Archived: Thursday, 24 March 2022 13:03:21
From: Middleton.TimM[OSC]
Sent: Wednesday, 11 September 2019 15:42:54
To: Krosch.MattN[OSC]
Subject: RE: DNA success per item
Sensitivity: Normal
Attachments:
dna_analysis_raw.xlsx ;

I was taking the words from both fields
The type of surface material eg glass/wood/plastic seems to be in description but the located/owner is location within the scene
Here is the raw data, I think powershell will have a grep equivalent Select-String which you can use regex to search

S.73

From: Middleton.TimM[OSC]
Sent: Wednesday, 11 September 2019 14:38
To: Krosch.MattN[OSC] CTPI [redacted]@police.qld.gov.au>
Subject: RE: DNA success per item

I'll do another sheet with 2 word combos instead and see how it is.
The thing is the more words the more likely it is to have a lot of combinations that only appear 1/2/3 times

S.73

S.73

From: Middleton.TimM[OSC]
Sent: Wednesday, 11 September 2019 13:37
To: Krosch.MattN[OSC] CTPI @police.qld.gov.au>
Subject: RE: DNA success per item

Hi Matt
I think I did something similar last year where I split all the exhibit descriptions into words and calculated percentage of them linked to profiles and idents
The descriptions are just free text so there is not a lot of consistency to it
but basically in this sheet, if the exhibit description has 'blood' in it, 73 percent would have a full profile result

S.73

Archived: Thursday, 24 March 2022 13:02:59
From: Neville.DavidH[OSC]
Sent: Friday, 27 September 2019 14:33:12
To: Krosch.MattN[OSC]
Subject: RE: DNA success per item
Sensitivity: Normal

That is bloody interesting. I am going to use this info

S.73

Archived: Thursday, 24 March 2022 13:08:38
From: Keatinge.DavidJ[OSC]
Sent: Friday, 1 November 2019 12:26:59
To: Krosch.MattN[OSC]
Subject: RE: DNA success rates draft paper
Sensitivity: Normal

Matt
I have had a quick read this morning and found the paper to be very informative considering the pool of data that was analysed. I do not think any of the data is too sensitive that it needs to be omitted from the paper. We will wait to here from DN. Well done.

Regards
Dave

David Keatinge
Inspector | Quality Manager | Forensic Services Group | Queensland Police Service
CTPI | Sch4p4(6) | Email: CTPI @police.qld.gov.au

S.73

Forensic DNA sampling success rates for common exhibits: a Queensland perspective.

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Field Code Changed

Forensic DNA sampling success rates for common exhibits: a Queensland perspective.

Abstract

Keywords: swabs, tapelifts, DNA profile,

Introduction

DNA sampling, particularly of touched objects and surfaces, has become an increasing focus for forensic analysts globally[1,2]. Resolution of DNA~~suspect~~ profiles from such items can be highly probative and thus understanding the relative success rates of recovering profiles from items is important for targeting sample collection and triaging for analysis. Such success rates ~~must necessarily~~should be considered in the context of the specific collection and analysis methods used by a given jurisdiction. Comparing data generated from different extraction and profiling methods may not necessarily represent a like-for-like comparison and ~~must~~ should be considered with ~~some~~ caution. Nevertheless, there can be great value in comparing between jurisdictions to determine whether substantial differences are apparent and where improvements could be made. Moreover, sampling of ~~putatively~~ possibly touched items can be a point of friction between investigators and forensic scientists who may have contrasting anecdotal experience concerning a questioned item. Finally, where jurisdictions use multiple collection methods for similar items (because of officer preference or simply what consumables are available at the time), it is important to assess whether one method ~~is~~ outperforms another to ensure operational procedures follow best practice. Therefore, there is a need for additional data to inform decision-making and assist forensic scientists in optimally targeting sampling effort.

There have been sporadic attempts over the last twelve years to address this issue in a range of national and state jurisdictions from New Zealand[3], Switzerland[4], Canada[5], ~~the~~ Netherlands[6], Singapore[7], and ~~New South Wales,~~ Australia[8], including a comparative analysis of experimental and casework samples from Western Switzerland[9]. These studies typically assessed the success rates of ~~analyse subsets of~~ various types of casework samples ~~for selected items of interest; either those most~~that were commonly collected~~, restricted to volume crime cases, or otherwise~~. Generally speaking, these studies were consistent in suggesting that, as expected, biological fluid traces (blood, saliva, semen) provided the greatest proportions of full profiles (up to 87.5%[9]), whereas touch samples were far less successful overall (<30%). Worn or touched items that often returned above average proportions of full profiles include hats/caps, gloves, adhesive tape, clothing, door handles and steering wheels[3-9] ~~,~~ – though in some cases these may represent victim~~complainant~~ profiles.

This study aimed to analyse success rates of DNA sampling from major and volume crime for the Queensland Police Service, Queensland, Australia over a period of roughly 20 months. Success rates were determined for sample types over the entire period, as well as broken down to selected items of interest, including those that are commonly encountered or have high probative value. Queensland data is~~are~~ then discussed in the context of previous literature.

Methods

Samples included in this analysis were collected from exhibits related to both major and volume crime between the 1st January 2017 and 11th September 2019. Methods of collection included swabbing with a rayon swab (Medical Wire, UK) pre-moistened with 70% ethanol, tapelifting with a custom 3M adhesive tape kit (Lovell Surgical Supplies, Australia), excision (e.g., fabric, cigarette butts), and scraping. All samples were processed at Queensland Health Forensic Scientific Services (QHFSS) following standard procedures: DNA extraction conducted using the DNA IQ™ Casework Pro Kit for Maxwell®16 (Promega Corp., Melbourne, Australia) on a Maxwell® 16 MDx (Promega Corp.); quantification using Quantifiler® Trio (ThermoFisher Scientific, Melbourne, Australia) on the 7500 Real Time PCR System (Applied Biosystems™, ThermoFisher Scientific), and STR amplification using PowerPlex® 21 (Promega Corp.). DNA quantification results determined progression to profiling, according to QHFSS standard procedures: samples of concentration <0.0088ng/µL were considered to have insufficient DNA and were thus categorised as 'no DNA'. Samples that yielded sufficient DNA (>0.0088ng/µL) proceeded to STR profiling.

Data was extracted from the in-house laboratory information management system (LIMS) for all DNA samples sent for processing between the 1st January 2017 and 11th September 2019. The LIMS was queried in such a way to return sample type (e.g., swab/tapelift) and exhibit description information, as well as STR profiling results categorised as 'full' (all 42 alleles present), 'partial/mixed' (less than 42 alleles, or more than one contributor), or 'no DNA' (DNA quantification insufficient for profiling). In some cases,

profiling results could include multiple categories; for example, full+partial/mixed profile results may indicate full profiles deconvoluted from mixtures, or no DNA+full or partial/mixed where sub-threshold information (<150rfu) was present, or where the original quantification was insufficient, but the sample was profiled following investigator request. Profiles were also recorded for whether they matched a suspect/offender reference sample. This master spreadsheet was queried using Windows Powershell to extract lines in which the exhibit description matched specific text strings. All resulting sub-sheets were manually reviewed to ensure only relevant data was included. Despite this, inconsistencies in spelling and terminology in the exhibit description limited the completeness of the analysis; however, this is unlikely to impact ~~dramatically~~ significantly on the interpretation of DNA success rates ~~here~~. Percentages of each profile result category were calculated for the total dataset, each collection method across all items, and then broken down for collection method from each selected item. Success rates were also ~~interrogated for~~assessed for porous versus non-porous ~~items/surfaces~~substrate surfaces. Sample metadata allowed separation of swabs from biological fluid stains (blood, saliva, semen) to be separated from those taken from putative touched areas or handled objects.

Results

In total, 61 344 total records (representing 60 332 unique exhibits) were analysed, the majority of which were swabs or tapelifts (Table 1). Swabs collected from biological fluids represented a much smaller proportion than those from touched areas/objects. Overall, 25.85% of samples returned full profiles: the greatest proportion of full profiles was obtained from samples of obvious stains of biological fluids, with the most successful being swabs of bloodstains (73.96%, Table 2). Partial/mixed profiles were rarely obtained from semen swabs (1.96%), but otherwise ranged up to 28.04% of DNA results from other sample types. Percentages of suspect identifications ranged from 13.49% (hair) to 41.55% (blood swabs). Both swabs and tapelifts of touched objects/surfaces returned suspect identifications from ~15% of samples, but there was a significant disparity between full profile results (swabs = 13.46%; tapelifts = 7.02%). Despite this, tapelifts provided nearly 25% of total suspect identifications compared with 17% for trace swabs (Table 1), suggesting that the success of tapelifting is often reliant on partial profiles or deconvolution of mixtures.

Commented [N1]: Really, we find semen almost always is mixed with complainant dna in saik

Individual items/surfaces showed great variation in their percentage success. The greatest success for exhibits where no visible stain was observed was for swabs and excised sections from drinking straws, which produced full profiles in ~47% of samples taken, whereas tapelifts from (what, staws) were slightly less successful at 33.3%. Bedding (swab), waistbands of lower garments (swab), rubber keys (swab), discharged ammunition (tapelift), underwear (both), zip/cable ties (both), and drinking vessels (both) all produced full profiles in >20% of samples. The least successful items (no full profiles recorded) included: swabs of cigarette packets, rocks, helmets, firearm barrels, shirt collars, power cords, rubber keys; tapelifts of external car door handles, ~~sweat~~ visible smears on cars ~~and~~ glovemarks; and both swabs and tapelifts of public phones, fingermarks and swabs of several tools. Despite this, several of these items did return suspect identifications based on partial profiles; including, external car door handles, shirt collars, and rubber ke~~ys~~. Among sexual assault kit samples, breast swabs identified the greatest percentage of suspects after penis swabs (suspect reference samples), no suspect identifications were recorded from perineum samples. The highest percentage of full profiles were reported from oral swabs (most likely complainant profiles, though 8.41% were identified a suspect), whereas the lowest proportion of full profiles were from breast swabs.

Some distinct differences in the recovery of full profiles from swabs and tapelifts of trace samples were observed for specific items. Swabs were at least twice as successful as tapelifts for car doors, car door handles, seatbelt straps & buckles, adhesive tapes, drinking vessels, firearm handles, sweat smears on cars, waistbands of lower garments, sledgehammers, mattock/pickaxes, torches, and bedding. In contrast, tapelifts were more successful for discharged car airbags, gearsticks, motorcycles (including handlebars), cigarette packets, power cords, flyscreen, rubber and metal keys, ammunition (both discharged and live), firearm barrels, mobile phones, shirt collars, helmets, hats, rocks, and several tools. In contrast to conventional wisdom, tapelifts of non-porous surfaces recovered slightly more full profiles than swabs, whereas swabs were better for porous surfaces (Table 3). Furthermore, porous surfaces returned a greater percentage of full profiles and suspect identifications than non-porous surfaces.

Commented [N2]: What is a rubber key- car key or keyboard?

Commented [N3]: Bullshit, I have never heard of dna from discharched ammo

Formatted: Highlight

Formatted: Highlight

Commented [N4]: Really, is there a penis swab in those kits. The vaginal swabs tend to yield most results. I don't think that penis swabs are in rape kits

Data caveats

A small number of samples were recorded as returning results in more than one category: 256 records were categorised as both partial/mixed and full (likely representing full profiles deconvoluted from mixtures), representing 2% of partial/mixed records and 1.6% of full profile results; 614 samples were categorised as both partial/mixed and no DNA, representing 1.7% of no DNA results and 4.8% of partial/mixed results; 3001 samples were categorised as both no DNA and full, representing 8.2% of no DNA results and 19% of full profile results; and 92 samples were categorised across all three categories. The vast bulk of such multiple categorisations are due to sub-threshold information present in otherwise full, partial or mixed profiles, or samples that fell below the internal quantification threshold for profiling but were processed following investigator request. In the context of the total dataset these multiple categorisations are not considered to substantially impact on the interpretation of profiling success rates. Manually reviewing every record was outside the scope of this project.

Discussion

The analysis presented here of over 18 months of DNA sampling data, representing more than 60 000 individual exhibits, from the Queensland Police Service has revealed some interesting patterns that can inform operational procedures. Averaged over all items/surfaces, trace swabs recovered more full profiles than tapelifts; however, there was substantial variation noted among exhibit types, including many for which tapelifts were the more successful method of collection. Increasing the granularity of the analysis therefore provided a deeper insight into DNA profiling success rates among items and methods of collection. Interestingly, percentage profiling successes for swabs and tapelifts from porous and non-porous surfaces were opposite to conventional wisdom.

It is difficult to compare the data presented here with previous studies from other jurisdictions. The specifics of collection technique, consumables, DNA extraction and STR

profiling procedures and kits between organisations and over time are likely to have significant influence on profiling success. In addition, there has been variation across studies in the exhibit categorisation strategy used and hence granularity of data analysed. For example, some studies lump all clothing samples together[4,7,9], whereas others separate them into subcategories for specific clothing types[3,5,6]. Further, some studies were deliberately restricted to samples taken from volume crime scenes[8,9], whereas others either were from all crime scenes or did not specify[3-7]. This limits the ability to make truly like-for-like comparisons between studies. Nevertheless, some general trends deserve discussion.

Overall, trace DNA success was similar for Queensland as for most jurisdictions compared here (Table 4). Interestingly, profiling success for many items included in the comparison was poorer than that reported from other jurisdictions, despite the current use in Queensland of a more sensitive DNA profiling kit than that used in many of these previous studies. This suggests that there were many other more successful items sampled by Queensland that made up the shortfall (possibly including SAIK swabs, for example). Trace DNA profile success was also relatively high for items from cars (airbags, seatbelts), drinking straws, chewing gum, ammunition, underwear and waistbands, and bedding. The majority of comparisons with previous literature related to swabbed items (Table 4); however, tapelift sampling of many of these items in fact returned more full profiles than swabs (11 out of 19 items). Perhaps the most striking discrepancies were for swabs from hats/caps, inside of gloves, and collars compared with the results of Mapes et al[6]. Within the Queensland data, clear differences in profiling success were observed between collection methods which will contribute toward updated operational procedures.

Commented [N5]: Qhfss might take offense.

These data provide valuable insight into DNA profiling success of one of Australia's largest police jurisdictions. Additional research is required to determine whether differences between Queensland and other published data stem from consumables used, collection technique, environmental effects (e.g., increased degradation), or some other factor. Some recent work has suggested that rayon swabs are not ideal for recovering maximum DNA from collected samples[10], although this appears to contradict other research that supports rayon swabs as among the most effective materials[11,12]. Additional research is still required here to

inform better consumables choice for forensic practitioners. Pleasingly, there is good support in the data presented here for the efficacy of forensic tapelifts, particularly in preference to swabs for many non-porous items. This accords with existing literature that supports tapelifting as a highly effective collection method[13,14], including for the specific tape product used by QPS forensic officers[15]. Future research and reporting by other agencies into their success rates would benefit from a consistent approach to item and profile success categorisation, to maximise comparability between studies. This study demonstrates that increasing the granularity of data captured can reveal important trends that can inform best practice at the crime scene and laboratory.

Acknowledgements:

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Disclosure Statement:

The author declares no conflict of interest.

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Tables

Table 1. Number of records included for analysis separated into major sample types (minor sample types or those not subsequently analysed are not shown). Percentages of total records, suspect identifications, full or partial/mixed profiles, and no DNA records provided for each sample type.

Sample type	Number of exhibit records	Percentage of total records	Percentage of total suspect identifications (N=14267)	Percentage of total full profiles (N=15855)	Percentage of total partial/mixed profiles (N=12784)	Percentage of total no DNA (N=36484)
Cigarette butts	2633	4.29	7.46	9.16	6.31	1.75
Fabric	1865	3.04	4.56	5.00	3.83	2.50
Hair	289	0.47	0.27	0.52	0.21	0.53
Scraping	922	1.50	2.28	2.34	0.82	1.53
Swab (blood)	7248	11.82	21.10	33.81	9.05	4.00
Swab (saliva)	4769	7.77	12.93	12.17	10.46	4.97
Swab (semen)	51	0.08	0.10	0.09	0.01	0.11
Swab (trace)	16491	26.88	17.15	14.00	20.22	34.07
Tapelift	22576	36.80	24.48	9.99	38.42	45.80
All trace	39067	63.69	41.63	23.99	58.64	79.88

Table 2. DNA profiling results for samples collected by QPS forensic officers between 1 January 2017 and 11 September 2019.

Item		Collection method	Total results	Percentage suspect identification	Percentage full profile	Percentage partial/mixed profile	Percentage no DNA
	All	All	61344	23.26	25.85	20.84	59.47
		Fabric	1865	34.91	42.52	26.27	48.90
		Hair	289	13.49	28.72	9.34	67.47
		Scrapings	922	35.25	40.24	11.39	60.74
		Swab (blood)	7247	41.55	73.96	15.97	20.15
		Swab (saliva)	4769	38.69	40.45	28.04	38.04
		Swab (semen)	51	27.45	29.41	1.96	76.47
		All trace	39066	15.20	9.73	19.19	74.60
		Swab	16491	14.84	13.46	15.68	75.38
		Tapelift	22575	15.47	7.02	21.75	74.02
Cars	Steering wheel	Swab (blood)	40	67.50	62.50	25.00	27.50
		All trace	3676	16.29	6.42	22.52	73.07
		Swab	693	12.27	4.18	17.89	79.65
		Tapelift	2983	17.23	6.94	23.60	71.54
	Airbags	Swab (blood)	53	69.81	84.91	13.21	15.09
		Excised	14	57.14	78.57	14.29	28.57
		All trace	236	31.78	18.64	27.12	61.44
		Swab	12	25.00	8.33	16.67	83.33
		Tapelift	224	32.14	19.20	27.68	60.27
	Gear stick	Swab (blood)	9	55.56	55.56	44.44	11.11
		All trace	761	10.91	5.65	15.24	82.00
		Swab	241	6.64	2.90	9.54	88.38
		Tapelift	520	11.73	5.96	16.73	78.85

	All doors	Swab (blood)	110	58.18	79.09	11.82	19.09
		All trace	164	12.80	6.71	14.02	80.49
		Swab	94	10.64	10.64	8.51	82.98
		Tapelift	70	15.71	1.43	21.43	77.14
	Internal door handle	Swab (blood)	50	62.00	74.00	14.00	28.00
		All trace	104	14.42	7.69	15.38	78.85
		Swab	55	14.55	12.73	10.91	80.00
		Tapelift	49	14.29	2.04	20.41	77.55
	External door handle	Swab (blood)	32	59.38	87.50	12.50	9.38
		All trace	39	7.69	5.13	12.82	82.05
		Swab	25	0.00	8.00	4.00	88.00
		Tapelift	14	21.43	0.00	28.57	71.43
	Seatbelt strap	Swab (blood)	2	0.00	100.00	0.00	100.00
		Fabric	1	0.00	0.00	0.00	100.00
		All trace	154	6.49	3.25	10.39	87.66
		Swab	7	28.57	14.29	28.57	71.43
		Tapelift	147	5.44	2.72	9.52	88.44
	Seatbelt buckle	All trace	96	8.33	5.21	11.46	88.54
		Swab	32	6.25	9.38	6.25	90.63
		Tapelift	64	9.38	3.13	14.06	87.50
Motorcycles		Swab (blood)	14	57.14	100.00	0.00	7.14
		All trace	83	8.43	3.61	12.05	86.75
		Swab	26	0.00	0.00	3.85	96.15
		Tapelift	57	12.28	5.26	15.79	82.46
	Handlebars	Swab (blood)	2	50.00	100.00	0.00	0.00
		All trace	73	8.22	4.11	12.33	86.30
		Swab	22	0.00	0.00	4.55	95.45
		Tapelift	51	11.76	5.88	15.69	82.35
Cigarette butt		Excised (majority)	2633	40.41	55.15	30.65	24.27

Cigarette packet		Swab (blood)	5	40.00	100.00	0.00	0.00
		All trace	12	8.33	8.33	33.33	58.33
		Swab	4	0.00	0.00	25.00	75.00
		Tapelift	8	12.50	12.50	37.50	50.00
Cigarette lighter		All trace	185	7.57	4.32	11.89	84.32
		Swab	141	8.51	4.26	11.35	84.40
		Tapelift	44	4.55	4.55	13.64	84.09
Bindings		All	421	9.50	10.93	14.73	77.91
	Rope	Tapelift (majority)	87	4.60	13.79	18.39	72.41
	Zip/cable ties	All trace	70	22.86	21.43	14.29	68.57
		Swab	45	17.78	22.22	8.89	71.11
		Tapelift	25	32.00	20.00	24.00	64.00
	Power cords	Swab (blood)	7	42.86	42.86	28.57	57.14
		All trace	183	4.92	3.83	10.38	87.43
		Swab	89	1.12	0.00	6.74	93.26
		Tapelift	94	8.51	7.45	13.83	81.91
	Tapes	All trace	150	10.00	8.00	13.33	82.67
		Swab	87	9.20	11.49	13.79	80.46
		Tapelift	63	11.11	3.17	12.70	85.71
	Deceased scenes	Tapelift (majority)	37	2.70	32.43	35.14	45.95
Door handles (premises)		Swab (blood)	66	51.52	66.67	25.76	22.73
		All trace	519	3.47	2.12	10.21	88.44
		Swab	278	2.88	1.44	8.99	90.29
		Tapelift	241	4.15	2.90	11.62	86.31
Window frames/sills		Swab (blood)	174	51.72	78.74	11.49	16.09
		All trace	126	8.73	7.14	6.35	88.89
		Swab	73	8.22	8.22	6.85	87.67
		Tapelift	53	9.43	5.66	5.66	90.57
Flyscreen mesh		Swab (blood)	37	59.46	81.08	8.11	13.51

