.1 – 0.8)</b>	<b>0.4 (0.2 – 1.0)</b>	<b>0.3 (0.1 – 0.9)</b>
Time of day of assault	140							
7 a.m. – 8 p.m.		9 (16)	3 (6)	4 (11)	2.9 (0.7 – 11.5)	2.2 (0.5 – 9.6)	1.5 (0.4 – 5.2)	1.3 (0.3 – 4.9)
8 p.m. – 7 a.m.		47 (84)	46 (94)	31 (89)	Ref	Ref	Ref	Ref
Interval from assault to sampling	142							
< 24 h		51 (91)	39 (78)	31 (86)	2.9 (0.9 – 9.0)	2.8 (0.8 – 9.7)	1.6 (0.4 – 6.1)	1.7 (0.4 – 6.6)
> 24 h		5 (9)	11 (22)	5 (14)	Ref	Ref	Ref	Ref
Interrogation suspect	130							
No		1 (2)	11 (25)	14 (48)	<b>0.05 (0.007 – 0.4)</b>	<b>0.05 (0.005 – 0.5)</b>	<b>0.02 (0.002 – 0.2)</b>	<b>0.02 (0.002 – 0.1)</b>
Yes		56 (98)	33 (75)	15 (52)	Ref	Ref	Ref	Ref
Interrogation witnesses	143							
No		3 (5)	8 (16)	5 (14)	0.3 (0.07 – 1.2)	0.3 (0.06 – 1.2)	0.3 (0.08 – 1.5)	0.4 (0.08 – 1.8)
Yes		54 (95)	42 (84)	31 (86)	Ref	Ref	Ref	Ref

<sup>a</sup> Cases classified as “other” regarding DNA match included: no reference (n=20); too small amounts of DNA to allow a conclusive DNA typing (n=13); missing information regarding the results of the DNA typing; no suspect; and no tested material (the latter three each n=1).<sup>b</sup> Adjusted for victim age, victim/suspect relationship, interval from assault to sampling, and inspection of the venue<sup>c</sup> Adjusted for victim age, interval from assault to sampling, and inspection of the venue

Inspection of the venue	142							
No		10 (18)	18 (37)	16 (44)	0.4 (0.2 – 0.9)	0.4 (0.2 – 1.1)	0.3 (0.1 – 0.7)	0.3 (0.1 – 0.7)
Yes		47 (83)	31 (63)	20 (56)	Ref	Ref	Ref	Ref
Admits sexual contact	100							
No		13 (24)	13 (42)	10 (71)	0.4 (0.2 – 1.1)	0.2 (0.07 – 0.7)	0.1 (0.03 – 0.5)	0.1 (0.02 – 0.5)
Yes		42 (76)	18 (58)	4 (29)	Ref	Ref	Ref	Ref
Admits rape/attempted rape	100							
No		53 (98)	32 (100)	14 (100)	NA	NA	NA	NA
Yes		1 (2)	0 (0)	0 (0)				
Legal outcome <sup>d</sup>	142							
Prosecuted in court		20 (35)	4 (8)	5 (14)	Ref	Ref	Ref	Ref
Insufficient evidence		35 (61)	27 (55)	10 (28)	0.3 (0.08 – 0.8)	0.3 (0.08 – 1.0)	0.9 (0.3 – 2.9)	1.3 (0.3 – 5.1)
No suspect identified		1 (2)	13 (27)	19 (53)				
No crime/complainant withdrawn		1 (2)	5 (10)	2 (6)				

<sup>d</sup> Adjusted for victim age, interval from assault to sampling, and inspection of the venue

10.06.2017

FSI-D-16-001129

1

Cristina Cattaneo, BSc, MA, PhD, MD  
Editor-in-Chief  
Forensic Science International

June 9, 2017

Dear editors

**Manuscript ID FSI-D-16-001129: "Factors associated with trace evidence analyses and DNA findings among police reported cases of rape"**

We gratefully acknowledge the valuable comments from the reviewer. We have performed major revisions as suggested by the reviewer.

