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Research paper

Lessons from a study of DNA contaminations from police services and forensic laboratories in Switzerland

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ABSTRACT

In Switzerland, the DNA profiles of police officers collecting crime scene traces as well as forensic genetic laboratories employees are stored in the staff index of the national DNA database to detect potential contaminations. Our study aimed at making a national inventory of contaminations to better understand their origin and to make recommendations in order to decrease their occurrence. For this purpose, a retrospective questionnaire was sent to both police services and forensic genetic laboratories for each case where there was a contamination.

Between 2011 and 2015, a total of 709 contaminations were detected. This represents a mean of 11.5 (9.6–13.4) contaminations per year per 1′000 profiles sent to the Swiss DNA database. Feedbacks were obtained from the police, the laboratory or both for 552/709 (78%) of the contaminations. Approximately 86% of these contaminations originated from police officers whereas only 11% were from genetic laboratories employees and 3% were associated to other sources (e.g. positive controls, stain–stain contaminations). Interestingly, a direct contact between the stain and the contaminant person occurred in only 51% of the laboratory contaminations whereas this number increased to 91% for police collaborators. The high level of indirect DNA transfer in laboratories might be explained by the presence of "DNA reservoirs" suggesting that cleaning procedures should be improved. At the police level, most contaminations originated from the person who collected the trace and likely occurred directly at the crime scene. Improving sampling practices could be beneficial to reduce these contaminations.

1. Introduction

With the current sensitivity of profiling STR kits, it is more common to detect minute amount of contaminating DNA left by persons collecting or analyzing crime scene traces [1–3]. These contaminations represent one of the most frequent source of error in forensic genetics and may have serious consequences on the result of an analysis [[1–3],[4]]. First, the contaminant profile might mask the DNA profile of a crime stain and prevent a relevant profile to be sent to the national database. Second, if unidentified, a contaminant profile might create erroneous investigative leads as illustrated in the classical example of the "Heilbronn phantom" [5]. This increases the risk of wrongfully discarding correct investigative leads and might have costly consequences (e.g. increase resources needed to process comparisons, delay the process of other cases) [4]. Third, contaminations may also create mixed DNA profiles and may therefore decrease the evidential value of a match with the DNA profile of a person [1]. Finally, if contaminations are not detected early enough, they may generate a lot of public or justice attention and may damage the reputation of forensic actors (i.e. police services or genetic laboratories) [1]. For these different reasons it is necessary to take all possible actions to keep the risk of contaminations as low as possible.

Contamination may occur through different modes (e.g. through direct or indirect transfer, as a result of ineffective cleaning procedures or as a result of contaminated material used to collect traces) and at any stage of the analysis of a DNA sample (i.e. from the collection at the crime scene to the analysis in the laboratory) [4]. Therefore, it is important to increase our understanding of the factors involved in contaminations. Although several recent studies tried to list and evaluate the occurrence of contaminations (e.g. [[7–11],[7–11],[4],6]) or focus on specific modes of contaminations (e.g. [7–11]), few studies tried to address contaminations from both the police and laboratory perspectives. Thus, several general important questions about contaminations are still open. These include knowing (i) the nature of the contaminated stains, (ii) the relative frequency of direct or indirect contaminations, (iii) the consequences of contaminations on the exploitation of a stain,

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Table 1
Representative questions and expected answers of the questionnaire sent to (a) the police services and (b) to the forensic genetic laboratories (a full version of the questionnaire is also available in supplementary Table 1).

(a) Police services

Questions	Expected answers
Date of the collection of the contaminated stain?	Date
Nature of the contaminated stain?	Trace DNA, blood, saliva, semen, unknown
Do you have an explanation about this contamination?	Yes, no
If yes, which one?	Text answer
Has the contaminant person been in direct contact with the stain?	Yes, no, unknown
If yes, where did the contact take place?	e.g. during collection of the stain, during handling of the box, during labeling, during storage, unknown
Where does the contaminant person work?	Only in the laboratory, only on crime scenes, in the laboratory and on crime scenes, other
Has another stain been collected on the same item?	Yes, no
If yes, did that allow to get another DNA profile different than the contaminant profile?	Yes, no
General remarks?	Text answer