		Excised	7	28.57	14.29	14.29	71.43
		All trace	1117	5.01	4.57	10.92	85.50
		Swab	158	2.53	1.90	6.33	92.41
		Tapelift	959	5.42	5.01	11.68	84.36
Mouth/rim of drinking vessel		All trace	4578	35.23	37.70	27.09	41.50
		Swab	4422	36.07	38.67	27.36	40.28
		Tapelift	156	11.54	10.26	19.23	76.28
Drinking straw		Excised	68	55.88	47.06	33.82	32.35
		All trace	506	50.20	46.44	28.66	33.79
		Swab	494	49.80	46.76	28.34	34.01
		Tapelift	12	66.67	33.33	41.67	25.00
Drug pipe/bong		Swab (majority)	215	26.98	11.16	30.23	61.40
Chewing gum		Whole item (majority)	47	14.89	63.83	12.77	31.91
Keys		All trace	425	5.88	2.35	11.29	87.29
		Swab	238	4.20	1.68	6.30	92.86
		Tapelift	187	8.02	3.21	17.65	80.21
	Rubber	All trace	12	8.33	8.33	16.67	83.33
		Swab	4	25.00	0.00	25.00	75.00
		Tapelift	8	0.00	12.50	12.50	87.50
	Metal	All trace	166	5.42	1.81	8.43	90.36
		Swab	106	2.83	0.94	4.72	94.34
		Tapelift	60	5.00	3.33	15.00	83.33
	Plastic	All trace	161	6.21	3.73	11.80	85.09
		Swab	70	4.29	2.86	4.29	92.86
		Tapelift	91	7.69	4.40	17.58	79.12
Ammunition		All trace	212	8.96	9.91	3.77	88.68
		Swab	125	6.40	5.60	2.40	92.80
		Tapelift	87	12.64	16.09	5.75	82.76

	Discharged	All trace	70	5.71	11.43	2.86	88.57
		Swab	41	4.88	4.88	0.00	95.12
		Tapelift	29	6.90	20.69	6.90	79.31
	Live	All trace	130	10.77	9.23	3.85	89.23
		Swab	78	7.69	6.41	3.85	91.03
		Tapelift	52	15.38	13.46	3.85	86.54
Firearm		Swab (blood)	18	44.44	83.33	11.11	22.22
		All trace	831	9.15	2.65	10.83	87.48
		Swab	443	7.67	2.03	9.71	89.84
		Tapelift	388	10.82	3.35	12.11	84.79
	Handle	All trace	232	8.62	2.16	10.78	88.36
		Swab	91	7.69	4.40	12.09	86.81
		Tapelift	141	9.22	0.71	9.93	89.36
	Barrel	All trace	31	6.45	3.23	12.90	87.10
		Swab	19	5.26	0.00	10.53	94.74
		Tapelift	12	8.33	8.33	16.67	75.00
	Trigger	All trace	273	8.79	2.56	10.99	87.55
		Swab	174	8.62	2.87	10.34	87.93
		Tapelift	99	9.09	2.02	12.12	86.87
Knife		Swab (blood)	363	34.71	50.69	34.16	26.45
		All trace	1329	15.65	7.22	18.96	77.20
		Swab	790	14.56	7.09	17.59	78.35
		Tapelift	539	17.25	7.42	20.96	75.51
	Handle	All trace	986	16.33	4.97	20.08	77.79
		Swab	522	14.75	3.64	18.01	80.46
		Tapelift	464	18.10	6.47	22.41	74.78
	Blade	All trace	235	13.62	14.47	17.45	72.34
		Swab	218	13.76	14.22	17.43	72.48
		Tapelift	17	11.76	17.65	17.65	70.59

Gloves		Swab (blood)	14	57.14	50.00	21.43	35.71
		Excised	12	50.00	8.33	41.67	50.00
		All trace	1686	20.23	6.47	24.67	70.82
		Swab	384	13.02	5.99	16.67	79.69
		Tapelift	1302	22.35	6.61	27.04	68.20
	Inside surfaces	All trace	1076	20.72	7.53	26.02	68.59
		Swab	223	15.25	8.07	18.39	75.34
		Tapelift	853	22.27	7.39	28.02	66.71
Fingermarks		Swab (blood)	10	20.00	40.00	20.00	40.00
		All trace	101	2.97	0.00	5.94	94.06
		Swab	84	3.57	0.00	7.14	92.86
		Tapelift	17	0.00	0.00	0.00	100.00
Glovemarks		All trace	140	2.14	0.71	2.86	97.14
		Swab	121	0.83	0.83	0.83	98.35
		Tapelift	19	10.53	0.00	15.79	89.47
Sweat smears	Premises	All trace	181	3.87	4.42	2.76	94.48
		Swab	157	3.82	4.46	3.18	94.27
		Tapelift	24	4.17	4.17	0.00	95.83
	Cars	All trace	40	0.00	5.00	2.50	95.00
		Swab	37	0.00	5.41	2.70	94.59
		Tapelift	3	0.00	0.00	0.00	100.00
Phones	Mobile phone	Swab (blood)	32	43.75	65.63	34.38	18.75
		All trace	174	13.79	4.02	23.56	74.14
		Swab	119	11.76	1.68	21.85	77.31
		Tapelift	55	18.18	9.09	27.27	67.27
	Public phone	Swab (blood)	2	100.00	100.00	0.00	100.00
		All trace	10	0.00	0.00	0.00	100.00
		Swab	6	0.00	0.00	0.00	100.00
		Tape	4	0.00	0.00	0.00	100.00

Keypad (eg., safe/alarm)		Swab (majority)	26	1	2	2	23
Computer keyboard		Swab (blood/trace)	5	1	3	0	2
Fingernails		Scrapings	549	56.83	39.89	47.91	30.42
		Clippings	71	25.35	67.61	26.76	22.54
Condom		Swab (majority)	253	50.59	23.72	45.45	46.25
Sexual assault (SAIK)		All	4586	22.50	48.95	22.55	41.95
		High vaginal	629	25.60	54.05	30.84	30.21
		Low vaginal	615	20.81	53.33	25.20	33.33
		Hymen	11	9.09	63.64	9.09	36.36
		Vaginal other	65	26.15	64.62	20.00	18.46
		Vulval	980	16.73	54.39	18.88	37.55
		Labial	202	13.86	63.37	17.33	31.19
		Perineum	28	0.00	50.00	0.00	50.00
		Perianal	442	14.03	35.75	17.19	56.79
		Anal	147	10.88	42.18	9.52	59.18
		Rectal	216	10.65	40.28	12.50	56.94
		Breast	46	39.13	6.52	41.30	67.39
		Oral	309	8.41	72.17	5.18	32.04
		Penis	450	55.56	26.44	36.67	49.78
Clothing	Collar	Swab (blood/saliva)	5	60.00	40.00	40.00	40.00
		Fabric	18	38.89	33.33	38.89	33.33
		All trace	409	27.14	7.33	34.23	61.86
		Swab	11	27.27	0.00	36.36	63.64
		Tapelift	398	27.14	7.54	34.17	61.81
	Beanie	Tapelift (majority)	89	34.83	6.74	38.20	57.30
	Balaclava	Tapelift (majority)	90	31.11	18.89	21.11	66.67
	Helmet	Swab (blood)	12	41.67	91.67	8.33	16.67
		All trace	148	29.05	8.11	31.76	62.84

	Swab	12	0.00	0.00	0.00	100.00
	Tapelift	136	31.62	8.82	34.56	59.56
Hat/cap	Swab (blood)	37	48.65	48.65	35.14	27.03
	All trace	888	28.83	10.47	33.45	60.02
	Swab	42	14.29	2.38	19.05	78.57
	Tapelift	846	29.55	10.87	34.16	59.10
Underwear	Excised/scraped	189	44.44	39.68	40.74	83.07
	All trace	324	40.43	25.62	66.36	68.52
	Swab	13	53.85	38.46	61.54	46.15
	Tapelift	311	39.87	25.08	66.56	69.45
Waistband shorts/pants	Excised/scraped	29	20.69	41.38	17.24	72.41
	All trace	194	20.10	5.67	35.57	62.89
	Swab	3	66.67	33.33	66.67	33.33
	Tapelift	191	19.37	5.24	35.08	63.35
Screwdriver	All trace	939	11.40	4.26	15.65	81.36
	Swab	468	9.62	3.85	12.18	85.04
	Tapelift	471	13.16	4.67	19.11	77.71
Sledge hammer	Swab (blood)	4	0.00	75.00	0.00	50.00
	All trace	75	9.33	2.67	12.00	85.33
	Swab	22	4.55	4.55	4.55	90.91
	Tapelift	53	11.32	1.89	15.09	83.02
Hammer	Swab (blood)	22	27.27	63.64	13.64	59.09
	All trace	356	10.39	3.65	13.48	83.71
	Swab	116	9.48	3.45	11.21	85.34
	Tapelift	240	10.83	3.75	14.58	82.92
Spanner	Swab (blood)	5	20.00	100.00	0.00	0.00
	All trace	104	8.65	2.88	8.65	89.42
	Swab	55	7.27	3.64	5.45	92.73
	Tapelift	49	10.20	2.04	12.24	85.71

	Chisel	All trace	66	16.67	3.03	16.67	81.82
		Swab	25	0.00	0.00	0.00	100.00
		Tapelift	41	26.83	4.88	26.83	70.73
	Shovel	Swab (blood)	2	0.00	100.00	0.00	100.00
		All trace	66	10.47	4.65	8.14	87.21
		Swab	25	7.14	0.00	7.14	92.86
		Tapelift	41	12.07	6.90	8.62	84.48
	Crow bar	All trace	268	5.97	2.99	7.09	91.79
		Swab	108	3.70	1.85	5.56	94.44
		Tapelift	160	7.50	3.75	8.13	90.00
	Axe	Swab (blood)	3	33.33	66.67	33.33	33.33
		All trace	114	12.28	3.51	13.16	84.21
		Swab	24	4.17	0.00	8.33	91.67
		Tapelift	90	14.44	4.44	14.44	82.22
	Mattock/Pickaxe	All trace	41	4.88	2.44	9.76	87.80
		Swab	7	0.00	14.29	14.29	71.43
		Tapelift	34	5.88	0.00	8.82	91.18
	Torch	All trace	376	19.95	10.11	19.68	72.87
		Swab	163	14.11	13.50	12.88	78.53
		Tapelift	213	24.41	7.51	24.88	68.54
Brick/rock		All	527	8.73	10.82	7.40	89.18
	Rock	Swab (blood)	14	14.29	64.29	7.14	28.57
		All trace	287	3.83	3.48	5.92	91.29
		Swab	21	0.00	0.00	4.76	95.24
		Tapelift	266	4.14	3.76	6.02	90.98
	Brick/paver	Swab (blood)	29	41.38	79.31	3.45	20.69
		All trace	227	9.25	6.61	8.81	87.22
		Swab	18	0.00	5.56	0.00	100.00
		Tapelift	209	10.05	6.70	9.57	86.12

Clip-seal plastic bag		All trace	266	15.04	8.27	13.53	81.20
		Swab	212	15.09	7.55	13.21	81.60
		Tapelift	54	14.81	11.11	14.81	79.63
Bedding		All	1440	25.76	28.47	23.19	60.97
		Excised	491	28.11	38.29	24.85	57.64
		Scraping	348	25.00	8.91	28.74	49.43
		Other	278	28.42	41.37	12.95	83.45
		Swab (blood)	96	31.25	56.25	27.08	27.08
		All trace	226	16.37	9.73	22.12	73.01
		Swab	5	0.00	40.00	20.00	60.00
		Tapelift	221	16.74	9.05	22.17	73.30
	Mattress	All	158	11.39	31.01	12.66	71.52
	Mattress protector	All	63	52.38	19.05	39.68	63.49
	Sheets	All	679	28.57	27.54	24.30	58.62
	Blanket	All	403	21.09	31.27	20.35	62.03
	Pillow	All	179	23.46	24.02	25.70	60.89

Table 3. Comparison of percentage success in DNA sampling between porous and non-porous items/surfaces from Table 2.

Surface	Collection method	Total results	Percentage suspect identification	Percentage full profile	Percentage partial/mixed profile	Percentage no DNA
Non-porous	All trace	23232	12.35	7.61	14.30	80.36
	Swab	11819	9.87	6.87	11.12	83.99
	Tapelift	11413	13.96	7.33	17.06	77.97
Porous	All trace	3123	21.19	12.41	26.89	71.37
	Swab	132	21.18	14.89	26.33	72.04
	Tapelift	2991	21.20	9.93	27.46	70.71

Table 4. Comparison of Queensland DNA profiling success data for specific items against equivalent data from the literature.

Exhibit category		This study	Netherlands[6]	Singapore[7]	Switzerland[4]	Switzerland[9]	New Zealand[3]	New South Wales[8]
	Profile / Collection	Full	Single	Single	Full/partial>5	Single	Full	Full/partial>12
Cigarette butt	Excised	55	84	81		70.6		
Hat/cap	Swab	2	42					
	Tapelift	11					25	
Collar	Swab	0*	34					
Glove (inside)	Swab	8	25a	11		18.8b		
	Tapelift	7					25	
Torch	Swab	14	27					
Drinking vessels	Swab	39	57	34		55.6	21c	
Knife handle	Swab	4*	19					
Lighter	Swab	4*	17					
Firearm grip	Swab	4	6					
Firearms (other)	Swab	2*						15
Handle motorcycle	Swab	0*	9					
Cartridge cases	Swab	6*	6					
Tape	Swab	11	9	16				
Keys	Swab	2*	12					
Hair	Excised	29		21.1				
Drug apparatus	Swab	11		15			21c	
Thrown stones	Swab	0*			7	7.5		
Cables/power cords	Swab	0*			29	12.2		
Tools	Swab	3*d	5e	10	22			15

Clothing	Swab	13		5	18.8b		
	Tapelift	12				15f	
	Excised	38					
Blood	Swab	74	68		87.5		
Dataset average	All trace	15g	25h	12	12h	16	14

*greater percentage full profiles from tapelifts where relevant
a combined here from latex & fabric glove results
b combined category clothing/gloves
c combined category drinking vessels/drug pipes
d averaged over all tools analysed in Table 2
e combined here from screwdriver/crowbar/hand-tools (other)
f combined here from underwear/socks/upper garments results
g average profiling success for trace samples only (i.e., excludes biological fluids, hair, cigarette butts)
h included bloodstain profiling results

Archived: Thursday, 24 March 2022 13:12:48
From: Cathie Allen
Sent: Tuesday, 11 February 2020 11:55:28
To: Krosch.MattN[OSC]
Cc: Keatinge.DavidJ[OSC]; John Doherty; Allison Lloyd
Subject: RE: DNA success rates manuscript
Sensitivity: Normal

Hi Matt

Thanks for your time on Friday to discuss the manuscript.

I've discussed with the Team Leaders from Forensic DNA Analysis regarding an appropriate FSS staff member, and Allison Lloyd is very happy to assist with this. Allison is currently acting in the role of Senior Scientist for the Intelligence team, so is suitably placed to assist with DNA success rates, given NCIDD is within her portfolio. I've included Allison on this email, but will email her the manuscript on a separate email.

We look forward to working with you on this and other projects in the future.

Cheers
Cathie

Cathie Allen
Managing Scientist
Police Services Stream, Forensic & Scientific Services
Health Support Queensland, Queensland Health
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a 39 Kessels Road, Coopers Plains, QLD 4108
e CTPI @health.qld.gov.au w www.health.qld.gov.au/healthsupport

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From: Cathie Allen CTPI @health.qld.gov.au>
Sent: Monday, 13 January 2020 09:16
To: Krosch.MattN[OSC] CTPI @police.qld.gov.au>
Cc: Keatinge.DavidJ[OSC] CTPI @police.qld.gov.au>; John Doherty <CTPI @health.qld.gov.au>
Subject: RE: DNA success rates manuscript

Hi Matt

Thanks for the email and the opportunity to review the manuscript.

It would be great if we could meet to discuss the paper and the data used within it. I'm happy to host you at FSS or alternatively, I'm happy to meet with you at QPS HQ. Please let me know your preference and availability.

Cheers
Cathie

Cathie Allen
Managing Scientist
Police Services Stream, Forensic & Scientific Services
Health Support Queensland, Queensland Health
p CTPI m Sch4p4(6)
a 39 Kessels Road, Coopers Plains, QLD 4108
e CTPI @health.qld.gov.au w www.health.qld.gov.au/healthsupport

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From: Krosch.MattN[OSC] CTPI @police.qld.gov.au>
Sent: Tuesday, 7 January 2020 1:02 PM
To: Cathie Allen CTPI @health.qld.gov.au>
Cc: Keatinge.DavidJ[OSC] CTPI @police.qld.gov.au>
Subject: DNA success rates manuscript

Dear Cathie,

Over the latter months of last year I spent some time summarising FR data for DNA results with a view to establish percentage successes for common items/substrates and collection methods. This was essentially a self-driven project that grew out of conversations with SOCOs and OICs and so the focus was on our side of the process to ensure we're making the best decisions on sampling to maximise success in the lab. In a nutshell it involved pulling information on the DNA results for every exhibit that was submitted over a set time period and searching the item description/location fields for keywords that allowed extraction of specific items/substrate results. The aim was to develop an evidence base on the success rates of sampling certain items to inform procedures and make recommendations to our officers on which collection methods were most effective for specific items based on recent data from actual casework.

I've now completed the analysis and have written the results up as a short paper that I hope to submit to AJFS as I believe this information is important to communicate to the forensic community. However, because the paper necessarily contains information about DNA profiling in Queensland we wish to offer you the opportunity to review the draft manuscript before submission to ensure that you and QHFSS are happy for the contents to be published. Please find attached the draft manuscript as a word document and the tables both at the end of the manuscript and as a separate excel file on individual sheets.

If you would like any further explanation on the methods or outcomes, please don't hesitate to get in touch.

Kind regards,

Matt

Dr. Matt Krosch
Research Officer
Quality Management Section, Forensic Services Group
Queensland Police Service
Ph: CTPI | M: Sch4p4(6) | Email: CTPI @police.qld.gov.au

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S.73

From: Allison Lloyd CTPI @health.qld.gov.au>
Sent: Friday, 14 February 2020 10:31
To: Krosch.MattN[OSC] CTPI @police.qld.gov.au>
Subject: FW: DNA success rates manuscript

Hi Matt,

I've been asked to go through your manuscript. I've given it a good read and have a few questions/comments… I'm more than happy to meet up or talk on the phone, whatever suits you better.

My number is CTPI or Sch4p4(6)

Looking forward to working with you on this.

Kind regards,

Allison Lloyd
A/Senior Scientist - Intelligence Team
Forensic DNA Analysis, Police Services Stream
Forensic & Scientific Services, Health Support Queensland, Queensland Health

p CTPI
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From: Cathie Allen CTPI @health.qld.gov.au>
Sent: Tuesday, 11 February 2020 12:04 PM
To: Allison Lloyd CTPI @health.qld.gov.au>
Cc: Justin Howes CTPI @health.qld.gov.au>; Paula Brisotto CTPI @health.qld.gov.au>
Subject: FW: DNA success rates manuscript

Hi Allison

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Archived: Thursday, 24 March 2022 12:58:18
From: Allison Lloyd
Sent: Friday, 14 February 2020 10:32:35
To: Krosch.MattN[OSC]
Subject: FW: DNA success rates manuscript
Sensitivity: Normal
Attachments:
Krosch_ms.docx ;Tables.xlsx ;

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S.73

From: Neville.DavidH[OSC]
Sent: Friday, 14 February 2020 14:42
To: Cathie Allen
Cc: Krosch.MattN[OSC]; McNab.BruceJ[OSC]; Keatinge.DavidJ[OSC]
Subject: FW: DNA success rates manuscript

Hi Cathie
Matt has forwarded me the below email and we have had a discussion in relation to this. Thanks for taking the time to review his work. This paper is aimed at crime scene examiners to help them better focus their sampling methodology. It is not aimed at the laboratory and the introduction of additional lab factors might unnecessarily complicate the matter. It is important that the possible the impact of micron be covered in the discussion, however I don't think it is necessary for us to rerun the data. In this instance we were looking to provide QHFSS an acknowledgement in the paper, however it was not anticipated that the article would be become lab focused. As a result, a general review is probably all that is needed, if possible please.

Regards

David Neville

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Sent: Friday, 14 February 2020 10:31
To: Krosch.MattN[OSC] CTPI @police.qld.gov.au>
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Variation in forensic DNA profiling success rate among sampled items and collection methods: a Queensland perspective.

Matt N. Krosch[a*]

[a]*Quality Management Section, Forensic Services Group, Queensland Police Service, 200 Roma Street, Brisbane, QLD 4000*

Corresponding author: CTPI @police.qld.gov.au, Ph CTPI ORCID 0000-0003-0354-8189

Variation in forensic DNA profiling success rate among sampled items and collection methods: a Queensland perspective.

Understanding the relative success rates of recovering DNA profiles from different touched evidentiary items/substrates and between different methods of collection is critical for optimal targeting of forensic sample collection and triaging for analysis. Further, reporting of such success rates allows comparison between jurisdictions that can drive improvements and prompt discussion between stakeholders. This study analysed success rates of DNA sampling from major and volume crimes attended by the Queensland Police Service, Australia, from January 2017 to September 2019. In total, 61 344 total records were analysed, representing the most comprehensive analysis of its kind to date. Success rates were determined for various sample types and items, including those that are commonly encountered or have high probative value. Results suggested that, overall, around 10% of trace DNA samples returned full profiles, but with some disparity between swabs (13.45%) and tapelifts (7.01%). Despite this, tapelifts provided nearly 25% of total suspect identifications compared with 17% for trace swabs. Substantial variation in profiling success among items/substrates was observed, as there was between swabs and tapelifts taken from the same item. These data contribute significantly to our understanding of DNA prevalence and recovery and provide a critical evidence base to inform changes to operational procedures.

Keywords: swabs, tapelifts, full profile, mixed profile, suspect identification

Introduction

DNA sampling, particularly of touched objects and surfaces, has become an increasing focus for forensic analysts globally[1,2]. Resolution of DNA profiles from such items can be highly probative and thus understanding the relative success rates of recovering profiles from items is important for targeting sample collection and triaging for analysis. Such success rates should be considered in the context of the specific collection and analysis methods used by a given jurisdiction. Comparing data generated from different extraction and profiling methods may not necessarily represent a like-for-like comparison and must be considered with some caution. Nevertheless, there can be great value in comparing between jurisdictions to determine whether substantial differences are apparent and where improvements could be made. Moreover, sampling of putatively touched items can be a point of friction between investigators and forensic scientists who may have contrasting anecdotal experience concerning a questioned item. Finally, where jurisdictions use multiple collection methods for similar items (because of officer preference or simply what consumables are available at the time), it is important to assess whether one method outperforms another to ensure operational procedures follow best practice. Therefore, there is a need for additional data to inform decision-making and assist forensic scientists in optimally targeting sampling effort.