In the following the reviewer's comments are written in *Italics*. Please find below our specific comments, according to which the manuscript has been revised. We hope the revisions are to your satisfaction. The comments are addressed as follows:

**Reviewers' Comments to Author**

**Reviewer # 2**

**General comments**

*The authors presented a retrospective study based on the data collected from 1997 to 2010 (14 years) by a Norwegian police district concerning cases of rapes (attempted or perpetrated). The claimed aim of the study is to understand whether peculiar characteristics of victim, suspect, assault mode and venue could be associated with the decision of the police to collect the biological traces and to submit them to a forensic lab for the detection of spermatozoa and for the DNA analysis.*

*The study is based on a descriptive collection and analysis of data already recorded by the police. In such cases, **the added value is the selection of the most useful statistical approach able to identify associations between and among the data, if any.***

**Specific comments**

*On the basis of this assumption, the statistical results here presented seem to me a sort of*

*"data fishing" instead, where the authors tried to seek any possible relationship between data. Unfortunately, this was done without a rationale, without making any hypothesis or discussing any association.*

*For examples, what is the meaning of the **claimed association between the analysis of trace evidence and a public venue**? Is this something which "may improve the quality of the health and police systems" as reported by the authors in the Conclusions?*

*The authors claimed an association between samples collected within 24h and the finding of spermatozoa. This is **a trivial result!** It is obvious that the sooner I analyze the traces more likely it will be the chance of finding spermatozoa! Do I need statistics for this result? The same argument can be applied even to the association between **penetrative sexual assault** and the finding of spermatozoa.*

*Even all associations claimed in Table 3 seem to me trivial. It is quite obvious that an association between the suspect admitting sexual contact with the victim and a DNA match can be found as well as the interrogation of the suspect and the inspection of the venue can be associated with a DNA match. Of course, if you have a DNA match with the suspect it is not surprising that the offence has been prosecuted in court!*

*The data collected by the authors can be interesting but they have to be analyzed with a rationale. In my opinion, the data will probably **benefit of a multivariate analysis** exploring the **interaction** of the variables more in detail calculating, for example, **the odd ratio**. In conclusion, I recommend to re-submit the paper after a major revision.*

## **Authors' response**

### **To the general comments**

We agree that the data may benefit from multivariate analyses to identify associations and interactions between the variables, and we have performed such analyses including calculating odd ratios as suggested by the reviewer, see below.

### **To the specific comments**

#### **Regarding hypothesis or our research question**

We are sorry if it seems that our analyses were done without a rationale. Given the scarcity of research on medico-legal evidence in sexual assault cases, our approach has been explorative rather than hypothesis-driven.

However, in our research protocol of 12.12.2014, which was submitted to and approved by the ethical committee (REK-Midt Reference number 2011/276-13) we made a power calculation based on the assumption that the police more often submit trace evidence collected from the victim for laboratory analysis when the assailant is a stranger. The power analysis was calculated with respect to answering the research question: "Is there any association between the victim's relationship to the suspect and analysis of the trace evidence?" The prevalence of stranger rapes and proportion of analyzed trace evidence kits were based on numbers from prior published articles from the same police district (1, 2).



We agree that we should have described this better, and we have included this information in the Introduction part of the revised manuscript on page 2.

### **Regarding meaning of the claimed association between the analysis of trace evidence and a public venue**

In a prior study from the same police district (1), the only medico-legal finding significantly associated with charge filing was the analysis of the collected trace evidence. Surprisingly, no more analyses were performed when the assailant had a more distant relationship to the victim. However, the results are difficult to interpret due to the small sample size.

From our clinical experience working at a Sexual assault center (SAC) and cooperating with the police, to us, a public venue more often seems to be associated with stranger or contact rape. Hence, in such cases, we hypothesized that the police could be more interested in trace evidence analysis to identify a potentially unknown suspect. This is in contrast to a given private setting, where we hypothesized that it would more likely be a known suspect and the suspect claiming the sexual actions were consensual. Here, the trace evidence analysis could give minimal extra information to the police or legal authorities.

