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# 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 97 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.

1,2,3

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<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.

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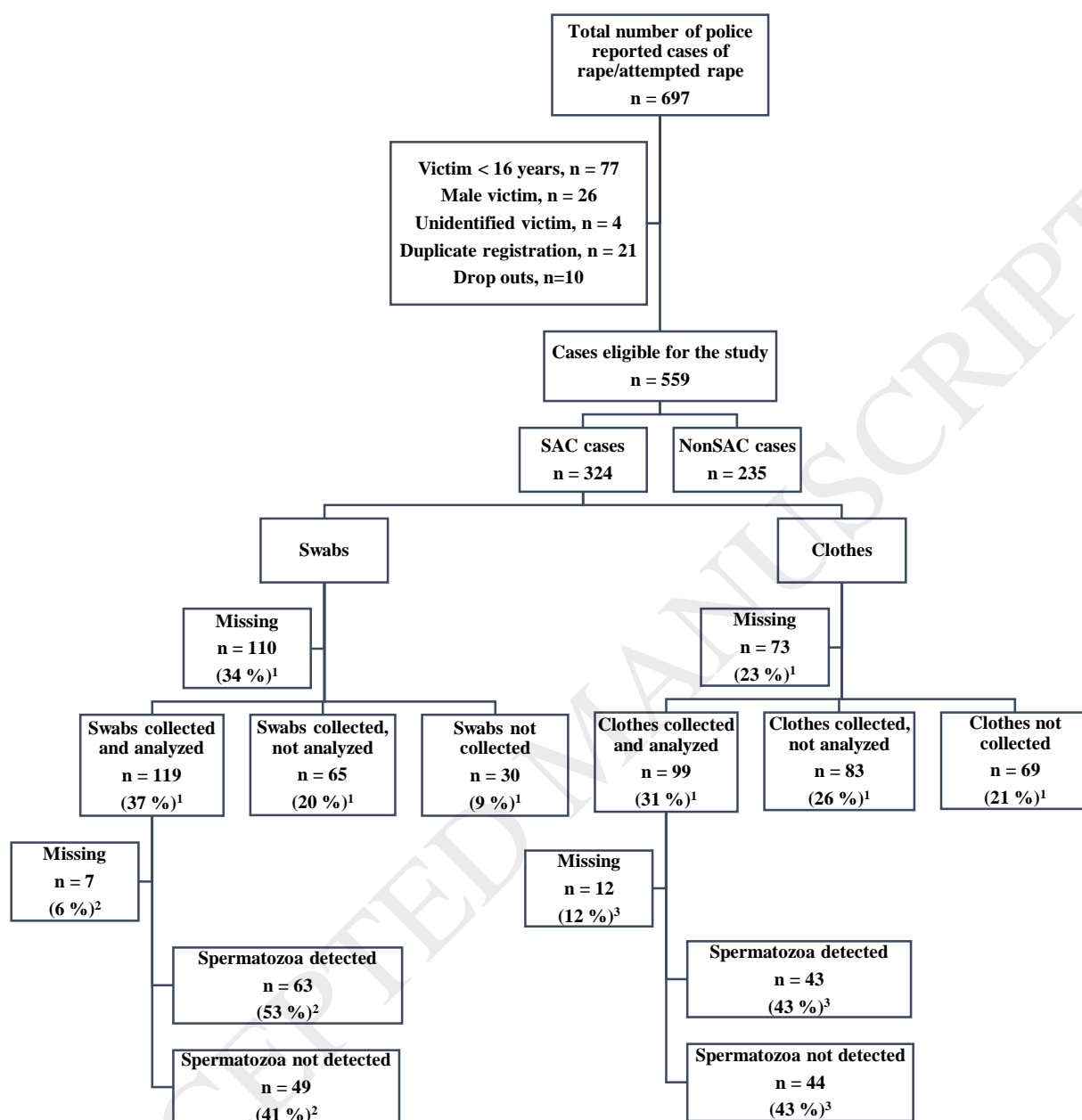
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**Figure 1** Flow chart of included and excluded police-reported cases of rape and attempted rape for the period 1997 – 2010 in the Sør-Trøndelag police district. Presentation of trace evidence analyses and detection of spermatozoa on swabs and clothes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

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

| <b>Characteristics</b>                          | <b>n (%)</b> |
|---|--------------|
| 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)      |