There have been sporadic attempts over the last twelve years to address this issue in a range of national and state jurisdictions from New Zealand[3], Switzerland[4], Canada[5], Netherlands[6], Singapore[7], and Australia[8], including a comparative analysis of experimental and casework samples from Western Switzerland[9]. These studies analysed success rates for various types of casework samples; either those most commonly collected, restricted to volume crime cases, or other items of interest. Generally speaking, these studies were consistent in suggesting that, as expected, biological fluid traces (blood, saliva, semen) provided the greatest proportions of full profiles (up to 87.5%[9]), whereas touch samples were far less successful overall (<30%). Worn or touched items that often returned above average proportions of full profiles include hats/caps, gloves, adhesive tape, clothing, door handles and steering wheels[3-9], though in some cases these may represent victim profiles.

This study aimed to analyse success rates of DNA sampling from major and volume crime for the Queensland Police Service, Queensland, Australia over a period of roughly 20 months. Success rates were determined for sample types over the entire period, as well as broken down to selected items of interest, including those that are commonly encountered or have high probative value. Queensland data are then discussed in the context of previous literature.

Methods

Samples included in this analysis were collected from exhibits related to both major and volume crime between the 1st January 2017 and 11th September 2019. Methods of collection included swabbing with a rayon swab (Medical Wire, UK) pre-moistened with 70% ethanol, tapelifting with a custom 3M adhesive tape kit (Lovell Surgical Supplies, Australia), excision (e.g., fabric, cigarette butts), and scraping. All samples were processed at Queensland Health Forensic Scientific Services (QHFSS) following standard procedures: DNA extraction conducted using the DNA IQ™ Casework Pro Kit for Maxwell®16 (Promega Corp., Melbourne, Australia) on a Maxwell® 16 MDx (Promega Corp.); quantification using Quantifiler® Trio (ThermoFisher Scientific, Melbourne, Australia) on the 7500 Real Time PCR System (Applied Biosystems™, ThermoFisher Scientific), and STR amplification using PowerPlex® 21 (Promega Corp.). DNA quantification results determined progression to profiling, according to QHFSS standard procedures: samples of concentration <0.0088ng/µL were considered to have insufficient DNA and were thus categorised as 'no DNA'. Samples that yielded sufficient DNA (>0.0088ng/µL) proceeded to STR profiling.

Data was extracted from the in-house laboratory information management system (LIMS) for all DNA samples sent for processing between the 1st January 2017 and 11th September 2019. The LIMS was queried in such a way to return sample type (e.g., swab/tapelift) and exhibit description information, as well as STR profiling results categorised as 'full' (all 42 alleles present), 'partial/mixed' (less than 42 alleles, or more than one contributor), or 'no DNA' (DNA quantification insufficient for profiling). In some cases, profiling results could include multiple categories; for example, full+partial/mixed profile results may indicate full profiles deconvoluted from mixtures, or no DNA+full or

partial/mixed where sub-threshold information (<150rfu) was present, or where the original quantification was insufficient, but the sample was profiled following investigator request. Profiles were also recorded for whether they matched a suspect/offender reference sample. This master spreadsheet was queried using Windows Powershell to extract lines in which the exhibit description matched specific text strings. All resulting sub-sheets were manually reviewed to ensure only relevant data was included. Despite this, inconsistencies in spelling and terminology in the exhibit description limited the completeness of the analysis; however, this is unlikely to impact dramatically on the interpretation of DNA success rates. Percentages of each profile result category were calculated for the total dataset, each collection method across all items, and then broken down for collection method from each selected item. Success rates were also assessed for porous versus non-porous substrate surfaces. Sample metadata allowed separation of swabs from biological fluid stains (blood, saliva, semen) to be separated from those taken from putative touched areas or handled objects.

Results

In total, 61 344 total records (representing 60 332 unique exhibits) were analysed, the majority of which were swabs or tapelifts (Table 1). Swabs collected from biological fluids represented a much smaller proportion than those from touched areas/objects. Overall, 25.85% of samples returned full profiles: the greatest proportion of full profiles was obtained from samples of obvious stains of biological fluids, with the most successful being swabs of bloodstains (73.96%, Table 2). Partial/mixed profiles were rarely obtained from non-sexual assault kit semen swabs (1.96%), but otherwise ranged up to 28.04% of DNA results from other sample types. Percentages of suspect identifications ranged from 13.49% (hair) to 41.55% (blood swabs). Both swabs and tapelifts of touched objects/surfaces returned suspect identifications from ~15% of samples, but there was a significant disparity between full profile results (swabs = 13.45%; tapelifts = 7.01%). Despite this, tapelifts provided nearly 25% of total suspect identifications compared with 17% for trace swabs (Table 1), suggesting that the success of tapelifting is often reliant on partial profiles or deconvolution of mixtures.

Individual items/surfaces showed great variation in their percentage success. The greatest success for exhibits where no visible stain was observed was for swabs and excised sections from drinking straws, which produced full profiles in ~47% of samples taken, whereas tapelifts from straws were slightly less successful at 33.3%. Bedding (swab), waistbands of lower garments (swab), discharged cartridge cases (tapelift), underwear (both), zip/cable ties (both), and drinking vessels (both) all produced full profiles in >20% of samples. The least successful items (no full profiles recorded) included: swabs of cigarette packets, rocks, helmets, firearm barrels, shirt collars, power cords, rubber key handles, and several tools; tapelifts of external car door handles, sweat smears on cars, and glovemarks; and both swabs and tapelifts of public phones and fingermarks. Despite this, several of these items did return suspect identifications based on partial profiles; including, external car door handles, shirt collars, and rubber key handles. Among sexual assault-related samples, breast swabs identified the greatest percentage of suspects after penis swabs (suspect reference samples), no suspect identifications were recorded from perineum samples. The highest percentage of full profiles were reported from oral swabs (most likely complainant profiles, though 8.41% were identified a suspect), whereas the lowest proportion of full profiles were from breast swabs.

Some distinct differences in the recovery of full profiles from swabs and tapelifts of trace samples were observed for specific items. Swabs were at least twice as successful as tapelifts for car doors, car door handles, seatbelt straps & buckles, adhesive tapes, drinking vessels, firearm handles, sweat smears on cars, waistbands of lower garments, sledgehammers, mattock/pickaxes, torches, and bedding. In contrast, tapelifts were more successful for discharged car airbags, gearsticks, motorcycles (including handlebars), cigarette packets, power cords, flyscreen, rubber and metal keys, cartridge cases (both discharged and live), firearm barrels, mobile phones, shirt collars, helmets, hats, rocks, and several tools. In contrast to conventional wisdom, tapelifts of non-porous surfaces recovered slightly more full profiles than swabs, whereas swabs were better for porous surfaces (Table 3). Furthermore, porous surfaces returned a greater percentage of full profiles and suspect identifications than non-porous surfaces.

Data caveats

A small number of samples were recorded as returning results in more than one category: 256 records were categorised as both partial/mixed and full (likely representing full profiles deconvoluted from mixtures), representing 2% of partial/mixed records and 1.6% of full profile results; 614 samples were categorised as both partial/mixed and no DNA, representing 1.7% of no DNA results and 4.8% of partial/mixed results; 3001 samples were categorised as both no DNA and full, representing 8.2% of no DNA results and 19% of full profile results; and 92 samples were categorised across all three categories. The vast bulk of such multiple categorisations are due to sub-threshold information present in otherwise full, partial or mixed profiles, or samples that fell below the internal quantification threshold for profiling but were processed following investigator request. In the context of the total dataset these multiple categorisations are not considered to substantially impact on the interpretation of profiling success rates. Manually reviewing every record was outside the scope of this project.

Discussion

The analysis presented here of over 18 months of DNA sampling data, representing more than 60 000 individual exhibits, from the Queensland Police Service has revealed some interesting patterns that can inform operational procedures. Averaged over all items/surfaces, trace swabs recovered more full profiles than tapelifts; however, there was substantial variation noted among exhibit types, including many for which tapelifts were the more successful method of collection. Increasing the granularity of the analysis therefore provided a deeper insight into DNA profiling success rates among items and methods of collection. Interestingly, percentage profiling successes for swabs and tapelifts from porous and non-porous surfaces were opposite to conventional wisdom.

It is difficult to compare the data presented here with previous studies from other jurisdictions. The specifics of collection technique, consumables, DNA extraction and STR profiling procedures and kits between organisations and over time are likely to have significant influence on profiling success. In addition, there has been variation across studies

in the exhibit categorisation strategy used and hence granularity of data analysed. For example, some studies lump all clothing samples together[4,7,9], whereas others separate them into subcategories for specific clothing types[3,5,6]. Further, some studies were deliberately restricted to samples taken from volume crime scenes[8,9], whereas others either were from all crime scenes or did not specify[3-7]. This limits the ability to make truly like-for-like comparisons between studies. Nevertheless, some general trends deserve discussion.

Overall, trace DNA success was similar for Queensland as for most jurisdictions compared here (Table 4). Interestingly, profiling success for many items included in the comparison was poorer than that reported from other jurisdictions, despite the current use in Queensland of a more sensitive DNA profiling kit than that used in many of these previous studies. This suggests that there were many other more successful items sampled by Queensland that made up the shortfall (possibly including SAIK swabs, for example). Alternatively, it could be because of different collection, storage, submission and triage procedures in other regions, or a factor of analysing total sample data rather than smaller, selected subsets. Trace DNA profile success was also relatively high for items from cars (airbags, seatbelts), drinking straws, chewing gum, cartridge cases, underwear and waistbands, and bedding. The majority of comparisons with previous literature related to swabbed items (Table 4); however, tapelift sampling of many of these items in fact returned more full profiles than swabs (11 out of 19 items). Perhaps the most striking discrepancies were for swabs from hats/caps, inside of gloves, and collars compared with the results of Mapes et al[6]. Within the Queensland data, clear differences in profiling success were observed between collection methods which will contribute toward updated operational procedures.

These data provide valuable insight into DNA profiling success of one of Australia's largest police jurisdictions. Additional research is required to determine whether differences between Queensland and other published data stem from consumables used, collection technique, environmental effects (e.g., increased degradation), or some other factor. Some recent work has suggested that rayon swabs are not ideal for recovering maximum DNA from collected samples[10], although this appears to contradict other research that supports rayon as

among the most effective swab materials[11,12]. Additional research is still required here to inform better consumables choice for forensic practitioners. Pleasingly, there is good support in the data presented here for the efficacy of forensic tapelifts, particularly in preference to swabs for many non-porous items. This accords with existing literature that supports tapelifting as a highly effective collection method[13,14], including for the specific tape product used by QPS forensic officers[15]. Future research and reporting by other agencies into their success rates would benefit from a consistent approach to item and profile success categorisation, to maximise comparability between studies. This study demonstrates that increasing the granularity of data captured can reveal important trends that can inform best practice at the crime scene and laboratory.

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Tables

Table 1. Number of records included for analysis separated into major sample types (minor sample types or those not subsequently analysed are not shown). Percentages of total records, suspect identifications, full or partial/mixed profiles, and no DNA records provided for each sample type.

Sample type	Number of exhibit records	Percentage of total records	Percentage of total suspect identifications (N=14267)	Percentage of total full profiles (N=15855)	Percentage of total partial/mixed profiles (N=12784)	Percentage of total no DNA (N=36484)
Cigarette butts	2633	4.29	7.46	9.16	6.31	1.75
Fabric	1865	3.04	4.56	5.00	3.83	2.50
Hair	289	0.47	0.27	0.52	0.21	0.53
Scraping	922	1.50	2.28	2.34	0.82	1.53
Swab (blood)	7248	11.82	21.10	33.81	9.05	4.00
Swab (saliva)	4769	7.77	12.93	12.17	10.46	4.97
Swab (semen)	51	0.08	0.10	0.09	0.01	0.11
Swab (trace)	16518	26.93	17.18	14.01	20.24	34.14
Tapelift	22576	36.76	24.45	9.97	38.40	45.74
All trace	39067	63.69	41.63	23.99	58.64	79.88

Table 2. DNA profiling results for samples collected by QPS forensic officers between 1 January 2017 and 11 September 2019.

Item		Collection method	Total results	Percentage suspect identification	Percentage full profile	Percentage partial/mixed profile	Percentage no DNA
	All	All	61344	23.26	25.85	20.84	59.47
		Fabric	1865	34.91	42.52	26.27	48.90
		Hair	289	13.49	28.72	9.34	67.47
		Scrapings	922	35.25	40.24	11.39	60.74
		Swab (blood)	7247	41.55	73.96	15.97	20.15
		Swab (saliva)	4769	38.69	40.45	28.04	38.04
		Swab (semen)	51	27.45	29.41	1.96	76.47
		All trace	39066	15.20	9.73	19.19	74.60
		Swab	16518	14.84	13.45	15.66	75.40
		Tapelift	22548	15.47	7.01	21.77	74.01
Cars	Steering wheel	Swab (blood)	40	67.50	62.50	25.00	27.50
		All trace	3676	16.29	6.41	22.52	73.07
		Swab	696	12.36	4.17	17.96	79.60
		Tapelift	2980	17.21	6.95	23.59	71.54
	Airbags	Swab (blood)	53	69.81	84.91	13.21	15.09
		Excised	14	57.14	78.57	14.29	28.57
		All trace	236	31.78	18.64	27.12	61.44
		Swab	12	25.00	8.33	16.67	83.33
		Tapelift	224	32.14	19.20	27.68	60.27
	Gear stick	Swab (blood)	9	55.56	55.56	44.44	11.11
		All trace	761	10.91	5.65	15.24	82.00
		Swab	241	6.64	2.90	9.54	88.38
		Tapelift	520	11.73	5.96	16.73	78.85

	All doors	Swab (blood)	110	58.18	79.09	11.82	19.09
		All trace	164	12.80	6.71	14.02	80.49
		Swab	94	10.64	10.64	8.51	82.98
		Tapelift	70	15.71	1.43	21.43	77.14
	Internal door handle	Swab (blood)	50	62.00	74.00	14.00	28.00
		All trace	104	14.42	7.69	15.38	78.85
		Swab	55	14.55	12.73	10.91	80.00
		Tapelift	49	14.29	2.04	20.41	77.55
	External door handle	Swab (blood)	32	59.38	87.50	12.50	9.38
		All trace	39	7.69	5.13	12.82	82.05
		Swab	25	0.00	8.00	4.00	88.00
		Tapelift	14	21.43	0.00	28.57	71.43
	Seatbelt strap	Swab (blood)	2	0.00	100.00	0.00	100.00
		Fabric	1	0.00	0.00	0.00	100.00
		All trace	154	6.49	3.25	10.39	87.66
		Swab	7	28.57	14.29	28.57	71.43
		Tapelift	147	5.44	2.72	9.52	88.44
	Seatbelt buckle	All trace	96	8.33	5.21	11.46	88.54
		Swab	32	6.25	9.38	6.25	90.63
		Tapelift	64	9.38	3.13	14.06	87.50
Motorcycles		Swab (blood)	14	57.14	100.00	0.00	7.14
		All trace	83	8.43	3.61	12.05	86.75
		Swab	26	0.00	0.00	3.85	96.15
		Tapelift	57	12.28	5.26	15.79	82.46
	Handlebars	Swab (blood)	2	50.00	100.00	0.00	0.00
		All trace	73	8.22	4.11	12.33	86.30
		Swab	22	0.00	0.00	4.55	95.45
		Tapelift	51	11.76	5.88	15.69	82.35
Cigarette butt		Excised (majority)	2633	40.41	55.15	30.65	24.27

Cigarette packet		Swab (blood)	5	40.00	100.00	0.00	0.00
		All trace	12	8.33	8.33	33.33	58.33
		Swab	4	0.00	0.00	25.00	75.00
		Tapelift	8	12.50	12.50	37.50	50.00
Cigarette lighter		All trace	185	7.57	4.32	11.89	84.32
		Swab	141	8.51	4.26	11.35	84.40
		Tapelift	44	4.55	4.55	13.64	84.09
Bindings		All	421	9.50	10.93	14.73	77.91
	Rope	Tapelift (majority)	87	4.60	13.79	18.39	72.41
	Zip/cable ties	All trace	70	22.86	21.43	14.29	68.57
		Swab	45	17.78	22.22	8.89	71.11
		Tapelift	25	32.00	20.00	24.00	64.00
	Power cords	Swab (blood)	7	42.86	42.86	28.57	57.14
		All trace	183	4.92	3.83	10.38	87.43
		Swab	89	1.12	0.00	6.74	93.26
		Tapelift	94	8.51	7.45	13.83	81.91
	Tapes	All trace	150	10.00	8.00	13.33	82.67
		Swab	87	9.20	11.49	13.79	80.46
		Tapelift	63	11.11	3.17	12.70	85.71
	Deceased scenes	Tapelift (majority)	37	2.70	32.43	35.14	45.95
Door handles (premises)		Swab (blood)	66	51.52	66.67	25.76	22.73
		All trace	519	3.47	2.12	10.21	88.44
		Swab	278	2.88	1.44	8.99	90.29
		Tapelift	241	4.15	2.90	11.62	86.31
Window frames/sills		Swab (blood)	174	51.72	78.74	11.49	16.09
		All trace	126	8.73	7.14	6.35	88.89
		Swab	73	8.22	8.22	6.85	87.67
		Tapelift	53	9.43	5.66	5.66	90.57
Flyscreen mesh		Swab (blood)	37	59.46	81.08	8.11	13.51

		Excised	7	28.57	14.29	14.29	71.43
		All trace	1117	5.01	4.57	10.92	85.50
		Swab	159	2.52	1.89	6.29	92.45
		Tapelift	958	5.43	5.01	11.69	84.34
Mouth/rim of drinking vessel		All trace	4578	35.23	37.70	27.09	41.50
		Swab	4423	36.08	38.68	27.36	40.29
		Tapelift	155	10.97	9.68	19.35	76.13
Drinking straw		Excised	68	55.88	47.06	33.82	32.35
		All trace	506	50.20	46.44	28.66	33.79
		Swab	494	49.80	46.76	28.34	34.01
		Tapelift	12	66.67	33.33	41.67	25.00
Drug pipe/bong		Swab (majority)	215	26.98	11.16	30.23	61.40
Chewing gum		Whole item (majority)	47	14.89	63.83	12.77	31.91
Keys		All trace	425	5.88	2.35	11.29	87.29
		Swab	238	4.20	1.68	6.30	92.86
		Tapelift	187	8.02	3.21	17.65	80.21
	Rubber	All trace	12	8.33	8.33	16.67	83.33
		Swab	4	25.00	0.00	25.00	75.00
		Tapelift	8	0.00	12.50	12.50	87.50
	Metal	All trace	166	5.42	1.81	8.43	90.36
		Swab	106	2.83	0.94	4.72	94.34
		Tapelift	60	5.00	3.33	15.00	83.33
	Plastic	All trace	161	6.21	3.73	11.80	85.09
		Swab	70	4.29	2.86	4.29	92.86
		Tapelift	91	7.69	4.40	17.58	79.12
Cartridge cases		All trace	212	8.96	9.91	3.77	89.62
		Swab	127	6.30	5.51	2.36	92.91
		Tapelift	85	12.94	16.47	5.88	82.35

	Discharged	All trace	70	5.71	11.43	2.86	88.57
		Swab	41	4.88	4.88	0.00	95.12
		Tapelift	29	6.90	20.69	6.90	79.31
	Live	All trace	130	10.77	9.23	3.85	89.23
		Swab	80	7.50	6.25	3.75	91.25
		Tapelift	50	16.00	14.00	4.00	86.00
Firearm		Swab (blood)	18	44.44	83.33	11.11	22.22
		All trace	831	9.15	2.65	10.83	87.48
		Swab	444	7.66	2.03	9.68	89.86
		Tapelift	387	10.85	3.36	12.14	84.75
	Handle	All trace	232	8.62	2.16	10.78	88.36
		Swab	92	7.61	4.35	11.96	86.96
		Tapelift	140	9.29	0.71	10.00	89.29
	Barrel	All trace	31	6.45	3.23	12.90	87.10
		Swab	19	5.26	0.00	10.53	94.74
		Tapelift	12	8.33	8.33	16.67	75.00
	Trigger	All trace	273	8.79	2.56	10.99	87.55
		Swab	174	8.62	2.87	10.34	87.93
		Tapelift	99	9.09	2.02	12.12	86.87
Knife		Swab (blood)	363	34.71	50.69	34.16	26.45
		All trace	1329	15.65	7.22	18.96	77.20
		Swab	792	14.52	7.20	17.55	78.28
		Tapelift	537	17.32	7.26	21.04	75.61
	Handle	All trace	986	16.33	4.97	20.08	77.79
		Swab	523	14.72	3.63	17.97	80.50
		Tapelift	463	18.14	6.48	22.46	74.73
	Blade	All trace	236	13.56	14.83	17.37	72.03
		Swab	219	13.70	14.61	17.35	72.15
		Tapelift	17	11.76	17.65	17.65	70.59

Gloves		Swab (blood)	14	57.14	50.00	21.43	35.71
		Excised	12	50.00	8.33	41.67	50.00
		All trace	1686	20.23	6.47	24.67	70.82
		Swab	384	13.02	5.99	16.67	79.69
		Tapelift	1302	22.35	6.61	27.04	68.20
	Inside surfaces	All trace	1076	20.72	7.53	26.02	68.59
		Swab	223	15.25	8.07	18.39	75.34
		Tapelift	853	22.27	7.39	28.02	66.71
Fingermarks		Swab (blood)	10	20.00	40.00	20.00	40.00
		All trace	102	2.94	0.00	5.88	94.12
		Swab	85	3.53	0.00	7.06	92.94
		Tapelift	17	0.00	0.00	0.00	100.00
Glovemarks		All trace	140	2.14	0.71	2.86	97.14
		Swab	121	0.83	0.83	0.83	98.35
		Tapelift	19	10.53	0.00	15.79	89.47
Sweat smears	Premises	All trace	181	3.87	4.42	2.76	94.48
		Swab	157	3.82	4.46	3.18	94.27
		Tapelift	24	4.17	4.17	0.00	95.83
	Cars	All trace	40	0.00	5.00	2.50	95.00
		Swab	37	0.00	5.41	2.70	94.59
		Tapelift	3	0.00	0.00	0.00	100.00
Phones	Mobile phone	Swab (blood)	32	43.75	65.63	34.38	18.75
		All trace	174	13.79	4.02	23.56	74.14
		Swab	119	11.76	1.68	21.85	77.31
		Tapelift	55	18.18	9.09	27.27	67.27
	Public phone	Swab (blood)	2	100.00	100.00	0.00	100.00
		All trace	10	0.00	0.00	0.00	100.00
		Swab	6	0.00	0.00	0.00	100.00
		Tape	4	0.00	0.00	0.00	100.00

