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Research paper

Study of criteria influencing the success rate of DNA swabs in operational conditions: A contribution to an evidence-based approach to crime scene investigation and triage

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ABSTRACT

DNA is nowadays swabbed routinely to investigate serious and volume crimes, but research remains scarce when it comes to determining the criteria that may impact the success rate of DNA swabs taken on different surfaces and situations. To investigate these criteria in fully operational conditions, DNA analysis results of 4772 swabs taken by the forensic unit of a police department in Western Switzerland over a 2.5-year period (2012–2014) in volume crime cases were considered.

A representative and random sample of 1236 swab analyses was extensively examined and codified, describing several criteria such as whether the swabbing was performed at the scene or in the lab, the zone of the scene where it was performed, the kind of object or surface that was swabbed, whether the target specimen was a touch surface or a biological fluid, and whether the swab targeted a single surface or combined different surfaces. The impact of each criterion and of their combination was assessed in regard to the success rate of DNA analysis, measured through the quality of the resulting profile, and whether the profile resulted in a hit in the national database or not.

Results show that some situations—such as swabs taken on door and window handles for instance—have a higher success rate than average swabs. Conversely, other situations lead to a marked decrease in the success rate, which should discourage further analyses of such swabs. Results also confirm that targeting a DNA swab on a single surface is preferable to swabbing different surfaces with the intent to aggregate cells deposited by the offender.

Such results assist in predicting the chance that the analysis of a swab taken in a given situation will lead to a positive result. The study could therefore inform an evidence-based approach to decision-making at the crime scene (what to swab or not) and at the triage step (what to analyse or not), contributing thus to save resource and increase the efficiency of forensic science efforts.

1. Introduction

Swabbing for DNA is currently the most widely spread technique to collect biological evidence on various surfaces at scenes of crime or in the lab [32]. In most jurisdictions, DNA swabs are used in the investigation of serious crime and more and more routinely for high-volume crimes as well. Concerning the latter category, it is recognised that DNA provides a major contribution to policing [5,11], for instance Roman et al. report that "*more than twice as many suspects identified, twice as many suspects arrested, and more than twice as many cases accepted for prosecution*" when comparing crime scenes investigated with traditional police practices versus those investigated with these practices plus DNA [26,27]. In order to enhance the contribution of DNA to crime fighting, Walsh et al. [33] emphasised more than a dozen years ago "*the need for constant assessment and refinement of the DNA profiling process so the highest probability of success is afforded to evidence samples. DNA laboratories should constantly monitor the analytical success rates of evidence types, as any improvement will directly increase the number of crimes solved*". Since then, the DNA profiling process has undergone many impressive developments. However, this recommendation should not only be followed by DNA labs but

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also by crime scene investigation units. In that regard, published research remains surprisingly scarce when it comes to determining in operational conditions the criteria that impact the success rate of swabs taken on various surfaces and in different situations.

Knowing how and where to collect DNA in order to optimise the quality, effectiveness and efficiency of forensic investigations is a key challenge, as accounted for by the intelligence-led crime scene processing model proposed by Ribaux et al. [22,23]. This model emphasises the critical need to inform decision-making at four different levels, one of them concerning the physical dimension associated with traces, their transfer and collection. For instance considering DNA, crime scene investigators need to be able to identify where to target their swabs and how to perform the swabbing to get as usable and useful results as possible. This is especially critical when considering touch DNA as this type of biological material is the hardest to locate and to profile [4,20,26].

Research work conducted in the UK report that whether the crime scene examiner is accredited or not as well as the sample condition of touch DNA and cigarette ends (damp, wet or dirty) are both predictors of the ability of successfully obtaining a profile. Besides fast-tracking and interviewing officers being accredited or not, the location (inside/outside the scene), the quantity (several matches of the same or different sources), and the type of DNA material are predicting factors of the ability to convert DNA matches into crime detections [4,3]. In Switzerland, with the intent to optimise results and expenses associated with DNA analyses, Albertini and Milon reviewed the results obtained by the police of Vaud over 2005–2008 [1,15]. Based on their findings concerning touch DNA, they identified supports and surfaces that were associated with negative results and that should be avoided in the future by crime scene officers. The consecutive introduction of recommendations enhanced their DNA results, and the better informed triage led to a greater control of expenses.