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<br>n = 135<br>(45 %)<br>n (%) | Not<br>analyzed<br>n = 164<br>(55 %)<br>n (%) | Crude<br>OR<br>(95%<br>CI) | Adjusted<br>OR <sup>4</sup><br>(95%<br>CI)   | N   | Spermatozoa<br>positive<br>n = 79 (61<br>%)<br>n (%) | Spermatozoa<br>negative<br>n = 50 (39<br>%)<br>n (%) | Crude<br>OR<br>(95%<br>CI) | Adjusted<br>OR <sup>5</sup><br>(95%<br>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<br>(0.9 –<br>2.3)      | 1.4 (0.8 –<br>2.5)   |     | 29 (37)  | 15 (30)  | 1.4<br>(0.6 –<br>2.9)      | 1.5 (0.7 –<br>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<br>(0.6 –<br>1.5)      | 0.9 (0.5 –<br>1.4)   |     | 50 (63)  | 30 (61)  | 1.1<br>(0.5 –<br>2.3)      | 1.0 (0.5 –<br>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<br>(0.4 –<br>1.1)      | 0.5 (0.3 –<br>1.0)   |     | 15 (22)  | 11 (23)  | 0.9<br>(0.4 –<br>2.3)      | 0.9 (0.3 –<br>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<br>(0.9 –<br>2.6)      | 1.6 (0.9 –<br>2.9)   |     | 29 (39)  | 13 (30)  | 1.5<br>(0.7 –<br>3.2)      | 1.2 (0.5 –<br>2.8)                         |
| Type of sexual assault            | 253   |  |   |                            |  | 111 |  |  |                            |  |
| No penetration                    |   | 18 (16)                                | 19 (14)                                       | 1.1<br>(0.6 –<br>2.3)      | 1.1 (0.5 –<br>2.3)   |     | 5 (7)  | 11 (26)  | 0.2<br>(0.1 –<br>0.7)      | 0.2 (0.1 –<br>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<br>(0.5 –<br>1.6)      | 1.1 (0.6 –<br>2.0)   |     | 13 (17)  | 13 (27)  | 0.5<br>(0.2 –<br>1.3)      | 0.5 (0.2 –<br>1.2)                         |
| Physical violence                 | 252   |  |   |                            |  | 110 |  |  |                            |  |
| No/Verbal                         |   | 25 (22)                                | 22 (16)                                       | 1.5<br>(0.8 –<br>2.7)      | 1.5 (0.8 –<br>3.0)   |     | 12 (18)  | 12 (28)  | 0.6<br>(0.2 –<br>1.4)      | 0.5 (0.2 –<br>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<br>(1.2 –<br>3.2)      | 3.2 (1.7 –<br>6.2)   |     | 28 (35)  | 25 (51)  | 0.5<br>(0.3 –<br>1.1)      | 0.6 (0.3 –<br>1.2)                         |
| Time of day of assault            | 289   |  |   |                            |  | 126 |  |  |                            |  |
| 7 a.m. – 8 p.m.                   |   | 13 (10)                                | 24 (15)                                       | 0.6<br>(0.3 –<br>1.2)      | 0.6 (0.3 –<br>1.2)   |     | 8 (10)   | 4 (9)  | 1.2<br>(0.3 –<br>4.3)      | 1.0 (0.3 –<br>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<br>(1.0 –<br>3.2)      | 1.8 (0.9 –<br>3.4)   |     | 71 (90)  | 34 (69)  | 3.9<br>(1.5 –<br>10.1)     | 3.6 (1.4 –<br>9.5)                         |
| > 24 h                            |   | 23 (17)                                | 45 (28)                                       | Ref                        | Ref  |     | 8 (10)   | 15 (31)  | Ref                        | Ref  |

<sup>4</sup> Adjusted for victim age, interval from assault to sampling, victim/suspect relationship, type of sexual assault (penetration), and inspection of the venue<sup>5</sup> Adjusted for victim age, interval from assault to sampling, and inspection of the venue

|                         |     |         |          |                       |                    |     |         |         |                       |                    |
|-------------------------|-----|---------|----------|-----------------------|--------------------|-----|---------|---------|-----------------------|--------------------|
| Inspection of the venue | 296 |         |          |                       |                    | 128 |         |         |                       |                    |
| No                      |     | 45 (34) | 64 (40)  | 0.8<br>(0.5 –<br>1.2) | 0.8 (0.5 –<br>1.4) |     | 23 (30) | 21 (42) | 0.6<br>(0.3 –<br>1.2) | 0.7 (0.3 –<br>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<br>(0.6 –<br>1.7) | 1.3 (0.6 –<br>2.7) |     | 18 (24) | 9 (21)  | 1.2<br>(0.5 –<br>2.9) | 1.1 (0.4 –<br>2.7) |
| Yes                     |     | 94 (77) | 117 (77) | Ref                   | Ref                |     | 56 (76) | 33 (79) | Ref                   | Ref                |

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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<br>n = 57<br>(40 %)<br>n (%) | No match<br>n = 50<br>(35 %)<br>n (%) | Other <sup>6</sup><br>n = 36<br>(25 %)<br>n (%) | Match vs. no match   |                                      |
|   |  |                                    |                                       |   | Crude OR<br>(95% CI) | Adjusted <sup>7</sup> OR<br>(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>8</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>6</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>7</sup>Adjusted for victim age, victim/suspect relationship, interval from assault to sampling, and inspection of the venue

<sup>8</sup>Adjusted for victim age, interval from assault to sampling, and inspection of the venue

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