Keypad (eg., safe/alarm)		Swab (majority)	26	3.85	7.69	7.69	88.46
Computer keyboard		Swab (blood/trace)	5	20.00	60.00	0.00	40.00
Fingernails		Scrapings	549	56.83	39.89	47.91	30.42
		Clippings	71	25.35	67.61	26.76	22.54
Condom		Swab (majority)	253	50.59	23.72	45.45	46.25
Sexual assault-related		All	4586	22.50	48.95	22.55	41.95
		High vaginal	629	25.60	54.05	30.84	30.21
		Low vaginal	615	20.81	53.33	25.20	33.33
		Hymen	11	9.09	63.64	9.09	36.36
		Vaginal other	65	26.15	64.62	20.00	18.46
		Vulval	980	16.73	54.39	18.88	37.55
		Labial	202	13.86	63.37	17.33	31.19
		Perineum	28	0.00	50.00	0.00	50.00
		Perianal	442	14.03	35.75	17.19	56.79
		Anal	147	10.88	42.18	9.52	59.18
		Rectal	216	10.65	40.28	12.50	56.94
		Breast	46	39.13	6.52	41.30	67.39
		Oral	309	8.41	72.17	5.18	32.04
		Penis	450	55.56	26.44	36.67	49.78
Clothing	Collar	Swab (blood/saliva)	5	60.00	40.00	40.00	40.00
		Fabric	18	38.89	33.33	38.89	33.33
		All trace	409	27.14	7.33	34.23	61.86
		Swab	11	27.27	0.00	36.36	63.64
		Tapelift	398	27.14	7.54	34.17	61.81
	Beanie	Tapelift (majority)	89	34.83	6.74	38.20	57.30
	Balaclava	Tapelift (majority)	90	31.11	18.89	21.11	66.67
	Helmet	Swab (blood)	12	41.67	91.67	8.33	16.67
		All trace	148	29.05	8.11	31.76	62.84

	Swab	12	0.00	0.00	0.00	100.00
	Tapelift	136	31.62	8.82	34.56	59.56
Hat/cap	Swab (blood)	37	48.65	48.65	35.14	27.03
	All trace	888	28.83	10.47	33.45	60.02
	Swab	42	14.29	2.38	19.05	78.57
	Tapelift	846	29.55	10.87	34.16	59.10
Underwear	Excised/scraped	189	44.44	39.68	40.74	83.07
	All trace	324	40.43	25.62	66.36	68.52
	Swab	13	53.85	38.46	61.54	46.15
	Tapelift	311	39.87	25.08	66.56	69.45
Waistband shorts/pants	Excised/scraped	29	20.69	41.38	17.24	72.41
	All trace	196	20.41	5.61	35.71	62.76
	Swab	5	60.00	20.00	60.00	40.00
	Tapelift	191	19.37	5.24	35.08	63.35
Screwdriver	All trace	939	11.40	4.37	15.65	81.36
	Swab	469	9.81	4.05	12.15	84.86
	Tapelift	470	12.98	4.47	19.15	77.87
Sledge hammer	Swab (blood)	4	0.00	75.00	0.00	50.00
	All trace	75	9.33	2.67	12.00	85.33
	Swab	22	4.55	4.55	4.55	90.91
	Tapelift	53	11.32	1.89	15.09	83.02
Hammer	Swab (blood)	22	27.27	63.64	13.64	59.09
	All trace	356	10.39	3.65	13.48	83.71
	Swab	116	9.48	3.45	11.21	85.34
	Tapelift	240	10.83	3.75	14.58	82.92
Spanner	Swab (blood)	5	20.00	100.00	0.00	0.00
	All trace	104	8.65	2.88	8.65	89.42
	Swab	55	7.27	3.64	5.45	92.73
	Tapelift	49	10.20	2.04	12.24	85.71

Chisel		All trace	66	16.67	3.03	16.67	81.82
		Swab	25	0.00	0.00	0.00	100.00
		Tapelift	41	26.83	4.88	26.83	70.73
Shovel		Swab (blood)	2	0.00	100.00	0.00	100.00
		All trace	66	10.47	4.65	8.14	87.21
		Swab	25	7.14	0.00	7.14	92.86
		Tapelift	41	12.07	6.90	8.62	84.48
Crow bar		All trace	268	5.97	2.99	7.09	91.79
		Swab	108	3.70	1.85	5.56	94.44
		Tapelift	160	7.50	3.75	8.13	90.00
Axe		Swab (blood)	3	33.33	66.67	33.33	33.33
		All trace	114	12.28	3.51	13.16	84.21
		Swab	24	4.17	0.00	8.33	91.67
		Tapelift	90	14.44	4.44	14.44	82.22
Mattock/Pickaxe		All trace	41	4.88	2.44	9.76	87.80
		Swab	7	0.00	14.29	14.29	71.43
		Tapelift	34	5.88	0.00	8.82	91.18
Torch		All trace	376	19.95	10.11	19.68	72.87
		Swab	163	14.11	13.50	12.88	78.53
		Tapelift	213	24.41	7.51	24.88	68.54
Brick/rock		All	527	8.73	10.82	7.40	89.18
	Rock	Swab (blood)	14	14.29	64.29	7.14	28.57
		All trace	287	3.83	3.48	5.92	91.29
		Swab	21	0.00	0.00	4.76	95.24
		Tapelift	266	4.14	3.76	6.02	90.98
	Brick/paver	Swab (blood)	29	41.38	79.31	3.45	20.69
		All trace	227	9.25	6.61	8.81	87.22
		Swab	18	0.00	5.56	0.00	100.00
		Tapelift	209	10.05	6.70	9.57	86.12

Clip-seal plastic bag		All trace	267	14.98	8.24	13.48	81.27
		Swab	213	15.02	7.51	13.15	81.69
		Tapelift	54	14.81	11.11	14.81	79.63
Bedding		All	1440	25.76	28.47	23.19	60.97
		Excised	491	28.11	38.29	24.85	57.64
		Scraping	348	25.00	8.91	28.74	49.43
		Other	278	28.42	41.37	12.95	83.45
		Swab (blood)	96	31.25	56.25	27.08	27.08
		All trace	226	16.37	9.73	22.12	73.01
		Swab	5	0.00	40.00	20.00	60.00
		Tapelift	221	16.74	9.05	22.17	73.30
	Mattress	All	158	11.39	31.01	12.66	71.52
	Mattress protector	All	63	52.38	19.05	39.68	63.49
	Sheets	All	679	28.57	27.54	24.30	58.62
	Blanket	All	403	21.09	31.27	20.35	62.03
	Pillow	All	179	23.46	24.02	25.70	60.89

Table 3. Comparison of percentage success in DNA sampling between porous and non-porous items/surfaces from Table 2.

Surface	Collection method	Total results	Percentage suspect identification	Percentage full profile	Percentage partial/mixed profile	Percentage no DNA
Non-porous	All trace	23234	12.35	7.61	14.30	80.38
	Swab	11836	9.87	6.88	11.11	83.99
	Tapelift	11398	13.97	7.33	17.08	77.95
Porous	All trace	3125	20.82	11.67	26.52	71.74
	Swab	134	20.44	13.41	25.59	72.78
	Tapelift	2991	21.20	9.93	27.46	70.71

Table 4. Comparison of Queensland DNA profiling success data for specific items against equivalent data from the literature.

Exhibit category		This study	Netherlands[6]	Singapore[7]	Switzerland[4]	Switzerland[9]	New Zealand[3]	New South Wales[8]
	Profile / Collection	Full	Single	Single	Full/partial>5 loci	Single	Full	Full/partial>12 loci
Cigarette butt	Excised	55	84	81		70.6		
Hat/cap	Swab	2	42					
	Tapelift	11					25	
Collar	Swab	0*	34					
Glove (inside)	Swab	8	25a	11		18.8b		
	Tapelift	7					25	
Torch	Swab	14	27					
Drinking vessels	Swab	39	57	34		55.6	21c	
Knife handle	Swab	4*	19					
Lighter	Swab	4*	17					
Firearm grip	Swab	4	6					
Firearms (other)	Swab	2*						15
Handle motorcycle	Swab	0*	9					
Cartridge cases	Swab	6*	6					
Tape	Swab	11	9	16				
Keys	Swab	2*	12					
Hair	Excised	29		21.1				
Drug apparatus	Swab	11		15			21c	
Thrown stones	Swab	0*			7	7.5		
Cables/power cords	Swab	0*			29	12.2		
Tools	Swab	4*d	5e	10	22			15

Clothing	Swab	29f		5	18.8b		
	Tapelift	12g				15h	
	Excised	38i					
Blood	Swab	74	68		87.5		
Dataset average	All trace	15j	25k	12	12k	16	14

*greater percentage full profiles from tapelifts where relevant
a combined here from latex & fabric glove results
b combined category clothing/gloves
c combined category drinking vessels/drug pipes
d averaged over all tools analysed in Table 2
e combined here from screwdriver/crowbar/hand-tools (other)
f averaged over underwear and waistband shorts/pants in Table 2
g averaged over collar/beanie/balaclava/helmet/hat/cap/underwear/waistband shorts/pants in Table 2
h combined here from underwear/socks/upper garments results
i averaged over collar/underwear/waistband shorts/pants in Table 2
j average profiling success for trace samples only (i.e., excludes biological fluids, hair, cigarette butts)
k included bloodstain profiling results

Variation in forensic DNA profiling success rate among sampled items and collection methods: a Queensland perspective.

Variation in forensic DNA profiling success rate among sampled items and collection methods: a Queensland perspective.

Understanding the relative success rates of recovering DNA profiles from different touched evidentiary items/substrates, and between different methods of collection, is critical for optimal targeting of forensic sample collection and triaging for analysis. Further, reporting of such success rates allows comparison between jurisdictions that can drive improvements and prompt discussion between stakeholders. This study analysed success rates of DNA sampling from major and volume crimes attended by the Queensland Police Service, Australia, from February 2018 to September 2019. In total, 36 416 total records were analysed, representing the most comprehensive analysis of its kind to date. Success rates were determined for various sample types and items, including those that are commonly encountered or have high probative value. Results suggested that, overall, around 9.5% of trace DNA samples returned full profiles, but with some disparity between swabs (13.48%) and tapelifts (6.02%). Nevertheless, trace DNA samples contributed nearly 40% of total suspect identifications (tapelifts 20.05%; swabs 18.76%). Substantial variation in profiling success among items/substrates was observed, as there was between swabs and tapelifts taken from the same item. These data contribute significantly to our understanding of DNA prevalence and recovery and provide a critical evidence base to inform changes to operational procedures.

Keywords: swabs, tapelifts, full profile, mixed profile, suspect identification

Introduction

DNA sampling, particularly of touched objects and surfaces, has become an increasing focus for forensic analysts globally[1,2]. Resolution of DNA profiles from such items can be highly probative and thus understanding the relative success rates of recovering profiles from items is important for targeting sample collection and triaging for analysis. Such success rates should be considered in the context of the specific collection and analysis methods used by a given jurisdiction. Comparing data generated from different extraction and profiling methods may not necessarily represent a like-for-like comparison and must be considered with some caution. Nevertheless, there can be great value in comparing between jurisdictions to determine whether substantial differences are apparent and where improvements could be made. Moreover, sampling of putatively touched items can be a point of friction between investigators and forensic scientists who may have contrasting anecdotal experience concerning a questioned item. Finally, where jurisdictions use multiple collection methods for similar items (because of officer preference or simply what consumables are available at the time), it is important to assess whether one method outperforms another to ensure operational procedures follow best practice. Therefore, there is a need for additional data to inform decision-making and assist forensic scientists in optimally targeting sampling effort.

There have been sporadic attempts over the last twelve years to address this issue in a range of national and state jurisdictions from New Zealand[3], Switzerland[4], Canada[5], Netherlands[6], Singapore[7], and Australia[8], including a comparative analysis of experimental and casework samples from Western Switzerland[9]. These studies analysed success rates for various types of casework samples; either those most commonly collected, restricted to volume crime cases, or other items of interest. Generally speaking, these studies were consistent in suggesting that, as expected, biological fluid traces (blood, saliva, semen) provided the greatest proportions of full profiles (up to 87.5%[9]), whereas touch samples were far less successful overall (<30%). Worn or touched items that often returned above average proportions of full profiles include hats/caps, gloves, adhesive tape, clothing, door handles and steering wheels[3-9], though in some cases these may represent victim profiles.

This study aimed to analyse success rates of DNA sampling from major and volume crime for the Queensland Police Service, Queensland, Australia over a period of roughly 20 months. Success rates were determined for sample types over the entire period, as well as broken down to selected items of interest, including those that are commonly encountered or have high probative value. Queensland data are then discussed in the context of previous literature.

Methods

Samples included in this analysis were collected from exhibits related to both major and volume crime between the 22nd February 2018 and 11th September 2019. Methods of collection included swabbing with a rayon swab (Medical Wire, UK) pre-moistened with 70% ethanol, tapelifting with a custom 3M adhesive tape kit (Lovell Surgical Supplies, Australia), excision (e.g., fabric, cigarette butts), and scraping. All samples were processed at Queensland Health Forensic Scientific Services (QHFSS) following standard procedures: DNA extraction conducted using either the DNA IQ™ Casework Pro Kit for Maxwell®16 (Promega Corp., Melbourne, Australia) on a Maxwell® 16 MDx (Promega Corp.) or DNA Investigator Kit (Qiagen, Melbourne, Australia) on a QIASymphony (Qiagen); quantification using Quantifiler® Trio (ThermoFisher Scientific, Melbourne, Australia) on the 7500 Real Time PCR System (Applied Biosystems™, ThermoFisher Scientific), and STR amplification using PowerPlex® 21 (Promega Corp.). DNA quantification results determined progression to profiling, according to QHFSS standard procedures: samples of concentration <0.0088ng/µL were considered to have insufficient DNA and were thus categorised as 'no DNA'. Samples that yielded sufficient DNA (>0.0088ng/µL) proceeded to STR profiling.

Data was extracted from the in-house laboratory information management system (LIMS) for all DNA samples sent for processing between the 22nd February 2018 and 11th September 2019. The LIMS was queried in such a way to return sample type (e.g., swab/tapelift) and exhibit description information, as well as STR profiling results categorised as 'full' (all 42 alleles present), 'partial/mixed' (less than 42 alleles, or more than one contributor), or 'no DNA' (insufficient DNA quantity for profiling, or unsuccessful profiling). In some cases, sample results were classified in multiple categories; for example,

full+partial/mixed profile results may indicate full suspect profiles deconvoluted from mixtures, or no DNA+full or partial/mixed where samples were amplified and genotyped more than once. Profiles were also recorded for whether they matched a suspect/offender reference sample. This master spreadsheet was queried using Windows Powershell to extract lines in which the exhibit description matched specific text strings. All resulting sub-sheets were manually reviewed to ensure only relevant data was included. Despite this, inconsistencies in spelling and terminology in the exhibit description limited the completeness of the analysis; however, this is unlikely to impact dramatically on the interpretation of DNA success rates. Percentages of each profile result category were calculated for the total dataset, each collection method across all items, and then broken down for collection method from each selected item. Success rates were also assessed for porous versus non-porous substrate surfaces. Sample metadata allowed separation of swabs from biological fluid stains (blood, saliva, semen) to be separated from those taken from putative touched areas or handled objects.

Results

In total, 36 416 total records (representing 35 722 unique exhibits) were analysed, the majority of which were swabs or tapelifts (Table 1). Swabs collected from biological fluids represented a much smaller proportion than those from touched areas/objects. Overall, 25.60% of samples returned full profiles: the greatest proportion of full profiles was obtained from samples of obvious stains of biological fluids, with the most successful being swabs of bloodstains (71.15%, Table 2). Partial/mixed profiles were rarely obtained from swabs of semen stains (2.86%), but otherwise ranged up to 30.02% of DNA results from other sample types. Percentages of suspect identifications ranged from 13.14% (hair) to 39.37% (blood swabs). Both swabs and tapelifts of touched objects/surfaces returned suspect identifications from ~14% of samples, but there was a significant disparity between full profile results (swabs = 13.48%; tapelifts = 6.02%). Despite this, tapelifts provided 20% of total suspect identifications compared with nearly 19% for trace swabs (Table 1), suggesting that the success of tapelifting is often reliant on partial profiles or deconvolution of mixtures.

Individual items/surfaces showed great variation in their percentage success (Table 2). The greatest success for exhibits where no visible stain was observed was for clippings from fingernails, which produced full profiles in ~72% of samples taken. Chewing gum, excisions from cigarette butts, bedding and waistbands of lower garments, all samples from drinking straws, and fingernail scrapings all produced full profiles in >40% of samples. The least successful items (no full profiles recorded) included swabs of rocks and pavers, helmets, firearm barrels, shirt collars, power cords, rubber, metal and plastic key handles, and several tools; tapelifts of cigarette lighters, firearm handles, and several tools; and both swabs and tapelifts of public phones, fingermarks, glovemarks, external car door handles, sweat smears on cars, and axe handles. Despite this, many of these items did return suspect identifications based on partial profiles (either single source or deconvoluted mixtures); including, external car door handles, shirt collars, and mobile phones. Among sexual assault-related samples, breast swabs identified the greatest percentage of suspects after penis swabs (suspect reference samples); no suspect identifications were recorded from perineum samples. The highest percentage of full profiles were reported from oral swabs (most likely complainant profiles, though 6.57% were identified a suspect), whereas the lowest proportion of full profiles were from breast swabs.

Some distinct differences in the recovery of full profiles from swabs and tapelifts of trace samples were observed for specific items. Swabs were at least twice as successful as tapelifts for seatbelt buckles, adhesive tapes, cigarette lighters, window frames/sills, drinking vessels, firearm handles, knife blades, sledgehammers, mattock/pickaxes, torches, and bedding. In contrast, tapelifts were more successful for discharged car airbags, gearsticks, seatbelt straps & buckles, motorcycles (including handlebars), power cords, keys, cartridge cases (both discharged and live), firearm barrels, sweat smears on buildings, mobile phones, shirt collars, helmets, hats, rocks, and several tools. In contrast to conventional wisdom, tapelifts of non-porous surfaces recovered slightly more full profiles than swabs, and did so also from porous surfaces (Table 3). Furthermore, porous surfaces returned a greater percentage of full profiles and suspect identifications than non-porous surfaces.

Data caveats

A small number of samples were recorded as returning results in more than one category: 106 records were categorised as both partial/mixed and full (likely representing full profiles deconvoluted from mixtures), representing 1.4% of partial/mixed records and 1.1% of full profile results; 339 samples were categorised as both partial/mixed and no DNA, representing 1.5% of no DNA results and 4.4% of partial/mixed results; 2103 samples were categorised as both no DNA and full, representing 9.6% of no DNA results and 22.5% of full profile results; and 23 samples were categorised across all three categories. The bulk of such multiple categorisations were due to samples being reworked, either by concentrating dilute samples that initially fell below the quantification threshold to proceed to profiling, or by reamplification of partial/failed genotyping runs. In the context of the total dataset these multiple categorisations are not considered to substantially impact on the interpretation of profiling success rates. Manually reviewing every record was outside the scope of this project.

Discussion

The analysis presented here of nearly 18 months of DNA sampling data, representing more than 36 000 individual exhibits, from the Queensland Police Service has revealed some interesting patterns that can inform operational procedures. Averaged over all items/surfaces, trace swabs recovered more full profiles than tapelifts; however, there was substantial variation noted among exhibit types, including many for which tapelifts were the more successful method of collection. Increasing the granularity of the analysis therefore provided a deeper insight into DNA profiling success rates among items and methods of collection. Interestingly, percentage profiling successes for swabs and tapelifts from porous and non-porous surfaces were opposite to conventional wisdom.

It is difficult to compare the data presented here with previous studies from other jurisdictions. The specifics of collection technique, consumables, DNA extraction and STR profiling procedures and kits between organisations and over time are likely to have significant influence on profiling success. In addition, there has been variation across studies in the exhibit categorisation strategy used and hence granularity of data analysed. For example, some studies lump all clothing samples together[4,7,9], whereas others separate them

into subcategories for specific clothing types[3,5,6]. Further, some studies were deliberately restricted to samples taken from volume crime scenes[8,9], whereas others either were from all crime scenes or did not specify[3-7]. This limits the ability to make truly like-for-like comparisons between studies. Nevertheless, some general trends deserve discussion.

Overall, trace DNA success was similar for Queensland as for most jurisdictions compared here (Table 4). Interestingly, profiling success for many items included in the comparison was poorer than that reported from other jurisdictions, despite the current use in Queensland of a more sensitive DNA profiling kit than that used in many of these previous studies. This suggests that there were many other more successful items sampled by Queensland that made up the shortfall (possibly including SAIK swabs, for example). Alternatively, it could be because of different collection, storage, submission, triage or laboratory procedures in other regions, or a factor of analysing total sample data rather than smaller, selected subsets. For example, the dataset used here included both major and volume crime samples, which are treated in different ways both at collection (only one sample per volume crime occurrence is allowed to be submitted, whereas major crime samples are unlimited) and in the laboratory (major crime samples are automatically reworked, whereas volume crime samples are not). Such inconsistencies between datasets render the comparison indicative only. Nevertheless, trace DNA profile success was relatively high for items from cars (airbags, seatbelts), drinking straws, chewing gum, cartridge cases, underwear and waistbands, and bedding. The majority of comparisons with previous literature related to swabbed items (Table 4); however, tapelift sampling of many of these items in fact returned more full profiles than swabs (9 out of 19 items). Perhaps the most striking discrepancies were for swabs from hats/caps, inside of gloves, and collars compared with the results of Mapes et al[6]. Within the Queensland data, clear differences in profiling success were observed between collection methods which will contribute toward updated operational procedures.