Using an extensive dataset gathered in fully operational conditions, the current study investigates the criteria that may influence the success rate of DNA swabs and their analysis. The aim is to devise evidence-based guidelines in order to support decision-making and prioritisation at the crime scene—*What to swab or not?*—as well as at the triage step—*What to analyse or not?* Evidence-based guidelines would be helpful in overcoming the common challenges associated with collecting more and more DNA at crime scenes, challenges that ultimately result in financial issues and in the risk of overwhelming the criminal justice system [11,26,27]. Indeed, such guidelines could assist in training patrol officers and forensic technicians so that they can better target their swabs, thus streamlining the time and efforts spent at crime scenes. Better targeted swabs and evidence-based guidelines to support triage would also assist in limiting backlog issues [16,19,27] and optimise in the end the contribution of DNA to crime fighting.

2. Method

The study considered retrospectively a comprehensive set of 4772 swabs (casework samples) that had been taken and sent for DNA analysis by the forensic unit of the Police of Neuchâtel over a 2.5 year period (April 2012–October 2014) in 2946 volume crime cases, making an average of 1.62 swabs analyses per crime. The jurisdiction of Neuchâtel is located in Western Switzerland and was populated by 177,000 inhabitants in 2014 (about 2.2% of the total Swiss national population). The forensic unit is staffed with 10.5 full-time equivalent crime scene investigators and has worked on 4500 crime events over the 2.5-year period, 86.4% (3890) being volume-crime related, mostly residential and commercial burglaries. Swabs associated with serious crimes were not considered in this study because they are much less representative due to their restricted number and their peculiarity—yielding significant proportions of sperm, bloodstains as well as specimens associated with dead bodies, which are not amongst the most frequent and challenging DNA specimens overall. Furthermore, results collated through the analysis of volume crime swabs are also valid for serious crime swabs (see Section 4).

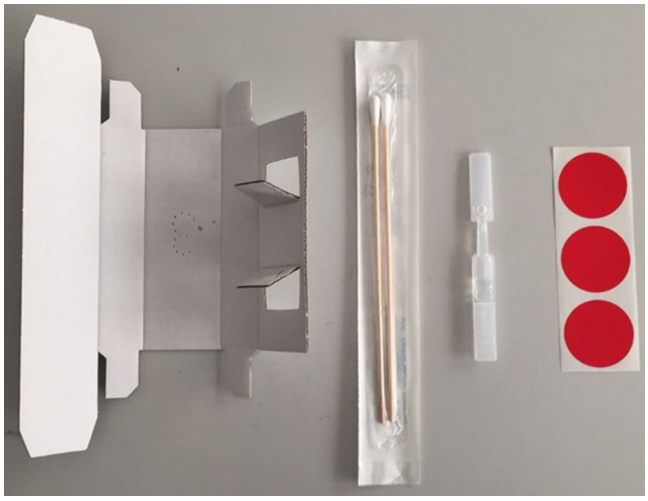

Fig. 1. Picture of the Forensix® cotton swabs kit provided by Applimed SA™ used to perform the double swab technique (1 dry, 1 moistened with sterile water). After collection, both swabs are allowed to dry in the cardboard box (left) that is closed using the red seals (right).

Each of the 4772 swabs[1] was performed by the double swab technique (1 dry, 1 moistened [29,17]) using Forensix® cotton swabs provided by Applimed SA™, a Swiss company (Fig. 1). All the 4772 swabs were analysed by the regional DNA lab, the *Centre Universitaire Romand de Médecine Légale* in Lausanne, using the forensic kit NGM SElect™ (Applied Biosystems™). Resulting profiles were uploaded in the national DNA database whenever they reached introduction thresholds, namely to yield at least 6 loci for a single profile, and at least 8 loci for a two-person mixture profile (mixtures of more than two persons are not allowed to be uploaded in the Swiss national DNA database).

A representative sample of 1236 swabs was randomly drawn from the total of 4772 in order to systematically examine and

Table 1
Proportion of swabs according to the 11 typical categories of objects/surfaces. *: by *Broken window/Blinds*, we mean swabs taken on the contact marks observed on glass (such as fatty-looking wipe marks or leaning marks close to or around the hole in the window) as well as on the sides of the blinds (where they have been damaged or bent by the offender). The category Bottle *neck/Piece of food* does not only cover bottles but any beverage container such as glasses and cans.

Kind of object or surface swabbed	Dataset [%] (n = 1236)
Drawer handle/Cable	21.9
Handheld object	19.7
Door or window handle/Steering wheel	18.5
*Broken window/Blinds**	13.6
Lock/Cylinder	10.8
Glove mark	5.3
Thrown stone	3.2
Clothes/Hand glove	2.8
*Bottle neck/Piece of food***	1.5
Cigarette butt	1.4
Bloodstain	1.3

[1] All the DNA evidence samples except 17 cigarette butts, or 0.35%, were swabs, so that word only is used throughout the article for convenience reasons.