(b) Forensic genetic laboratories

Questions	Expected answers
How was the contamination detected?	National database (CODIS), local staff database, other
Quantification value [ng/ul]?	Concentration value
Kit used?	e.g. NGM select, ESI, Global filer, SGM Plus, SEfiler, minifiler, ESX
Characterization of the contaminated profile?	profile appearing as single source; mixture profile, major for CODIS, minor not interpretable; mixture profile, major for CODIS, minor for local comparison; mixture profile of 2 contributors; reduced profile; profile kept for local comparison; other
After the detection of the contamination, how was it possible to use the profile?	Profile other than the contaminant profile sent to CODIS as a mixture; profile other than the contaminant profile sent to CODIS as a reduced profile; profile kept for local comparison; no other profile than the contaminant profile; other
At what step do you think the contamination occured?	Storage; reception/control/registration; collection of the stain; extraction; quantification; amplification; During the handling of the stain by the police; unknown; other
In cases of contamination by a laboratory employee, has the person worked with the sample?	Yes, no, unknown
If yes, at which step?	Storage; reception/control/registration; collection of the stain; extraction; quatification; amplification; other
General remarks?	Text answer

(iv) where and when do contaminations occur the most likely, and (v) whether there are differences between laboratory or police contaminations. Answering such questions might help improve procedures, design good forensic practices to prevent DNA contaminations both at crime scene and in the laboratories and provide better education to the persons involved in the collection and the analysis of DNA stains.

Switzerland is a country with approximately 8 million inhabitants. It is divided into 27 police services and has 7 accredited forensic DNA laboratories independent of the police. Although some variability exists among services and laboratories regarding how crime scene samples are to be processed, stains or crime scene items are mostly collected directly at the crime scene by police collaborators. In other cases, these items are sent to police or forensic DNA laboratories for stain collections by scientific collaborators. The stains are then analyzed in the ISO 17025 accredited laboratories using various STR kits and protocols. According to the Swiss law [12], at least two PCR amplifications are necessary to validate a DNA profile. Based on the concordance between replicates, the result at a locus can be validated. The profiles are generally characterized into several categories: (i) no DNA profile, (ii) profile not interpretable, (iii) profile appearing as single source, (iv) mixed DNA profile appearing as 2 person mixture, (v) mixed DNA profile with a major component of one or two contributors and a minor component not interpretable or available for local comparisons, (vi) mixed DNA profile of more than two contributors available for local comparisons. Both the profiles of one contributor (single or major contributor) and the mixtures of two contributors can be sent to the Swiss national DNA database if at least six, respectively eight, loci have been validated. In contrast, mixtures of more than two contributors and minor components of mixtures cannot be sent to the database. The Swiss database has been initiated in 2000 and is based on the CODIS software. At the end of the study period (2015), approximately 62′000 stain profiles and 175′000 person profiles were in the database. Since 2012, the database accepts profiles of new generation kits such as for example NGM SElect or PowerPlex ESI 17. At the end of 2015, the DNA profiles of 2018 police collaborators collecting crime scene stains, 429 forensic genetic laboratories collaborators, as well as 10 profiles of other types (such as positive controls) were stored in the staff index of the national DNA database. However, no nationwide legislation requires Swiss crime scene officers and laboratory employees to submit their DNA profile to the staff index. Therefore, each police service and laboratory have their own regulations on whose DNA profile must be included or not in the staff index. Each new profile transferred to the national DNA database is not only compared to the person and stain indexes, but also to the staff index to detect potential contaminations. Once a potential contamination has been detected and validated, the laboratory and the head of the police department that handled the stain are informed so that appropriate measures can be taken. However, each entity generally addresses their contaminations independently.

In such a context, we decided to conduct a large DNA contamination study in Switzerland. In this regard, a retrospective questionnaire was sent to both police departments and forensic genetic laboratories for each contamination detected between 2011 and 2015. Our aims were to (i) make a national inventory of DNA contaminations, (ii) increase our understanding of their origins and of the mechanisms involved in these contaminations and (iii) identify potential measures to minimize their occurrences. In addition, this study aimed at increasing communications about forensic errors such as contaminations as recently recommended by [1].

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