These data provide valuable insight into DNA profiling success of one of Australia's largest police jurisdictions. Additional research is required to determine whether differences between Queensland and other published data stem from consumables used, collection

technique, environmental effects (e.g., increased degradation), or some other factor. Some recent work has suggested that rayon swabs are not ideal for recovering maximum DNA from collected samples[10], although this appears to contradict other research that supports rayon as among the most effective swab materials[11,12]. Additional research is still required here to inform better consumables choice for forensic practitioners. Pleasingly, there is good support in the data presented here for the efficacy of forensic tapelifts, particularly in preference to swabs for many non-porous items. This accords with existing literature that supports tapelifting as a highly effective collection method[13,14], including for the specific tape product used by QPS forensic officers[15]. Future research and reporting by other agencies into their success rates would benefit from a consistent approach to item and profile success categorisation, to maximise comparability between studies. This study demonstrates that increasing the granularity of data captured can reveal important trends that can inform best practice at the crime scene and laboratory.

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Tables

Table 1. Number of records included for analysis separated into major sample types (minor sample types or those not subsequently analysed are not shown). Percentages of total records, suspect identifications, full or partial/mixed profiles, and no DNA records provided for each sample type.

Sample type	Number of exhibit records	Percentage of total records	Percentage of total suspect identifications (N=8263)	Percentage of total full profiles (N=9323)	Percentage of total partial/mixed profiles (N=7698)	Percentage of total no DNA (N=21919)
Cigarette butts	2633	4.29	7.46	9.16	6.31	1.75
Fabric	1865	3.04	4.56	5.00	3.83	2.50
Hair	289	0.47	0.27	0.52	0.21	0.53
Scraping	922	1.50	2.28	2.34	0.82	1.53
Swab (blood)	7248	11.82	21.10	33.81	9.05	4.00
Swab (saliva)	4769	7.77	12.93	12.17	10.46	4.97
Swab (semen)	51	0.08	0.10	0.09	0.01	0.11
Swab (trace)	16518	26.93	17.18	14.01	20.24	34.14
Tapelift	22576	36.76	24.45	9.97	38.40	45.74
All trace	39067	63.69	41.63	23.99	58.64	79.88

Table 2. DNA profiling results for samples collected by QPS forensic officers between 22 February 2018 and 11 September 2019.

Item		Collection method	Total results	Percentage suspect identification	Percentage full profile	Percentage partial/mixed profile	Percentage no DNA
All		All	36416	22.69	25.60	21.14	60.19
		Fabric	1050	34.95	38.57	24.76	49.43
		Hair	205	13.14	31.22	8.78	65.37
		Scrapings	709	34.27	42.74	9.03	60.08
		Swab (blood)	4361	39.37	71.15	17.77	23.25
		Swab (saliva)	2688	38.28	39.51	30.02	39.62
		Swab (semen)	35	22.86	22.86	2.86	82.86
		All trace	22556	14.22	9.45	18.71	75.90
		Swab	10372	14.94	13.48	16.11	75.34
		Tapelift	12184	13.60	6.02	20.93	76.39
Cars	Steering wheel	Swab (blood)	20	60.00	60.00	25.00	35.00
		All trace	1934	12.62	4.55	21.04	76.78
		Swab	431	10.67	2.55	18.10	80.74
		Tapelift	1503	13.17	5.12	21.89	75.65
	Airbags	Swab (blood)	37	67.57	81.08	16.22	16.22
		Excised	9	33.33	66.67	22.22	44.44
		All trace	130	26.92	15.38	25.38	70.00
		Swab	8	12.50	0.00	12.50	87.50
		Tapelift	122	27.87	16.39	26.23	68.85
	Gear stick	Swab (blood)	4	50.00	100.00	0.00	25.00
		All trace	371	8.36	3.77	14.82	83.02
		Swab	113	5.31	0.00	9.73	90.27
		Tapelift	258	9.69	5.43	17.05	79.84

	All doors	Swab (blood)	69	60.87	73.91	11.59	27.54
		All trace	99	7.07	2.02	8.08	89.90
		Swab	60	8.33	1.67	8.33	90.00
		Tapelift	39	5.13	2.56	7.69	89.74
	Internal door handle	Swab (blood)	33	60.61	69.70	12.12	36.36
		All trace	61	6.56	3.28	6.56	90.16
		Swab	35	8.57	2.86	8.57	88.57
		Tapelift	26	3.85	3.85	3.85	92.31
	External door handle	Swab (blood)	20	70.00	80.00	20.00	15.00
		All trace	28	3.57	0.00	7.14	92.86
		Swab	17	0.00	0.00	0.00	100.00
		Tapelift	11	9.09	0.00	18.18	81.82
	Seatbelt strap	Swab (blood)	1	0.00	100.00	0.00	100.00
		Fabric	1	0.00	0.00	0.00	100.00
		All trace	85	4.71	3.53	9.41	88.24
		Swab	3	0.00	0.00	33.33	66.67
		Tapelift	82	4.88	3.66	8.54	89.02
	Seatbelt buckle	All trace	63	9.52	4.76	11.11	87.30
		Swab	20	5.00	10.00	0.00	90.00
		Tapelift	43	11.63	2.33	16.28	86.05
Motorcycles		Swab (blood)	4	100.00	100.00	0.00	0.00
		All trace	39	5.13	5.13	7.69	92.31
		Swab	12	0.00	0.00	0.00	100.00
		Tapelift	27	7.41	7.41	11.11	88.89
	Handlebars	Swab (blood)	-	-	-	-	-
		All trace	34	5.88	5.88	8.82	91.18
		Swab	10	0.00	0.00	0.00	100.00
		Tapelift	24	8.33	8.33	12.50	87.50
Cigarette butt		Excised (majority)	1546	40.10	53.75	31.89	27.04

Cigarette packet		Swab (blood)	5	40.00	100.00	0.00	0.00
		Tapelift	4	25.00	25.00	75.00	100.00
Cigarette lighter		All trace	110	3.64	1.82	8.18	90.00
		Swab	88	4.55	2.27	7.95	89.77
		Tapelift	22	0.00	0.00	9.09	90.91
Bindings		All	229	9.17	10.48	17.03	77.73
	Rope	Tapelift (majority)	57	3.51	14.04	22.81	70.18
	Zip/cable ties	All trace	29	13.79	13.79	6.90	82.76
		Swab	16	6.25	12.50	0.00	93.75
		Tapelift	13	23.08	15.38	15.38	69.23
	Power cords	Swab (blood)	4	25.00	50.00	25.00	75.00
		All trace	86	9.30	5.81	11.63	84.88
		Swab	45	2.22	0.00	6.67	93.33
		Tapelift	41	17.07	12.20	17.07	75.61
	Tapes	All trace	92	9.78	5.43	10.87	89.13
		Swab	58	10.34	6.90	13.79	86.21
		Tapelift	34	8.82	2.94	5.88	94.12
	Deceased scenes	Tapelift (majority)	32	3.13	28.13	37.50	59.38
Door handles (premises)		Swab (blood)	38	57.89	65.79	28.95	28.95
		All trace	252	2.78	2.78	7.14	90.87
		Swab	136	2.21	2.94	5.15	93.38
		Tapelift	116	3.45	2.59	9.48	87.93
Window frames/sills		Swab (blood)	113	48.67	76.11	14.16	18.58
		All trace	61	13.11	9.84	8.20	85.25
		Swab	38	13.16	13.16	7.89	84.21
		Tapelift	23	13.04	4.35	8.70	86.96
Flyscreen mesh		Swab (blood)	20	45.00	70.00	10.00	25.00
		Excised	1	100.00	100.00	0.00	0.00
		All trace	611	4.42	3.93	9.17	88.22

		Swab	94	0.00	2.13	4.26	94.68
		Tapelift	517	5.22	4.26	10.06	87.04
Mouth/rim of drinking vessel		All trace	2525	34.93	37.43	28.83	42.85
		Swab	2450	35.67	38.33	29.14	41.63
		Tapelift	75	10.67	8.00	18.67	82.67
Drinking straw		Excised	33	54.55	48.48	36.36	30.30
		All trace	311	47.91	45.98	29.26	38.26
		Swab	305	47.87	45.90	29.51	38.36
		Tapelift	6	50.00	50.00	16.67	33.33
Drug pipe/bong		Swab (majority)	118	28.81	11.86	35.59	56.78
Chewing gum		Whole item (majority)	16	12.50	62.50	18.75	43.75
Keys		All trace	223	4.04	1.79	12.11	87.89
		Swab	134	1.49	0.75	5.97	94.78
		Tapelift	89	7.87	3.37	21.35	77.53
	Rubber	All trace	6	0.00	16.67	0.00	100.00
		Swab	1	0.00	0.00	0.00	100.00
		Tapelift	5	0.00	20.00	20.00	100.00
	Metal	All trace	93	2.15	1.08	7.53	92.47
		Swab	68	1.47	0.00	5.88	94.12
		Tapelift	25	4.00	4.00	12.00	88.00
	Plastic	All trace	87	4.60	2.30	12.64	86.21
		Swab	41	2.44	0.00	4.88	95.12
		Tapelift	46	6.52	4.35	19.57	78.26
Cartridge cases		All trace	130	3.08	5.38	3.85	93.08
		Swab	75	2.67	1.33	1.33	97.33
		Tapelift	55	3.64	10.91	7.27	87.27
	Discharged	All trace	47	4.26	12.77	4.26	87.23
		Swab	25	4.00	4.00	0.00	96.00

		Tapelift	22	4.55	22.73	9.09	77.27
	Live	All trace	77	2.60	1.30	2.60	97.40
		Swab	46	2.17	0.00	2.17	97.83
		Tapelift	31	3.23	3.23	3.23	96.77
Firearm		Swab (blood)	8	12.50	75.00	25.00	25.00
		All trace	499	8.02	2.40	8.82	89.98
		Swab	308	7.79	2.60	9.09	90.26
		Tapelift	191	8.38	2.09	8.38	89.53
	Handle	All trace	129	8.53	2.33	10.85	88.37
		Swab	60	8.33	5.00	11.67	86.67
		Tapelift	69	8.70	0.00	10.14	89.86
	Barrel	All trace	13	0.00	7.69	7.69	92.31
		Swab	7	0.00	0.00	14.29	100.00
		Tapelift	6	0.00	16.67	0.00	83.33
	Trigger	All trace	164	7.93	3.05	7.93	89.63
		Swab	121	8.26	3.31	9.09	88.43
		Tapelift	43	6.98	2.33	4.65	93.02
Knife		Swab (blood)	218	33.49	47.25	37.16	27.52
		All trace	769	15.34	6.11	19.25	77.89
		Swab	491	13.85	6.31	18.13	78.82
		Tapelift	278	17.99	5.76	21.22	76.26
	Handle	All trace	578	15.74	3.81	19.55	79.24
		Swab	330	13.94	3.03	17.58	81.82
		Tapelift	248	18.15	4.84	22.18	75.81
	Blade	All trace	138	13.04	12.32	21.74	69.57
		Swab	132	12.88	12.88	21.21	69.70
		Tapelift	6	16.67	0.00	33.33	66.67
Gloves		Swab (blood)	8	37.50	25.00	37.50	37.50
		Excised	7	71.43	0.00	71.43	28.57

		All trace	1003	15.05	4.49	22.33	75.27
		Swab	228	7.02	3.95	13.16	85.09
		Tapelift	775	17.42	4.65	25.03	72.39
	Inside surfaces	All trace	640	14.22	4.69	23.28	74.22
	Inside surfaces	Swab	139	7.91	5.04	13.67	83.45
	Inside surfaces	Tapelift	501	15.97	4.59	25.95	71.66
Fingermarks		Swab (blood)	6	16.67	33.33	33.33	33.33
Fingermarks		All trace	67	4.48	0.00	7.46	92.54
Fingermarks		Swab	58	5.17	0.00	8.62	91.38
Fingermarks		Tapelift	9	0.00	0.00	0.00	100.00
Glovemarks		All trace	64	0.00	0.00	0.00	100.00
Glovemarks		Swab	60	0.00	0.00	0.00	100.00
Glovemarks		Tapelift	4	0.00	0.00	0.00	100.00
Sweat smears	Premises	All trace	73	5.48	4.11	2.74	95.89
Sweat smears	Premises	Swab	67	4.48	2.99	2.99	97.01
Sweat smears	Premises	Tapelift	6	16.67	16.67	0.00	83.33
Sweat smears	Cars	All trace	20	0.00	0.00	5.00	95.00
Sweat smears	Cars	Swab	18	0.00	0.00	5.56	94.44
Sweat smears	Cars	Tapelift	2	0.00	0.00	0.00	100.00
Phones	Mobile phone	Swab (blood)	19	52.63	57.89	42.11	21.05
Phones	Mobile phone	All trace	81	19.75	2.47	22.22	75.31
Phones	Mobile phone	Swab	63	15.87	0.00	22.22	77.78
Phones	Mobile phone	Tapelift	18	33.33	11.11	22.22	66.67
Phones	Public phone	Swab (blood)	2	100.00	100.00	0.00	100.00
Phones	Public phone	All trace	8	0.00	0.00	0.00	100.00
Phones	Public phone	Swab	5	0.00	0.00	0.00	100.00
Phones	Public phone	Tapelift	3	0.00	0.00	0.00	100.00
Keypad (eg., safe/alarm)		Swab (majority)	18	5.56	11.11	11.11	83.33
Computer keyboard		Swab (blood/trace)	2	50.00	50.00	0.00	50.00

Fingernails		Scrapings	357	53.50	41.46	44.26	32.21
		Clippings	47	17.02	72.34	25.53	19.15
Condom		Swab (majority)	205	50.24	17.56	49.27	46.83
Sexual assault-related		All	3428	22.35	45.92	22.58	42.68
		High vaginal	478	26.78	50.42	31.59	32.64
		Low vaginal	473	20.93	50.95	25.79	34.46
		Hymen	8	12.50	62.50	12.50	37.50
		Vaginal other	55	30.91	61.82	23.64	18.18
		Vulval	756	17.59	51.59	19.97	38.23
		Labial	158	15.19	61.39	20.25	32.28
		Perineum	12	0.00	58.33	0.00	41.67
		Perianal	319	14.73	34.17	19.75	55.17
		Anal	111	8.11	36.94	9.91	63.06
		Rectal	176	9.66	39.77	11.36	57.95
		Breast	33	39.39	9.09	42.42	66.67
		Oral	213	6.57	67.61	6.10	35.68
		Penis	320	55.63	27.19	34.06	52.19
Clothing	Collar	Swab (blood)	2	100.00	50.00	50.00	50.00
		Fabric	10	30.00	40.00	20.00	50.00
		All trace	256	24.61	5.86	31.64	66.80
		Swab	11	27.27	0.00	36.36	63.64
		Tapelift	245	24.49	6.12	31.43	66.94
	Beanie	Tapelift (majority)	65	33.85	3.08	40.00	60.00
	Balaclava	Tapelift (majority)	56	26.79	17.86	16.07	73.21
	Helmet	Swab (blood)	6	66.67	100.00	0.00	33.33
		All trace	89	25.84	4.49	31.46	67.42
		Swab	8	0.00	0.00	0.00	100.00
		Tapelift	81	28.40	4.94	34.57	64.20
	Hat/cap	Swab (blood)	27	59.26	40.74	40.74	33.33

		All trace	509	25.54	7.86	34.97	62.48
		Swab	29	13.79	3.45	20.69	75.86
		Tapelift	480	26.25	8.13	35.83	61.67
	Underwear	Excised/scraped	193	29.02	21.76	22.80	64.25
		All trace	308	25.32	14.94	43.18	49.35
		Swab	14	42.86	21.43	50.00	28.57
		Tapelift	294	24.49	14.63	42.86	50.34
	Waistband shorts/pants	Excised/scraped	12	33.33	41.67	8.33	83.33
		All trace	120	20.00	4.17	35.83	64.17
		Swab	4	50.00	0.00	50.00	50.00
		Tapelift	116	18.97	4.31	35.34	64.66
Screwdriver		All trace	498	9.24	2.41	16.06	83.13
		Swab	253	8.70	2.37	13.44	85.38
		Tapelift	245	9.80	2.45	18.78	80.82
Sledge hammer		Swab (blood)	3	0.00	66.67	0.00	66.67
		All trace	35	11.43	2.86	11.43	85.71
		Swab	10	10.00	10.00	0.00	90.00
		Tapelift	25	12.00	0.00	16.00	84.00
Hammer		Swab (blood)	17	35.29	64.71	17.65	58.82
		All trace	183	7.10	2.73	11.48	86.89
		Swab	60	5.00	3.33	10.00	86.67
		Tapelift	123	8.13	2.44	12.20	86.99
Spanner		Swab (blood)	4	25.00	100.00	0.00	0.00
		All trace	57	3.51	3.51	3.51	94.74
		Swab	32	0.00	3.13	0.00	100.00
		Tapelift	25	8.00	4.00	8.00	88.00
Chisel		All trace	30	13.33	3.33	10.00	90.00
		Swab	17	0.00	0.00	0.00	100.00
		Tapelift	13	30.77	7.69	23.08	76.92

Shovel		Swab (blood)	1	0.00	100.00	0.00	100.00
		All trace	45	13.33	2.22	11.11	86.67
		Swab	19	10.53	0.00	10.53	89.47
		Tapelift	26	15.38	3.85	11.54	84.62
Crow bar		All trace	158	5.70	3.16	6.33	93.04
		Swab	59	3.39	3.39	3.39	96.61
		Tapelift	99	7.07	3.03	8.08	90.91
Axe		Swab (blood)	1	100.00	100.00	0.00	100.00
		All trace	60	8.33	0.00	13.33	86.67
		Swab	14	0.00	0.00	7.14	92.86
		Tapelift	46	10.87	0.00	15.22	84.78
Mattock/Pickaxe		All trace	18	0.00	5.56	5.56	88.89
		Swab	5	0.00	20.00	0.00	80.00
		Tapelift	13	0.00	0.00	7.69	92.31
Torch		All trace	212	17.92	8.49	19.81	75.47
		Swab	100	16.00	12.00	15.00	80.00
		Tapelift	112	19.64	5.36	24.11	71.43
Brick/rock		All	298	6.71	8.39	6.71	87.25
	Rock	Swab (blood)	9	11.11	66.67	11.11	22.22
		All trace	143	1.40	0.70	3.50	96.50
		Swab	10	0.00	0.00	0.00	100.00
		Tapelift	133	1.50	0.75	3.76	96.24
	Brick/paver	Swab (blood)	17	35.29	76.47	5.88	23.53
		All trace	129	8.53	3.88	10.08	89.92
		Swab	13	0.00	0.00	0.00	100.00
		Tapelift	116	9.48	4.31	11.21	88.79
Clip-seal plastic bag		All trace	150	12.67	4.67	14.67	83.33
		Swab	125	12.00	4.00	13.60	84.00
		Tapelift	25	16.00	8.00	20.00	80.00

Bedding		All	968	25.72	27.79	22.62	58.68
		Excised	241	25.31	40.25	19.50	48.96
		Scraping	276	22.83	34.42	10.87	65.22
		Other	253	32.41	11.07	38.74	60.08
		Swab (blood)	56	26.79	55.36	23.21	35.71
		All trace	142	19.72	12.68	22.54	69.01
		Swab	5	0.00	40.00	20.00	60.00
		Tapelift	137	20.44	11.68	22.63	69.34
	Mattress	All	88	14.77	22.73	12.50	72.73
	Mattress protector	All	63	11.11	11.11	11.11	100.00
	Sheets	All	679	32.78	28.25	25.57	53.40
	Blanket	All	403	17.01	28.91	19.39	63.27
	Pillow	All	179	21.26	24.41	22.05	62.20

Table 3. Comparison of percentage success in DNA sampling between porous and non-porous items/surfaces from Table 2.

Surface	Collection method	Total results	Percentage suspect identification	Percentage full profile	Percentage partial/mixed profile	Percentage no DNA
Non-porous	All trace	13290	9.15	5.83	11.58	85.98
	Swab	7243	7.17	5.16	8.61	88.30
	Tapelift	6047	11.17	6.51	14.60	83.62
Porous	All trace	2000	17.57	8.09	24.74	71.02
	Swab	97	16.27	7.21	24.77	70.25
	Tapelift	1903	18.54	8.75	24.73	71.60

Table 4. Comparison of Queensland DNA profiling success data for specific items against equivalent data from the literature.

Exhibit category		This study	Netherlands[6]	Singapore[7]	Switzerland[4]	Switzerland[9]	New Zealand[3]	New South Wales[8]
	Profile / Collection	Full	Single	Single	Full/partial>5 loci	Single	Full	Full/partial>12 loci
Cigarette butt	Excised	54	84	81		70.6		
Hat/cap	Swab	3	42					
	Tapelift	8					25	
Collar	Swab	0*	34					
Glove (inside)	Swab	5	25a	11		18.8b		
	Tapelift	5					25	
Torch	Swab	12	27					
Drinking vessels	Swab	38	57	34		55.6	21c	
Knife handle	Swab	3*	19					
Lighter	Swab	2	17					
Firearm grip	Swab	5	6					
Firearms (other)	Swab	3*						15
Handle motorcycle	Swab	3*	9					
Cartridge cases	Swab	4*	6					
Tape	Swab	7	9	16				
Keys	Swab	1*	12					
Hair	Excised	31		21.1				
Drug apparatus	Swab	12		15			21c	
Thrown stones	Swab	0*			7	7.5		
Cables/power cords	Swab	0*			29	12.2		
Tools	Swab	5*d	5e	10	22			15

Clothing	Swab	8f		5		18.8b		
	Tapelift	9g					15h	
	Excised	32i						
Blood	Swab	71	68			87.5		
Dataset average	All trace	9j	25k	12		12k	16	14

*greater percentage full profiles from tapelifts where relevant
a combined here from latex & fabric glove results
b combined category clothing/gloves
c combined category drinking vessels/drug pipes
d averaged over all tools analysed in Table 2
e combined here from screwdriver/crowbar/hand-tools (other)
f averaged over hat/cap/underwear/waistband shorts/pants in Table 2
g averaged over beanie/balaclava/helmet/hat/cap/underwear/waistband shorts/pants in Table 2
h combined here from underwear/socks/upper garments results
i averaged over underwear/waistband shorts/pants in Table 2
j average profiling success for trace samples only (i.e., excludes biological fluids, hair, cigarette butts)
k included bloodstain profiling results

24/02/2020

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Dear Editor,

Please accept the attached manuscript for consideration for publication in the *Australian Journal of Forensic Sciences*. The manuscript reports on a meta-analysis of DNA over 36,000 profiling results from Queensland for the period 22/2/18 – 11/9/19, with particular focus on trace DNA results. The data is broken down into exhibit types and collection methods to interrogate sampling success at increased granularity than is available in much of the existing literature. Success is measured via the indices of suspect identification, full profile, partial/mixed profile, and no DNA detected. The results suggest that ~10% of trace DNA samples produce full profiles, but these samples contribute nearly 40% of suspect identifications. There was substantial variation observed between the success rates of collection methods (excision, swab, tapelift) for many exhibit types. These results are useful for informing operational procedures to ensure that evidence informativeness is maximised.