In the original analysis performed by chi square test, we found a significant association between public venue and the police decision to analyse trace evidence collected from the victim. Also, after multivariable logistic regression analysis adjusted for victim age, interval from assault to sampling, victim/suspect relationship, type of sexual assault (penetration vs. no penetration), and inspection of the venue (as an indicator of the quality of the police investigation), the association was still statistically significant. Thus, our hypothesis of an association between public venue and decision to analyze trace evidence was confirmed; however, it could not be fully explained by the relationship between victim and suspect. These results are given in the revised Table 2 and on page 7 in the revised manuscript. Again, in the revised manuscript we have described our hypothesis in the introduction part on page 2 and discussed these findings further on page 9.

### **Regarding the sentence in the conclusion "may improve the quality of the health and police systems"**

We have chosen to withdraw this sentence from the Conclusion. Our results are important feed-back for police and health care personnel. However, we cannot infer any causal relationships by our approach and design. Instead, we have re-written the last sentence in the conclusion: "To strengthen the justice response to sexual assault, it is essential to generate knowledge about the role of medico-legal evidence in such cases, and there are obviously other non-medical factors influencing the legal decisions" on page 12.

### **Regarding the association between samples collected within 24h/penetrative assault and the finding of spermatozoa – trivial results**

It is true that it is logical that the sooner SAC personnel collect trace evidence from the victim or her clothing, the more likely it will be to find spermatozoa. However, new technology has made it possible to find spermatozoa even longer than the earlier recommended time limit of 72h after a sexual assault with vaginal penetration. As seen from our revised manuscript page and Table 2, our findings show that more than a third of the samples collected after 24h were positive for spermatozoa. This knowledge may be important in the police's decision on whether or not to submit samples for analysis after 24h.

The same argument could be applied for penetrative assault and association with sperm detection. Even if the association still was valid after adjustments, one third of the non-penetrative assaults left spermatozoa on clothing or on other body surface areas than the inside of the vagina/anus/mouth that could be worthwhile testing for. We agree that these associations were highly expected, however, our main purpose was actually to describe what was found in our SAC/police material and report the exact numbers.

#### **All associations claimed in Table 3 seem trivial**

The reviewer claims that “if you have a DNA match with the suspect it is not surprising that the offence has been prosecuted in court”. We agree that this association is not surprising; however, it is still important to report the actual numbers to gain insight into the importance of a DNA match in legal proceedings. As stated above, if the police’s interrogation of the suspect suggests that the sexual contact was consensual, a DNA match may be of no value as evidence in the case. After performing logistic regression with adjustments, we still found a significant association between prosecution in court and DNA match. Nevertheless, a substantial proportion of cases with DNA match was dismissed because of insufficient evidence. As stated in the revised manuscript page 8: “Among the 29 cases prosecuted in court 20 cases had a matching DNA result, and after adjustment, having a DNA match was associated with prosecution. However, despite a DNA match 35 cases were anyway dismissed because of insufficient evidence.”

#### **Regarding that the data will probably benefit of a multivariate analysis exploring the interaction of the variables more in detail calculating, for example, the odd ratio.**

In accordance with the reviewer’s remarks, we have performed binary and multivariable analyses and calculated odd ratios for all dichotomous outcomes in the revised Tables 2 and 3 (i.e., “analysis of swabs and/or clothes collected from victim”; “detection of spermatozoa on analyzed swabs and/or clothes collected from victim”; “detection of DNA match (between the victim and the suspect) versus no match”). For the outcome “analysis of swabs and/or clothes collected from victim”, we adjusted for victim age, interval from assault to sampling, victim/suspect relationship, type of sexual assault (penetration vs. no penetration), and inspection of the venue (as an indicator of the quality of the police investigation). Due to statistical power considerations, we had to limit the number of freedom degrees to three and four for the outcomes “detection of spermatozoa on analyzed swabs and/or clothes collected from victim” and “detection of DNA match versus no match”, respectively. The statistical approach is described in the revised manuscript on page 4.

#### **Final remarks**

In addition to the revisions described above, some changes have been applied throughout the revised manuscript (highlighted by track changes). We include two versions of the manuscript, one with “track changes” and another without. In addition, we include one version of Table 3 meant for publication, but also a version of this table meant for the editor and the reviewer only.

(Manuscript word count after revision: 3938)

**References**

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