I believe that this manuscript is highly suitable for the *Australian Journal of Forensic Sciences* and will garner significant readership and ongoing interest.

Yours sincerely,

Dr. Matt Krosch

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Variation in forensic DNA profiling success rate among sampled items and collection methods: a Queensland perspective.

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Variation in forensic DNA profiling success rate among sampled items and collection methods: a Queensland perspective.

Understanding the relative success rates of recovering DNA profiles from different touched evidentiary items/substrates, and between different methods of collection, is critical for optimal targeting of forensic sample collection and triaging for analysis. Further, reporting of such success rates allows comparison between jurisdictions that can drive improvements and prompt discussion between stakeholders. This study analysed success rates of DNA sampling from major and volume crimes attended by the Queensland Police Service, Australia, from February 2018 to September 2019. In total, 36 416 total records were analysed, representing the most comprehensive analysis of its kind to date. Success rates were determined for various sample types and items, including those that are commonly encountered or have high probative value. Results suggested that, overall, around 9.5% of trace DNA samples returned full profiles, but with some disparity between swabs (13.48%) and tapelifts (6.02%). Nevertheless, trace DNA samples contributed nearly 40% of total suspect identifications (tapelifts 20.05%; swabs 18.76%). Substantial variation in profiling success among items/substrates was observed, as there was between swabs and tapelifts taken from the same item. These data contribute significantly to our understanding of DNA prevalence and recovery and provide a critical evidence base to inform changes to operational procedures.

Keywords: swabs, tapelifts, full profile, mixed profile, suspect identification

Introduction

DNA sampling, particularly of touched objects and surfaces, has become an increasing focus for forensic analysts globally[1,2]. Resolution of DNA profiles from such items can be highly probative and thus understanding the relative success rates of recovering profiles from items is important for targeting sample collection and triaging for analysis. Such success rates should be considered in the context of the specific collection and analysis methods used by a given jurisdiction. Comparing data generated from different extraction and profiling methods may not necessarily represent a like-for-like comparison and must be considered with some caution. Nevertheless, there can be great value in comparing between jurisdictions to determine whether substantial differences are apparent and where improvements could be made. Moreover, sampling of putatively touched items can be a point of friction between investigators and forensic scientists who may have contrasting anecdotal experience concerning a questioned item. Finally, where jurisdictions use multiple collection methods for similar items (because of officer preference or simply what consumables are available at the time), it is important to assess whether one method outperforms another to ensure operational procedures follow best practice. Therefore, there is a need for additional data to inform decision-making and assist forensic scientists in optimally targeting sampling effort.

There have been sporadic attempts over the last twelve years to address this issue in a range of national and state jurisdictions from New Zealand[3], Switzerland[4], Canada[5], Netherlands[6], Singapore[7], and Australia[8], including a comparative analysis of experimental and casework samples from Western Switzerland[9]. These studies analysed success rates for various types of casework samples; either those most commonly collected, restricted to volume crime cases, or other items of interest. Generally speaking, these studies were consistent in suggesting that, as expected, biological fluid traces (blood, saliva, semen) provided the greatest proportions of full profiles (up to 87.5%[9]), whereas touch samples were far less successful overall (<30%). Worn or touched items that often returned above average proportions of full profiles include hats/caps, gloves, adhesive tape, clothing, door handles and steering wheels[3-9], though in some cases these may represent victim profiles.

This study aimed to analyse success rates of DNA sampling from major and volume crime for the Queensland Police Service, Queensland, Australia over a period of roughly 20 months. Success rates were determined for sample types over the entire period, as well as broken down to selected items of interest, including those that are commonly encountered or have high probative value. Queensland data are then discussed in the context of previous literature.

Methods

Samples included in this analysis were collected from exhibits related to both major and volume crime between the 22nd February 2018 and 11th September 2019. Methods of collection included swabbing with a rayon swab (Medical Wire, UK) pre-moistened with 70% ethanol, tapelifting with a custom 3M adhesive tape kit (Lovell Surgical Supplies, Australia), excision (e.g., fabric, cigarette butts), and scraping. All samples were processed at Queensland Health Forensic Scientific Services (QHFSS) following standard procedures: DNA extraction conducted using either the DNA IQ™ Casework Pro Kit for Maxwell®16 (Promega Corp., Melbourne, Australia) on a Maxwell® 16 MDx (Promega Corp.) or DNA Investigator Kit (Qiagen, Melbourne, Australia) on a QIASymphony (Qiagen); quantification using Quantifiler® Trio (ThermoFisher Scientific, Melbourne, Australia) on the 7500 Real Time PCR System (Applied Biosystems™, ThermoFisher Scientific), and STR amplification using PowerPlex® 21 (Promega Corp.). DNA quantification results determined progression to profiling, according to QHFSS standard procedures: samples of concentration <0.0088ng/µL were considered to have insufficient DNA and were thus categorised as 'no DNA'. Samples that yielded sufficient DNA (>0.0088ng/µL) proceeded to STR profiling.

Data was extracted from the in-house laboratory information management system (LIMS) for all DNA samples sent for processing between the 22nd February 2018 and 11th September 2019. The LIMS was queried in such a way to return sample type (e.g., swab/tapelift) and exhibit description information, as well as STR profiling results categorised as 'full' (all 42 alleles present), 'partial/mixed' (less than 42 alleles, or more than one contributor), or 'no DNA' (insufficient DNA quantity for profiling, or unsuccessful profiling). In some cases, sample results were classified in multiple categories; for example,

full+partial/mixed profile results may indicate full suspect profiles deconvoluted from mixtures, or no DNA+full or partial/mixed where samples were amplified and genotyped more than once. Profiles were also recorded for whether they matched a suspect/offender reference sample. This master spreadsheet was queried using Windows Powershell to extract lines in which the exhibit description matched specific text strings. All resulting sub-sheets were manually reviewed to ensure only relevant data was included. Despite this, inconsistencies in spelling and terminology in the exhibit description limited the completeness of the analysis; however, this is unlikely to impact dramatically on the interpretation of DNA success rates. Percentages of each profile result category were calculated for the total dataset, each collection method across all items, and then broken down for collection method from each selected item. Success rates were also assessed for porous versus non-porous substrate surfaces. Sample metadata allowed separation of swabs from biological fluid stains (blood, saliva, semen) to be separated from those taken from putative touched areas or handled objects.

Results

In total, 36 416 total records (representing 35 722 unique exhibits) were analysed, the majority of which were swabs or tapelifts (Table 1). Swabs collected from biological fluids represented a much smaller proportion than those from touched areas/objects. Overall, 25.60% of samples returned full profiles: the greatest proportion of full profiles was obtained from samples of obvious stains of biological fluids, with the most successful being swabs of bloodstains (71.15%, Table 2). Partial/mixed profiles were rarely obtained from swabs of semen stains (2.86%), but otherwise ranged up to 30.02% of DNA results from other sample types. Percentages of suspect identifications ranged from 13.14% (hair) to 39.37% (blood swabs). Both swabs and tapelifts of touched objects/surfaces returned suspect identifications from ~14% of samples, but there was a significant disparity between full profile results (swabs = 13.48%; tapelifts = 6.02%). Despite this, tapelifts provided 20% of total suspect identifications compared with nearly 19% for trace swabs (Table 1), suggesting that the success of tapelifting is often reliant on partial profiles or deconvolution of mixtures.

Individual items/surfaces showed great variation in their percentage success (Table 2). The greatest success for exhibits where no visible stain was observed was for clippings from fingernails, which produced full profiles in ~72% of samples taken. Chewing gum, excisions from cigarette butts, bedding and waistbands of lower garments, all samples from drinking straws, and fingernail scrapings all produced full profiles in >40% of samples. The least successful items (no full profiles recorded) included swabs of rocks and pavers, helmets, firearm barrels, shirt collars, power cords, rubber, metal and plastic key handles, and several tools; tapelifts of cigarette lighters, firearm handles, and several tools; and both swabs and tapelifts of public phones, fingermarks, glovemarks, external car door handles, sweat smears on cars, and axe handles. Despite this, many of these items did return suspect identifications based on partial profiles (either single source or deconvoluted mixtures); including, external car door handles, shirt collars, and mobile phones. Among sexual assault-related samples, breast swabs identified the greatest percentage of suspects after penis swabs (suspect reference samples); no suspect identifications were recorded from perineum samples. The highest percentage of full profiles were reported from oral swabs (most likely complainant profiles, though 6.57% were identified a suspect), whereas the lowest proportion of full profiles were from breast swabs.

Some distinct differences in the recovery of full profiles from swabs and tapelifts of trace samples were observed for specific items. Swabs were at least twice as successful as tapelifts for seatbelt buckles, adhesive tapes, cigarette lighters, window frames/sills, drinking vessels, firearm handles, knife blades, sledgehammers, mattock/pickaxes, torches, and bedding. In contrast, tapelifts were more successful for discharged car airbags, gearsticks, seatbelt straps & buckles, motorcycles (including handlebars), power cords, keys, cartridge cases (both discharged and live), firearm barrels, sweat smears on buildings, mobile phones, shirt collars, helmets, hats, rocks, and several tools. In contrast to conventional wisdom, tapelifts of non-porous surfaces recovered slightly more full profiles than swabs, and did so also from porous surfaces (Table 3). Furthermore, porous surfaces returned a greater percentage of full profiles and suspect identifications than non-porous surfaces.

Data caveats

A small number of samples were recorded as returning results in more than one category: 106 records were categorised as both partial/mixed and full (likely representing full profiles deconvoluted from mixtures), representing 1.4% of partial/mixed records and 1.1% of full profile results; 339 samples were categorised as both partial/mixed and no DNA, representing 1.5% of no DNA results and 4.4% of partial/mixed results; 2103 samples were categorised as both no DNA and full, representing 9.6% of no DNA results and 22.5% of full profile results; and 23 samples were categorised across all three categories. The bulk of such multiple categorisations were due to samples being reworked, either by concentrating dilute samples that initially fell below the quantification threshold to proceed to profiling, or by reamplification of partial/failed genotyping runs. In the context of the total dataset these multiple categorisations are not considered to substantially impact on the interpretation of profiling success rates. Manually reviewing every record was outside the scope of this project.

Discussion

The analysis presented here of nearly 18 months of DNA sampling data, representing more than 36 000 individual exhibits, from the Queensland Police Service has revealed some interesting patterns that can inform operational procedures. Averaged over all items/surfaces, trace swabs recovered more full profiles than tapelifts; however, there was substantial variation noted among exhibit types, including many for which tapelifts were the more successful method of collection. Increasing the granularity of the analysis therefore provided a deeper insight into DNA profiling success rates among items and methods of collection. Interestingly, percentage profiling successes for swabs and tapelifts from porous and non-porous surfaces were opposite to conventional wisdom.

It is difficult to compare the data presented here with previous studies from other jurisdictions. The specifics of collection technique, consumables, DNA extraction and STR profiling procedures and kits between organisations and over time are likely to have significant influence on profiling success. In addition, there has been variation across studies in the exhibit categorisation strategy used and hence granularity of data analysed. For example, some studies lump all clothing samples together[4,7,9], whereas others separate them

into subcategories for specific clothing types[3,5,6]. Further, some studies were deliberately restricted to samples taken from volume crime scenes[8,9], whereas others either were from all crime scenes or did not specify[3-7]. This limits the ability to make truly like-for-like comparisons between studies. Nevertheless, some general trends deserve discussion.

Overall, trace DNA success was similar for Queensland as for most jurisdictions compared here (Table 4). Interestingly, profiling success for many items included in the comparison was poorer than that reported from other jurisdictions, despite the current use in Queensland of a more sensitive DNA profiling kit than that used in many of these previous studies. This suggests that there were many other more successful items sampled by Queensland that made up the shortfall (possibly including SAIK swabs, for example). Alternatively, it could be because of different collection, storage, submission, triage or laboratory procedures in other regions, or a factor of analysing total sample data rather than smaller, selected subsets. For example, the dataset used here included both major and volume crime samples, which are treated in different ways both at collection (only one sample per volume crime occurrence is allowed to be submitted, whereas major crime samples are unlimited) and in the laboratory (major crime samples are automatically reworked, whereas volume crime samples are not). Such inconsistencies between datasets render the comparison indicative only. Nevertheless, trace DNA profile success was relatively high for items from cars (airbags, seatbelts), drinking straws, chewing gum, cartridge cases, underwear and waistbands, and bedding. The majority of comparisons with previous literature related to swabbed items (Table 4); however, tapelift sampling of many of these items in fact returned more full profiles than swabs (9 out of 19 items). Perhaps the most striking discrepancies were for swabs from hats/caps, inside of gloves, and collars compared with the results of Mapes et al[6]. Within the Queensland data, clear differences in profiling success were observed between collection methods which will contribute toward updated operational procedures.

These data provide valuable insight into DNA profiling success of one of Australia's largest police jurisdictions. Additional research is required to determine whether differences between Queensland and other published data stem from consumables used, collection

technique, environmental effects (e.g., increased degradation), or some other factor. Some recent work has suggested that rayon swabs are not ideal for recovering maximum DNA from collected samples[10], although this appears to contradict other research that supports rayon as among the most effective swab materials[11,12]. Additional research is still required here to inform better consumables choice for forensic practitioners. Pleasingly, there is good support in the data presented here for the efficacy of forensic tapelifts, particularly in preference to swabs for many non-porous items. This accords with existing literature that supports tapelifting as a highly effective collection method[13,14], including for the specific tape product used by QPS forensic officers[15]. Future research and reporting by other agencies into their success rates would benefit from a consistent approach to item and profile success categorisation, to maximise comparability between studies. This study demonstrates that increasing the granularity of data captured can reveal important trends that can inform best practice at the crime scene and laboratory.

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Tables

Table 1. Number of records included for analysis separated into major sample types (minor sample types or those not subsequently analysed are not shown). Percentages of total records, suspect identifications, full or partial/mixed profiles, and no DNA records provided for each sample type.

Sample type	Number of exhibit records	Percentage of total records	Percentage of total suspect identifications (N=8263)	Percentage of total full profiles (N=9323)	Percentage of total partial/mixed profiles (N=7698)	Percentage of total no DNA (N=21919)
Cigarette butts	2633	4.29	7.46	9.16	6.31	1.75
Fabric	1865	3.04	4.56	5.00	3.83	2.50
Hair	289	0.47	0.27	0.52	0.21	0.53
Scraping	922	1.50	2.28	2.34	0.82	1.53
Swab (blood)	7248	11.82	21.10	33.81	9.05	4.00
Swab (saliva)	4769	7.77	12.93	12.17	10.46	4.97
Swab (semen)	51	0.08	0.10	0.09	0.01	0.11
Swab (trace)	16518	26.93	17.18	14.01	20.24	34.14
Tapelift	22576	36.76	24.45	9.97	38.40	45.74
All trace	39067	63.69	41.63	23.99	58.64	79.88

Table 2. DNA profiling results for samples collected by QPS forensic officers between 22 February 2018 and 11 September 2019.

Item		Collection method	Total results	Percentage suspect identification	Percentage full profile	Percentage partial/mixed profile	Percentage no DNA
All		All	36416	22.69	25.60	21.14	60.19
		Fabric	1050	34.95	38.57	24.76	49.43
		Hair	205	13.14	31.22	8.78	65.37
		Scrapings	709	34.27	42.74	9.03	60.08
		Swab (blood)	4361	39.37	71.15	17.77	23.25
		Swab (saliva)	2688	38.28	39.51	30.02	39.62
		Swab (semen)	35	22.86	22.86	2.86	82.86
		All trace	22556	14.22	9.45	18.71	75.90
		Swab	10372	14.94	13.48	16.11	75.34
		Tapelift	12184	13.60	6.02	20.93	76.39
Cars	Steering wheel	Swab (blood)	20	60.00	60.00	25.00	35.00
		All trace	1934	12.62	4.55	21.04	76.78
		Swab	431	10.67	2.55	18.10	80.74
		Tapelift	1503	13.17	5.12	21.89	75.65
	Airbags	Swab (blood)	37	67.57	81.08	16.22	16.22
		Excised	9	33.33	66.67	22.22	44.44
		All trace	130	26.92	15.38	25.38	70.00
		Swab	8	12.50	0.00	12.50	87.50
		Tapelift	122	27.87	16.39	26.23	68.85
	Gear stick	Swab (blood)	4	50.00	100.00	0.00	25.00
		All trace	371	8.36	3.77	14.82	83.02
		Swab	113	5.31	0.00	9.73	90.27
		Tapelift	258	9.69	5.43	17.05	79.84

	All doors	Swab (blood)	69	60.87	73.91	11.59	27.54
		All trace	99	7.07	2.02	8.08	89.90
		Swab	60	8.33	1.67	8.33	90.00
		Tapelift	39	5.13	2.56	7.69	89.74
	Internal door handle	Swab (blood)	33	60.61	69.70	12.12	36.36
		All trace	61	6.56	3.28	6.56	90.16
		Swab	35	8.57	2.86	8.57	88.57
		Tapelift	26	3.85	3.85	3.85	92.31
	External door handle	Swab (blood)	20	70.00	80.00	20.00	15.00
		All trace	28	3.57	0.00	7.14	92.86
		Swab	17	0.00	0.00	0.00	100.00
		Tapelift	11	9.09	0.00	18.18	81.82
	Seatbelt strap	Swab (blood)	1	0.00	100.00	0.00	100.00
		Fabric	1	0.00	0.00	0.00	100.00
		All trace	85	4.71	3.53	9.41	88.24
		Swab	3	0.00	0.00	33.33	66.67
		Tapelift	82	4.88	3.66	8.54	89.02
	Seatbelt buckle	All trace	63	9.52	4.76	11.11	87.30
		Swab	20	5.00	10.00	0.00	90.00
		Tapelift	43	11.63	2.33	16.28	86.05
Motorcycles		Swab (blood)	4	100.00	100.00	0.00	0.00
		All trace	39	5.13	5.13	7.69	92.31
		Swab	12	0.00	0.00	0.00	100.00
		Tapelift	27	7.41	7.41	11.11	88.89
	Handlebars	Swab (blood)	-	-	-	-	-
		All trace	34	5.88	5.88	8.82	91.18
		Swab	10	0.00	0.00	0.00	100.00
		Tapelift	24	8.33	8.33	12.50	87.50
Cigarette butt		Excised (majority)	1546	40.10	53.75	31.89	27.04

Cigarette packet		Swab (blood)	5	40.00	100.00	0.00	0.00
		Tapelift	4	25.00	25.00	75.00	100.00
Cigarette lighter		All trace	110	3.64	1.82	8.18	90.00
		Swab	88	4.55	2.27	7.95	89.77
		Tapelift	22	0.00	0.00	9.09	90.91
Bindings		All	229	9.17	10.48	17.03	77.73
	Rope	Tapelift (majority)	57	3.51	14.04	22.81	70.18
	Zip/cable ties	All trace	29	13.79	13.79	6.90	82.76
		Swab	16	6.25	12.50	0.00	93.75
		Tapelift	13	23.08	15.38	15.38	69.23
	Power cords	Swab (blood)	4	25.00	50.00	25.00	75.00
		All trace	86	9.30	5.81	11.63	84.88
		Swab	45	2.22	0.00	6.67	93.33
		Tapelift	41	17.07	12.20	17.07	75.61
	Tapes	All trace	92	9.78	5.43	10.87	89.13
		Swab	58	10.34	6.90	13.79	86.21
		Tapelift	34	8.82	2.94	5.88	94.12
	Deceased scenes	Tapelift (majority)	32	3.13	28.13	37.50	59.38
Door handles (premises)		Swab (blood)	38	57.89	65.79	28.95	28.95
		All trace	252	2.78	2.78	7.14	90.87
		Swab	136	2.21	2.94	5.15	93.38
		Tapelift	116	3.45	2.59	9.48	87.93
Window frames/sills		Swab (blood)	113	48.67	76.11	14.16	18.58
		All trace	61	13.11	9.84	8.20	85.25
		Swab	38	13.16	13.16	7.89	84.21
		Tapelift	23	13.04	4.35	8.70	86.96
Flyscreen mesh		Swab (blood)	20	45.00	70.00	10.00	25.00
		Excised	1	100.00	100.00	0.00	0.00
		All trace	611	4.42	3.93	9.17	88.22

		Swab	94	0.00	2.13	4.26	94.68
		Tapelift	517	5.22	4.26	10.06	87.04
Mouth/rim of drinking vessel		All trace	2525	34.93	37.43	28.83	42.85
		Swab	2450	35.67	38.33	29.14	41.63
		Tapelift	75	10.67	8.00	18.67	82.67
Drinking straw		Excised	33	54.55	48.48	36.36	30.30
		All trace	311	47.91	45.98	29.26	38.26
		Swab	305	47.87	45.90	29.51	38.36
		Tapelift	6	50.00	50.00	16.67	33.33
Drug pipe/bong		Swab (majority)	118	28.81	11.86	35.59	56.78
Chewing gum		Whole item (majority)	16	12.50	62.50	18.75	43.75
Keys		All trace	223	4.04	1.79	12.11	87.89
		Swab	134	1.49	0.75	5.97	94.78
		Tapelift	89	7.87	3.37	21.35	77.53
	Rubber	All trace	6	0.00	16.67	0.00	100.00
		Swab	1	0.00	0.00	0.00	100.00
		Tapelift	5	0.00	20.00	20.00	100.00
	Metal	All trace	93	2.15	1.08	7.53	92.47
		Swab	68	1.47	0.00	5.88	94.12
		Tapelift	25	4.00	4.00	12.00	88.00
	Plastic	All trace	87	4.60	2.30	12.64	86.21
		Swab	41	2.44	0.00	4.88	95.12
		Tapelift	46	6.52	4.35	19.57	78.26
Cartridge cases		All trace	130	3.08	5.38	3.85	93.08
		Swab	75	2.67	1.33	1.33	97.33
		Tapelift	55	3.64	10.91	7.27	87.27
	Discharged	All trace	47	4.26	12.77	4.26	87.23
		Swab	25	4.00	4.00	0.00	96.00

		Tapelift	22	4.55	22.73	9.09	77.27
	Live	All trace	77	2.60	1.30	2.60	97.40
		Swab	46	2.17	0.00	2.17	97.83
		Tapelift	31	3.23	3.23	3.23	96.77
Firearm		Swab (blood)	8	12.50	75.00	25.00	25.00
		All trace	499	8.02	2.40	8.82	89.98
		Swab	308	7.79	2.60	9.09	90.26
		Tapelift	191	8.38	2.09	8.38	89.53
	Handle	All trace	129	8.53	2.33	10.85	88.37
		Swab	60	8.33	5.00	11.67	86.67
		Tapelift	69	8.70	0.00	10.14	89.86
	Barrel	All trace	13	0.00	7.69	7.69	92.31
		Swab	7	0.00	0.00	14.29	100.00
		Tapelift	6	0.00	16.67	0.00	83.33
	Trigger	All trace	164	7.93	3.05	7.93	89.63
		Swab	121	8.26	3.31	9.09	88.43
		Tapelift	43	6.98	2.33	4.65	93.02
Knife		Swab (blood)	218	33.49	47.25	37.16	27.52
		All trace	769	15.34	6.11	19.25	77.89
		Swab	491	13.85	6.31	18.13	78.82
		Tapelift	278	17.99	5.76	21.22	76.26
	Handle	All trace	578	15.74	3.81	19.55	79.24
		Swab	330	13.94	3.03	17.58	81.82
		Tapelift	248	18.15	4.84	22.18	75.81
	Blade	All trace	138	13.04	12.32	21.74	69.57
		Swab	132	12.88	12.88	21.21	69.70
		Tapelift	6	16.67	0.00	33.33	66.67
Gloves		Swab (blood)	8	37.50	25.00	37.50	37.50
		Excised	7	71.43	0.00	71.43	28.57

		All trace	1003	15.05	4.49	22.33	75.27
		Swab	228	7.02	3.95	13.16	85.09
		Tapelift	775	17.42	4.65	25.03	72.39
	Inside surfaces	All trace	640	14.22	4.69	23.28	74.22
	Inside surfaces	Swab	139	7.91	5.04	13.67	83.45
	Inside surfaces	Tapelift	501	15.97	4.59	25.95	71.66
Fingermarks		Swab (blood)	6	16.67	33.33	33.33	33.33
Fingermarks		All trace	67	4.48	0.00	7.46	92.54
Fingermarks		Swab	58	5.17	0.00	8.62	91.38
Fingermarks		Tapelift	9	0.00	0.00	0.00	100.00
Glovemarks		All trace	64	0.00	0.00	0.00	100.00
Glovemarks		Swab	60	0.00	0.00	0.00	100.00
Glovemarks		Tapelift	4	0.00	0.00	0.00	100.00
Sweat smears	Premises	All trace	73	5.48	4.11	2.74	95.89
Sweat smears	Premises	Swab	67	4.48	2.99	2.99	97.01
Sweat smears	Premises	Tapelift	6	16.67	16.67	0.00	83.33
Sweat smears	Cars	All trace	20	0.00	0.00	5.00	95.00
Sweat smears	Cars	Swab	18	0.00	0.00	5.56	94.44
Sweat smears	Cars	Tapelift	2	0.00	0.00	0.00	100.00
Phones	Mobile phone	Swab (blood)	19	52.63	57.89	42.11	21.05
Phones	Mobile phone	All trace	81	19.75	2.47	22.22	75.31
Phones	Mobile phone	Swab	63	15.87	0.00	22.22	77.78
Phones	Mobile phone	Tapelift	18	33.33	11.11	22.22	66.67
Phones	Public phone	Swab (blood)	2	100.00	100.00	0.00	100.00
Phones	Public phone	All trace	8	0.00	0.00	0.00	100.00
Phones	Public phone	Swab	5	0.00	0.00	0.00	100.00
Phones	Public phone	Tapelift	3	0.00	0.00	0.00	100.00
Keypad (eg., safe/alarm)		Swab (majority)	18	5.56	11.11	11.11	83.33
Computer keyboard		Swab (blood/trace)	2	50.00	50.00	0.00	50.00

Fingernails		Scrapings	357	53.50	41.46	44.26	32.21
		Clippings	47	17.02	72.34	25.53	19.15
Condom		Swab (majority)	205	50.24	17.56	49.27	46.83
Sexual assault-related		All	3428	22.35	45.92	22.58	42.68
		High vaginal	478	26.78	50.42	31.59	32.64
		Low vaginal	473	20.93	50.95	25.79	34.46
		Hymen	8	12.50	62.50	12.50	37.50
		Vaginal other	55	30.91	61.82	23.64	18.18
		Vulval	756	17.59	51.59	19.97	38.23
		Labial	158	15.19	61.39	20.25	32.28
		Perineum	12	0.00	58.33	0.00	41.67
		Perianal	319	14.73	34.17	19.75	55.17
		Anal	111	8.11	36.94	9.91	63.06
		Rectal	176	9.66	39.77	11.36	57.95
		Breast	33	39.39	9.09	42.42	66.67
		Oral	213	6.57	67.61	6.10	35.68
		Penis	320	55.63	27.19	34.06	52.19
Clothing	Collar	Swab (blood)	2	100.00	50.00	50.00	50.00
		Fabric	10	30.00	40.00	20.00	50.00
		All trace	256	24.61	5.86	31.64	66.80
		Swab	11	27.27	0.00	36.36	63.64
		Tapelift	245	24.49	6.12	31.43	66.94
	Beanie	Tapelift (majority)	65	33.85	3.08	40.00	60.00
	Balaclava	Tapelift (majority)	56	26.79	17.86	16.07	73.21
	Helmet	Swab (blood)	6	66.67	100.00	0.00	33.33
		All trace	89	25.84	4.49	31.46	67.42
		Swab	8	0.00	0.00	0.00	100.00
		Tapelift	81	28.40	4.94	34.57	64.20
	Hat/cap	Swab (blood)	27	59.26	40.74	40.74	33.33

		All trace	509	25.54	7.86	34.97	62.48
		Swab	29	13.79	3.45	20.69	75.86
		Tapelift	480	26.25	8.13	35.83	61.67
	Underwear	Excised/scraped	193	29.02	21.76	22.80	64.25
		All trace	308	25.32	14.94	43.18	49.35
		Swab	14	42.86	21.43	50.00	28.57
		Tapelift	294	24.49	14.63	42.86	50.34
	Waistband shorts/pants	Excised/scraped	12	33.33	41.67	8.33	83.33
		All trace	120	20.00	4.17	35.83	64.17
		Swab	4	50.00	0.00	50.00	50.00
		Tapelift	116	18.97	4.31	35.34	64.66
Screwdriver		All trace	498	9.24	2.41	16.06	83.13
		Swab	253	8.70	2.37	13.44	85.38
		Tapelift	245	9.80	2.45	18.78	80.82
Sledge hammer		Swab (blood)	3	0.00	66.67	0.00	66.67
		All trace	35	11.43	2.86	11.43	85.71
		Swab	10	10.00	10.00	0.00	90.00
		Tapelift	25	12.00	0.00	16.00	84.00
Hammer		Swab (blood)	17	35.29	64.71	17.65	58.82
		All trace	183	7.10	2.73	11.48	86.89
		Swab	60	5.00	3.33	10.00	86.67
		Tapelift	123	8.13	2.44	12.20	86.99
Spanner		Swab (blood)	4	25.00	100.00	0.00	0.00
		All trace	57	3.51	3.51	3.51	94.74
		Swab	32	0.00	3.13	0.00	100.00
		Tapelift	25	8.00	4.00	8.00	88.00
Chisel		All trace	30	13.33	3.33	10.00	90.00
		Swab	17	0.00	0.00	0.00	100.00
		Tapelift	13	30.77	7.69	23.08	76.92

Shovel		Swab (blood)	1	0.00	100.00	0.00	100.00
		All trace	45	13.33	2.22	11.11	86.67
		Swab	19	10.53	0.00	10.53	89.47
		Tapelift	26	15.38	3.85	11.54	84.62
Crow bar		All trace	158	5.70	3.16	6.33	93.04
		Swab	59	3.39	3.39	3.39	96.61
		Tapelift	99	7.07	3.03	8.08	90.91
Axe		Swab (blood)	1	100.00	100.00	0.00	100.00
		All trace	60	8.33	0.00	13.33	86.67
		Swab	14	0.00	0.00	7.14	92.86
		Tapelift	46	10.87	0.00	15.22	84.78
Mattock/Pickaxe		All trace	18	0.00	5.56	5.56	88.89
		Swab	5	0.00	20.00	0.00	80.00
		Tapelift	13	0.00	0.00	7.69	92.31
Torch		All trace	212	17.92	8.49	19.81	75.47
		Swab	100	16.00	12.00	15.00	80.00
		Tapelift	112	19.64	5.36	24.11	71.43
Brick/rock		All	298	6.71	8.39	6.71	87.25
	Rock	Swab (blood)	9	11.11	66.67	11.11	22.22
		All trace	143	1.40	0.70	3.50	96.50
		Swab	10	0.00	0.00	0.00	100.00
		Tapelift	133	1.50	0.75	3.76	96.24
	Brick/paver	Swab (blood)	17	35.29	76.47	5.88	23.53
		All trace	129	8.53	3.88	10.08	89.92
		Swab	13	0.00	0.00	0.00	100.00
		Tapelift	116	9.48	4.31	11.21	88.79
Clip-seal plastic bag		All trace	150	12.67	4.67	14.67	83.33
		Swab	125	12.00	4.00	13.60	84.00
		Tapelift	25	16.00	8.00	20.00	80.00

Bedding		All	968	25.72	27.79	22.62	58.68
		Excised	241	25.31	40.25	19.50	48.96
		Scraping	276	22.83	34.42	10.87	65.22
		Other	253	32.41	11.07	38.74	60.08
		Swab (blood)	56	26.79	55.36	23.21	35.71
		All trace	142	19.72	12.68	22.54	69.01
		Swab	5	0.00	40.00	20.00	60.00
		Tapelift	137	20.44	11.68	22.63	69.34
	Mattress	All	88	14.77	22.73	12.50	72.73
	Mattress protector	All	63	11.11	11.11	11.11	100.00
	Sheets	All	679	32.78	28.25	25.57	53.40
	Blanket	All	403	17.01	28.91	19.39	63.27
	Pillow	All	179	21.26	24.41	22.05	62.20

Table 3. Comparison of percentage success in DNA sampling between porous and non-porous items/surfaces from Table 2.

Surface	Collection method	Total results	Percentage suspect identification	Percentage full profile	Percentage partial/mixed profile	Percentage no DNA
Non-porous	All trace	13290	9.15	5.83	11.58	85.98
	Swab	7243	7.17	5.16	8.61	88.30
	Tapelift	6047	11.17	6.51	14.60	83.62
Porous	All trace	2000	17.57	8.09	24.74	71.02
	Swab	97	16.27	7.21	24.77	70.25
	Tapelift	1903	18.54	8.75	24.73	71.60

Table 4. Comparison of Queensland DNA profiling success data for specific items against equivalent data from the literature.

Exhibit category		This study	Netherlands[6]	Singapore[7]	Switzerland[4]	Switzerland[9]	New Zealand[3]	New South Wales[8]
	Profile / Collection	Full	Single	Single	Full/partial>5 loci	Single	Full	Full/partial>12 loci
Cigarette butt	Excised	54	84	81		70.6		
Hat/cap	Swab	3	42					
	Tapelift	8					25	
Collar	Swab	0*	34					
Glove (inside)	Swab	5	25a	11		18.8b		
	Tapelift	5					25	
Torch	Swab	12	27					
Drinking vessels	Swab	38	57	34		55.6	21c	
Knife handle	Swab	3*	19					
Lighter	Swab	2	17					
Firearm grip	Swab	5	6					
Firearms (other)	Swab	3*						15
Handle motorcycle	Swab	3*	9					
Cartridge cases	Swab	4*	6					
Tape	Swab	7	9	16				
Keys	Swab	1*	12					
Hair	Excised	31		21.1				
Drug apparatus	Swab	12		15			21c	
Thrown stones	Swab	0*			7	7.5		
Cables/power cords	Swab	0*			29	12.2		
Tools	Swab	5*d	5e	10	22			15

Clothing	Swab	8f		5		18.8b		
	Tapelift	9g					15h	
	Excised	32i						
Blood	Swab	71	68			87.5		
Dataset average	All trace	9j	25k	12		12k	16	14

*greater percentage full profiles from tapelifts where relevant
a combined here from latex & fabric glove results
b combined category clothing/gloves
c combined category drinking vessels/drug pipes
d averaged over all tools analysed in Table 2
e combined here from screwdriver/crowbar/hand-tools (other)
f averaged over hat/cap/underwear/waistband shorts/pants in Table 2
g averaged over beanie/balaclava/helmet/hat/cap/underwear/waistband shorts/pants in Table 2
h combined here from underwear/socks/upper garments results
i averaged over underwear/waistband shorts/pants in Table 2
j average profiling success for trace samples only (i.e., excludes biological fluids, hair, cigarette butts)
k included bloodstain profiling results

Variation in forensic DNA profiling success among sampled items and collection methods: a Queensland perspective.

Variation in forensic DNA profiling success among sampled items and collection methods: a Queensland perspective.

Understanding the relative success of recovering DNA profiles from different touched evidentiary items/substrates, and between different methods of collection, is critical for optimal targeting of forensic sample collection and triaging for analysis. Further, reporting of such success statistics allows comparison between jurisdictions that can drive improvements and prompt discussion between stakeholders. This study analysed success statistics for DNA sampling from major and volume crimes attended by the Queensland Police Service, Australia, from February 2018 to September 2019. In total, 36 416 total records were analysed, representing the most comprehensive analysis of its kind to date. Percentage successes were determined for various sample types and items, including those that are commonly encountered or have high probative value. Results suggested that, overall, around 9.5% of trace DNA samples returned full profiles, but with some disparity between swabs (13.48%) and tapelifts (6.02%). Nevertheless, trace DNA samples contributed nearly 40% of total suspect identifications (tapelifts 20.05%; swabs 18.76%). Substantial variation in profiling success among items/substrates was observed, as there was between swabs and tapelifts taken from the same item. These data contribute significantly to our understanding of DNA prevalence and recovery and provide a critical evidence base to inform changes to operational procedures.

Keywords: swabs, tapelifts, full profile, mixed profile, suspect identification

Introduction

DNA sampling, particularly of touched objects and surfaces, has become an increasing focus for forensic analysts globally[1,2]. Resolution of DNA profiles from such items can be highly probative and thus understanding the relative success of recovering profiles from items is important for targeting sample collection and triaging for analysis. Such success statistics should be considered in the context of the specific collection and analysis methods used by a given jurisdiction. Comparing data generated from different extraction and profiling methods may not necessarily represent a like-for-like comparison and must be considered with some caution. Nevertheless, there can be great value in comparing between jurisdictions to determine whether substantial differences are apparent and where improvements could be made. Moreover, sampling of putatively touched items can be a point of friction between investigators and forensic scientists who may have contrasting anecdotal experience concerning a questioned item. Finally, where jurisdictions use multiple collection methods for similar items (because of officer preference or simply what consumables are available at the time), it is important to assess whether one method outperforms another to ensure operational procedures follow best practice. Therefore, there is a need for additional data to inform decision-making and assist forensic scientists in optimally targeting sampling effort.

There have been sporadic attempts over the last twelve years to address this issue in a range of national and state jurisdictions from New Zealand[3], Switzerland[4], Canada[5], Netherlands[6], Singapore[7], and Australia[8], including a comparative analysis of experimental and casework samples from Western Switzerland[9]. These studies analysed success statistics for various types of casework samples; either those most commonly collected, restricted to volume crime cases, or other items of interest. Generally speaking, these studies were consistent in suggesting that, as expected, biological fluid traces (blood, saliva, semen) provided the greatest proportions of full profiles (up to 87.5%[9]), whereas touch samples were far less successful overall (<30%). Worn or touched items that often returned above average proportions of full profiles include hats/caps, gloves, adhesive tape, clothing, door handles and steering wheels[3-9], though in some cases these may represent victim (wearer) profiles.

This study aimed to analyse success statistics of DNA sampling from major and volume crime for the Queensland Police Service, Queensland, Australia over a period of roughly 20 months. Percentage successes were determined for sample types over the entire period, as well as broken down to selected items of interest, including those that are commonly encountered or have high probative value. Queensland data are then discussed in the context of previous literature.

Methods

Samples included in this analysis were collected from exhibits related to both major and volume crime between the 22nd February 2018 and 11th September 2019. Methods of collection included: swabbing with a rayon swab (Medical Wire, UK) pre-moistened with 70% ethanol; tapelifting with a custom 3M adhesive tape kit (Lovell Surgical Supplies, Australia); excision (e.g., fabric, cigarette butts); and scraping. All samples were processed at Queensland Health Forensic Scientific Services (QHFSS) following standard procedures: DNA extraction conducted using either the DNA IQ™ Casework Pro Kit for Maxwell®16 (Promega Corp., Melbourne, Australia) on a Maxwell® 16 MDx (Promega Corp.) or DNA Investigator Kit (Qiagen, Melbourne, Australia) on a QIASymphony (Qiagen); quantification using Quantifiler® Trio (ThermoFisher Scientific, Melbourne, Australia) on the 7500 Real Time PCR System (Applied Biosystems™, ThermoFisher Scientific), and STR amplification using PowerPlex® 21 (Promega Corp.). DNA quantification results determined progression to profiling, according to QHFSS standard procedures: samples of concentration <0.0088 ng/µL were considered to have insufficient DNA and were thus categorised as 'no DNA'. Samples that yielded sufficient DNA (>0.0088 ng/µL) proceeded to STR profiling.

Data were extracted from the in-house laboratory information management system (LIMS) for all DNA samples sent for processing between the 22nd February 2018 and 11th September 2019. The LIMS was queried in such a way to return sample type (e.g., swab/tapelift) and exhibit description information, as well as STR profiling results categorised as 'full' (all 42 alleles present), 'partial/mixed' (less than 42 alleles, or more than one contributor), or 'no DNA' (insufficient DNA quantity for profiling, or unsuccessful profiling). In some cases, sample results were classified in multiple categories; for example,

full+partial/mixed profile results may indicate full suspect profiles deconvoluted from mixtures, or no DNA+full or partial/mixed where samples were amplified and genotyped more than once. Profiles were also recorded for whether they matched a suspect/offender reference sample. This master spreadsheet was queried using Windows Powershell to extract lines in which the exhibit description matched specific text strings. All resulting sub-sheets were manually reviewed to ensure only relevant data were included. Despite this, inconsistencies in spelling and terminology in the exhibit description limited the completeness of the analysis; however, this is unlikely to impact dramatically on the interpretation of DNA success statistics. Percentages of each profile result category were calculated for the total dataset, each collection method across all items, and then broken down for collection method from each selected item. Percentage successes were also assessed for porous versus non-porous substrate surfaces. Sample metadata allowed separation of swabs from biological fluid stains (blood, saliva, semen) to be separated from those taken from putative touched areas or handled objects.

Results

In total, 36 416 total records (representing 35 722 unique exhibits) were analysed, the majority of which were swabs or tapelifts (Table 1). Swabs collected from biological fluids represented a much smaller proportion than those from touched areas/objects. Overall, 25.60% of samples returned full profiles: the greatest proportion of full profiles was obtained from samples of obvious stains of biological fluids, with the most successful being swabs of bloodstains (71.15%, Table 2). Partial/mixed profiles were rarely obtained from swabs of semen stains (2.86%), but otherwise ranged up to 30.02% of DNA results from other sample types. Percentages of suspect identifications ranged from 13.14% (hair) to 39.37% (blood swabs). Both swabs and tapelifts of touched objects/surfaces returned suspect identifications from ~14% of samples, but there was a significant disparity between full profile results (swabs = 13.48%; tapelifts = 6.02%). Despite this, tapelifts provided 20% of total suspect identifications compared with nearly 19% for trace swabs (Table 1), suggesting that the success of tapelifting is often reliant on partial profiles or deconvolution of mixtures.

Individual items/surfaces showed great variation in their percentage success (Table 2). The greatest success for exhibits where no visible stain was observed was for clippings from fingernails, which produced full profiles in ~72% of samples taken. Chewing gum, excisions from cigarette butts, bedding and waistbands of lower garments, all samples from drinking straws, and fingernail scrapings all produced full profiles in >40% of samples. The least successful items (no full profiles recorded) included swabs of rocks and pavers, helmets, mobile phones, firearm barrels, shirt collars, power cords, rubber, metal and plastic key handles, and several tools; tapelifts of cigarette lighters, firearm handles, and several tools; and both swabs and tapelifts of public phones, fingermarks, glovemarks, external car door handles, sweat smears on cars, and axe handles. Despite this, many of these items did return suspect identifications based on partial profiles (either single source or deconvoluted mixtures); including, external car door handles, shirt collars, and mobile phones. Among sexual assault-related samples, breast swabs identified the greatest percentage of suspects after penis swabs (suspect reference samples); no suspect identifications were recorded from perineum samples. The highest percentage of full profiles were reported from oral swabs (most likely complainant profiles, though 6.57% were identified a suspect), whereas the lowest proportion of full profiles were from breast swabs.

Some distinct differences in the recovery of full profiles from swabs and tapelifts of trace samples were observed for specific items. Swabs were at least twice as successful as tapelifts for seatbelt buckles, adhesive tapes, cigarette lighters, window frames/sills, drinking vessels, firearm handles, knife blades, sledgehammers, mattock/pickaxes, torches, and bedding. In contrast, tapelifts were more successful for discharged car airbags, steering wheels, gearsticks, seatbelt straps, motorcycles (including handlebars), power cords, keys, clip seal plastic bags, cartridge cases (both discharged and live), firearm barrels, sweat smears on buildings, mobile phones, shirt collars, helmets, hats, rocks, pavers, and several tools. In contrast to conventional wisdom, tapelifts of non-porous surfaces recovered slightly more full profiles than swabs, and did so also from porous surfaces (Table 3). Furthermore, porous surfaces returned a greater percentage of full profiles and suspect identifications than non-porous surfaces.

Data caveats

A small number of samples were recorded as returning results in more than one category: 106 records were categorised as both partial/mixed and full (likely representing full profiles deconvoluted from mixtures), representing 1.4% of partial/mixed records and 1.1% of full profile results; 339 samples were categorised as both partial/mixed and no DNA, representing 1.5% of no DNA results and 4.4% of partial/mixed results; 2103 samples were categorised as both no DNA and full, representing 9.6% of no DNA results and 22.5% of full profile results; and 23 samples were categorised across all three categories. The bulk of such multiple categorisations were due to samples being reworked, either by concentrating dilute samples that initially fell below the quantification threshold to proceed to profiling, or by reamplification of partial/failed genotyping runs. In the context of the total dataset these multiple categorisations are not considered to substantially impact on the interpretation of profiling success statistics. Manually reviewing every record was outside the scope of this project.

Discussion

The analysis presented here of nearly 18 months of DNA sampling data, representing more than 36 000 individual exhibits, from the Queensland Police Service has revealed some interesting patterns that can inform operational procedures. Averaged over all items/surfaces, trace swabs recovered more full profiles than tapelifts; however, there was substantial variation noted among exhibit types, including many for which tapelifts were the more successful method of collection. Increasing the resolution of the analysis therefore provided a deeper insight into DNA profiling success among items and methods of collection. Interestingly, percentage profiling successes for swabs and tapelifts from porous and non-porous surfaces were highly similar, in apparent contradiction of conventional wisdom that swabs are more successful for non-porous surfaces whereas tapelifts are better for porous surfaces.

It is difficult to compare the data presented here with previous studies from other jurisdictions. The specifics of collection technique, consumables, DNA extraction and STR

profiling procedures and kits between organisations and over time are likely to have significant influence on profiling success. In addition, there has been variation across studies in the exhibit categorisation strategy used and hence granularity of data analysed. For example, some studies lump all clothing samples together[4,7,9], whereas others separate them into subcategories for specific clothing types[3,5,6]. Further, some studies were deliberately restricted to samples taken from volume crime scenes[8,9], whereas others either were from all crime scenes or did not specify[3-7]. This limits the ability to make truly like-for-like comparisons between studies. Nevertheless, some general trends deserve discussion.

Overall, full profile recovery from trace DNA samples was slightly lower in Queensland than reported from other jurisdictions compared here (Table 4). Interestingly, profiling success for many items included in the comparison was also poorer than that reported from other jurisdictions, despite the current use in Queensland of a more sensitive DNA profiling kit than that used in many of these previous studies. This increased sensitivity may have resulted in increased mixed profile recovery in Queensland. Alternatively, the observed differences could be because of different collection, storage, submission, triage or laboratory procedures in other regions, or a factor of analysing total sample data rather than smaller, selected subsets. For example, the dataset used here included both major and volume crime samples, which are treated in different ways both at collection (only one sample per volume crime occurrence is allowed to be submitted, whereas major crime samples are unlimited) and in the laboratory (major crime samples are automatically reworked, whereas volume crime samples are not). Such inconsistencies between datasets render the comparison indicative only. Nevertheless, trace DNA profile success was relatively high for items from cars (airbags, seatbelts), drinking straws, chewing gum, cartridge cases, underwear and waistbands, and bedding. The majority of comparisons with previous literature related to swabbed items (Table 4); however, tapelift sampling of many of these items in fact returned more full profiles than swabs (9 out of 19 items). Perhaps the most striking discrepancies were for swabs from hats/caps, inside of gloves, and collars compared with the results of Mapes et al[6]. Within the Queensland data, clear differences in profiling success were observed between collection methods which will contribute toward updated operational procedures.

These data provide valuable insight into DNA profiling success of one of Australia's largest police jurisdictions. Additional research is required to determine whether differences between Queensland and other published data stem from consumables used, collection technique, environmental effects (e.g., increased degradation), or some other factor. Some recent work has suggested that rayon swabs are not ideal for recovering maximum DNA from collected samples[10], although this appears to contradict other research that supports rayon as among the most effective swab materials[11,12]. Additional research is still required here to inform better consumables choice for forensic practitioners. Pleasingly, there is good support in the data presented here for the efficacy of forensic tapelifts, particularly in preference to swabs for many non-porous items. This accords with existing literature that supports tapelifting as a highly effective collection method[13,14], including for the specific tape product used by QPS forensic officers[15]. Future research and reporting by other agencies into their success statistics would benefit from a consistent approach to item and profile success categorisation, to maximise comparability between studies. This study demonstrates that increasing the granularity of data captured can reveal important trends that can inform best practice at the crime scene and laboratory.

Disclosure Statement:

The author declares no conflict of interest.

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Tables

Table 1. Number of records included for analysis separated into major sample types (minor sample types or those not subsequently analysed are not shown). Percentages of total records, suspect identifications, full or partial/mixed profiles, and no DNA records provided for each sample type.

Sample type	Number of exhibit records	Percentage of total records	Percentage of total suspect identifications (N=8263)	Percentage of total full profiles (N=9323)	Percentage of total partial/mixed profiles (N=7698)	Percentage of total no DNA (N=21919)
Cigarette butts	1546	4.25	7.50	8.91	6.40	1.91
Fabric	1050	2.88	4.44	4.34	3.38	2.37
Hair	205	0.56	0.33	0.69	0.23	0.61
Scraping	709	1.95	2.94	3.25	0.83	1.94
Swab (blood)	4361	11.98	20.78	33.28	10.07	4.63
Swab (saliva)	2688	7.38	12.45	11.39	10.48	4.86
Swab (semen)	35	0.10	0.10	0.09	0.01	0.13
Swab (trace)	10372	28.48	18.76	15.00	21.71	35.65
Tapelift	12184	33.46	20.05	7.87	33.13	42.46
All trace	22556	61.94	38.81	22.87	54.83	78.11

Table 2. DNA profiling results for samples collected by QPS forensic officers between 22 February 2018 and 11 September 2019.

Item		Collection method	Total results	Percentage suspect identification	Percentage full profile	Percentage partial/mixed profile	Percentage no DNA
All		All	36416	22.69	25.60	21.14	60.19
		Fabric	1050	34.95	38.57	24.76	49.43
		Hair	205	13.14	31.22	8.78	65.37
		Scrapings	709	34.27	42.74	9.03	60.08
		Swab (blood)	4361	39.37	71.15	17.77	23.25
		Swab (saliva)	2688	38.28	39.51	30.02	39.62
		Swab (semen)	35	22.86	22.86	2.86	82.86
		All trace	22556	14.22	9.45	18.71	75.90
		Swab	10372	14.94	13.48	16.11	75.34
		Tapelift	12184	13.60	6.02	20.93	76.39
Cars	Steering wheel	Swab (blood)	20	60.00	60.00	25.00	35.00
		All trace	1934	12.62	4.55	21.04	76.78
		Swab	431	10.67	2.55	18.10	80.74
		Tapelift	1503	13.17	5.12	21.89	75.65
	Airbags	Swab (blood)	37	67.57	81.08	16.22	16.22
		Excised	9	33.33	66.67	22.22	44.44
		All trace	130	26.92	15.38	25.38	70.00
		Swab	8	12.50	0.00	12.50	87.50
		Tapelift	122	27.87	16.39	26.23	68.85
	Gear stick	Swab (blood)	4	50.00	100.00	0.00	25.00
		All trace	371	8.36	3.77	14.82	83.02
		Swab	113	5.31	0.00	9.73	90.27
		Tapelift	258	9.69	5.43	17.05	79.84

	All doors	Swab (blood)	69	60.87	73.91	11.59	27.54
		All trace	99	7.07	2.02	8.08	89.90
		Swab	60	8.33	1.67	8.33	90.00
		Tapelift	39	5.13	2.56	7.69	89.74
	Internal door handle	Swab (blood)	33	60.61	69.70	12.12	36.36
		All trace	61	6.56	3.28	6.56	90.16
		Swab	35	8.57	2.86	8.57	88.57
		Tapelift	26	3.85	3.85	3.85	92.31
	External door handle	Swab (blood)	20	70.00	80.00	20.00	15.00
		All trace	28	3.57	0.00	7.14	92.86
		Swab	17	0.00	0.00	0.00	100.00
		Tapelift	11	9.09	0.00	18.18	81.82
	Seatbelt strap	Swab (blood)	1	0.00	100.00	0.00	100.00
		Fabric	1	0.00	0.00	0.00	100.00
		All trace	85	4.71	3.53	9.41	88.24
		Swab	3	0.00	0.00	33.33	66.67
		Tapelift	82	4.88	3.66	8.54	89.02
	Seatbelt buckle	All trace	63	9.52	4.76	11.11	87.30
		Swab	20	5.00	10.00	0.00	90.00
		Tapelift	43	11.63	2.33	16.28	86.05
Motorcycles		Swab (blood)	4	100.00	100.00	0.00	0.00
		All trace	39	5.13	5.13	7.69	92.31
		Swab	12	0.00	0.00	0.00	100.00
		Tapelift	27	7.41	7.41	11.11	88.89
	Handlebars	Swab (blood)	-	-	-	-	-
		All trace	34	5.88	5.88	8.82	91.18
		Swab	10	0.00	0.00	0.00	100.00
		Tapelift	24	8.33	8.33	12.50	87.50
Cigarette butt		Excised (majority)	1546	40.10	53.75	31.89	27.04

Cigarette packet		Swab (blood)	5	40.00	100.00	0.00	0.00
		Tapelift	4	25.00	25.00	75.00	100.00
Cigarette lighter		All trace	110	3.64	1.82	8.18	90.00
		Swab	88	4.55	2.27	7.95	89.77
		Tapelift	22	0.00	0.00	9.09	90.91
Bindings		All	229	9.17	10.48	17.03	77.73
	Rope	Tapelift (majority)	57	3.51	14.04	22.81	70.18
	Zip/cable ties	All trace	29	13.79	13.79	6.90	82.76
		Swab	16	6.25	12.50	0.00	93.75
		Tapelift	13	23.08	15.38	15.38	69.23
	Power cords	Swab (blood)	4	25.00	50.00	25.00	75.00
		All trace	86	9.30	5.81	11.63	84.88
		Swab	45	2.22	0.00	6.67	93.33
		Tapelift	41	17.07	12.20	17.07	75.61
	Tapes	All trace	92	9.78	5.43	10.87	89.13
		Swab	58	10.34	6.90	13.79	86.21
		Tapelift	34	8.82	2.94	5.88	94.12
	Deceased scenes	Tapelift (majority)	32	3.13	28.13	37.50	59.38
Door handles (premises)		Swab (blood)	38	57.89	65.79	28.95	28.95
		All trace	252	2.78	2.78	7.14	90.87
		Swab	136	2.21	2.94	5.15	93.38
		Tapelift	116	3.45	2.59	9.48	87.93
Window frames/sills		Swab (blood)	113	48.67	76.11	14.16	18.58
		All trace	61	13.11	9.84	8.20	85.25
		Swab	38	13.16	13.16	7.89	84.21
		Tapelift	23	13.04	4.35	8.70	86.96
Flyscreen mesh		Swab (blood)	20	45.00	70.00	10.00	25.00
		Excised	1	100.00	100.00	0.00	0.00
		All trace	611	4.42	3.93	9.17	88.22

		Swab	94	0.00	2.13	4.26	94.68
		Tapelift	517	5.22	4.26	10.06	87.04
Mouth/rim of drinking vessel		All trace	2525	34.93	37.43	28.83	42.85
		Swab	2450	35.67	38.33	29.14	41.63
		Tapelift	75	10.67	8.00	18.67	82.67
Drinking straw		Excised	33	54.55	48.48	36.36	30.30
		All trace	311	47.91	45.98	29.26	38.26
		Swab	305	47.87	45.90	29.51	38.36
		Tapelift	6	50.00	50.00	16.67	33.33
Drug pipe/bong		Swab (majority)	118	28.81	11.86	35.59	56.78
Chewing gum		Whole item (majority)	16	12.50	62.50	18.75	43.75
Keys		All trace	223	4.04	1.79	12.11	87.89
		Swab	134	1.49	0.75	5.97	94.78
		Tapelift	89	7.87	3.37	21.35	77.53
	Rubber	All trace	6	0.00	16.67	0.00	100.00
		Swab	1	0.00	0.00	0.00	100.00
		Tapelift	5	0.00	20.00	20.00	100.00
	Metal	All trace	93	2.15	1.08	7.53	92.47
		Swab	68	1.47	0.00	5.88	94.12
		Tapelift	25	4.00	4.00	12.00	88.00
	Plastic	All trace	87	4.60	2.30	12.64	86.21
		Swab	41	2.44	0.00	4.88	95.12
		Tapelift	46	6.52	4.35	19.57	78.26
Cartridge cases		All trace	130	3.08	5.38	3.85	93.08
		Swab	75	2.67	1.33	1.33	97.33
		Tapelift	55	3.64	10.91	7.27	87.27
	Discharged	All trace	47	4.26	12.77	4.26	87.23
		Swab	25	4.00	4.00	0.00	96.00

		Tapelift	22	4.55	22.73	9.09	77.27
	Live	All trace	77	2.60	1.30	2.60	97.40
		Swab	46	2.17	0.00	2.17	97.83
		Tapelift	31	3.23	3.23	3.23	96.77
Firearm		Swab (blood)	8	12.50	75.00	25.00	25.00
		All trace	499	8.02	2.40	8.82	89.98
		Swab	308	7.79	2.60	9.09	90.26
		Tapelift	191	8.38	2.09	8.38	89.53
	Handle	All trace	129	8.53	2.33	10.85	88.37
		Swab	60	8.33	5.00	11.67	86.67
		Tapelift	69	8.70	0.00	10.14	89.86
	Barrel	All trace	13	0.00	7.69	7.69	92.31
		Swab	7	0.00	0.00	14.29	100.00
		Tapelift	6	0.00	16.67	0.00	83.33
	Trigger	All trace	164	7.93	3.05	7.93	89.63
		Swab	121	8.26	3.31	9.09	88.43
		Tapelift	43	6.98	2.33	4.65	93.02
Knife		Swab (blood)	218	33.49	47.25	37.16	27.52
		All trace	769	15.34	6.11	19.25	77.89
		Swab	491	13.85	6.31	18.13	78.82
		Tapelift	278	17.99	5.76	21.22	76.26
	Handle	All trace	578	15.74	3.81	19.55	79.24
		Swab	330	13.94	3.03	17.58	81.82
		Tapelift	248	18.15	4.84	22.18	75.81
	Blade	All trace	138	13.04	12.32	21.74	69.57
		Swab	132	12.88	12.88	21.21	69.70
		Tapelift	6	16.67	0.00	33.33	66.67
Gloves		Swab (blood)	8	37.50	25.00	37.50	37.50
		Excised	7	71.43	0.00	71.43	28.57

		All trace	1003	15.05	4.49	22.33	75.27
		Swab	228	7.02	3.95	13.16	85.09
		Tapelift	775	17.42	4.65	25.03	72.39
	Inside surfaces	All trace	640	14.22	4.69	23.28	74.22
	Inside surfaces	Swab	139	7.91	5.04	13.67	83.45
	Inside surfaces	Tapelift	501	15.97	4.59	25.95	71.66
Fingermarks		Swab (blood)	6	16.67	33.33	33.33	33.33
Fingermarks		All trace	67	4.48	0.00	7.46	92.54
Fingermarks		Swab	58	5.17	0.00	8.62	91.38
Fingermarks		Tapelift	9	0.00	0.00	0.00	100.00
Glovemarks		All trace	64	0.00	0.00	0.00	100.00
Glovemarks		Swab	60	0.00	0.00	0.00	100.00
Glovemarks		Tapelift	4	0.00	0.00	0.00	100.00
Sweat smears	Premises	All trace	73	5.48	4.11	2.74	95.89
Sweat smears	Premises	Swab	67	4.48	2.99	2.99	97.01
Sweat smears	Premises	Tapelift	6	16.67	16.67	0.00	83.33
Sweat smears	Cars	All trace	20	0.00	0.00	5.00	95.00
Sweat smears	Cars	Swab	18	0.00	0.00	5.56	94.44
Sweat smears	Cars	Tapelift	2	0.00	0.00	0.00	100.00
Phones	Mobile phone	Swab (blood)	19	52.63	57.89	42.11	21.05
Phones	Mobile phone	All trace	81	19.75	2.47	22.22	75.31
Phones	Mobile phone	Swab	63	15.87	0.00	22.22	77.78
Phones	Mobile phone	Tapelift	18	33.33	11.11	22.22	66.67
Phones	Public phone	Swab (blood)	2	100.00	100.00	0.00	100.00
Phones	Public phone	All trace	8	0.00	0.00	0.00	100.00
Phones	Public phone	Swab	5	0.00	0.00	0.00	100.00
Phones	Public phone	Tapelift	3	0.00	0.00	0.00	100.00
Keypad (eg., safe/alarm)		Swab (majority)	18	5.56	11.11	11.11	83.33
Computer keyboard		Swab (blood/trace)	2	50.00	50.00	0.00	50.00

Fingernails		Scrapings	357	53.50	41.46	44.26	32.21
		Clippings	47	17.02	72.34	25.53	19.15
Condom		Swab (majority)	205	50.24	17.56	49.27	46.83
Sexual assault-related		All	3428	22.35	45.92	22.58	42.68
		High vaginal	478	26.78	50.42	31.59	32.64
		Low vaginal	473	20.93	50.95	25.79	34.46
		Hymen	8	12.50	62.50	12.50	37.50
		Vaginal other	55	30.91	61.82	23.64	18.18
		Vulval	756	17.59	51.59	19.97	38.23
		Labial	158	15.19	61.39	20.25	32.28
		Perineum	12	0.00	58.33	0.00	41.67
		Perianal	319	14.73	34.17	19.75	55.17
		Anal	111	8.11	36.94	9.91	63.06
		Rectal	176	9.66	39.77	11.36	57.95
		Breast	33	39.39	9.09	42.42	66.67
		Oral	213	6.57	67.61	6.10	35.68
		Penis	320	55.63	27.19	34.06	52.19
Clothing	Collar	Swab (blood)	2	100.00	50.00	50.00	50.00
		Fabric	10	30.00	40.00	20.00	50.00
		All trace	256	24.61	5.86	31.64	66.80
		Swab	11	27.27	0.00	36.36	63.64
		Tapelift	245	24.49	6.12	31.43	66.94
	Beanie	Tapelift (majority)	65	33.85	3.08	40.00	60.00
	Balaclava	Tapelift (majority)	56	26.79	17.86	16.07	73.21
	Helmet	Swab (blood)	6	66.67	100.00	0.00	33.33
		All trace	89	25.84	4.49	31.46	67.42
		Swab	8	0.00	0.00	0.00	100.00
		Tapelift	81	28.40	4.94	34.57	64.20
	Hat/cap	Swab (blood)	27	59.26	40.74	40.74	33.33

		All trace	509	25.54	7.86	34.97	62.48
		Swab	29	13.79	3.45	20.69	75.86
		Tapelift	480	26.25	8.13	35.83	61.67
	Underwear	Excised/scraped	193	29.02	21.76	22.80	64.25
		All trace	308	25.32	14.94	43.18	49.35
		Swab	14	42.86	21.43	50.00	28.57
		Tapelift	294	24.49	14.63	42.86	50.34
	Waistband shorts/pants	Excised/scraped	12	33.33	41.67	8.33	83.33
		All trace	120	20.00	4.17	35.83	64.17
		Swab	4	50.00	0.00	50.00	50.00
		Tapelift	116	18.97	4.31	35.34	64.66
Screwdriver		All trace	498	9.24	2.41	16.06	83.13
		Swab	253	8.70	2.37	13.44	85.38
		Tapelift	245	9.80	2.45	18.78	80.82
Sledge hammer		Swab (blood)	3	0.00	66.67	0.00	66.67
		All trace	35	11.43	2.86	11.43	85.71
		Swab	10	10.00	10.00	0.00	90.00
		Tapelift	25	12.00	0.00	16.00	84.00
Hammer		Swab (blood)	17	35.29	64.71	17.65	58.82
		All trace	183	7.10	2.73	11.48	86.89
		Swab	60	5.00	3.33	10.00	86.67
		Tapelift	123	8.13	2.44	12.20	86.99
Spanner		Swab (blood)	4	25.00	100.00	0.00	0.00
		All trace	57	3.51	3.51	3.51	94.74
		Swab	32	0.00	3.13	0.00	100.00
		Tapelift	25	8.00	4.00	8.00	88.00
Chisel		All trace	30	13.33	3.33	10.00	90.00
		Swab	17	0.00	0.00	0.00	100.00
		Tapelift	13	30.77	7.69	23.08	76.92

Shovel		Swab (blood)	1	0.00	100.00	0.00	100.00
		All trace	45	13.33	2.22	11.11	86.67
		Swab	19	10.53	0.00	10.53	89.47
		Tapelift	26	15.38	3.85	11.54	84.62
Crow bar		All trace	158	5.70	3.16	6.33	93.04
		Swab	59	3.39	3.39	3.39	96.61
		Tapelift	99	7.07	3.03	8.08	90.91
Axe		Swab (blood)	1	100.00	100.00	0.00	100.00
		All trace	60	8.33	0.00	13.33	86.67
		Swab	14	0.00	0.00	7.14	92.86
		Tapelift	46	10.87	0.00	15.22	84.78
Mattock/Pickaxe		All trace	18	0.00	5.56	5.56	88.89
		Swab	5	0.00	20.00	0.00	80.00
		Tapelift	13	0.00	0.00	7.69	92.31
Torch		All trace	212	17.92	8.49	19.81	75.47
		Swab	100	16.00	12.00	15.00	80.00
		Tapelift	112	19.64	5.36	24.11	71.43
Brick/rock		All	298	6.71	8.39	6.71	87.25
	Rock	Swab (blood)	9	11.11	66.67	11.11	22.22
		All trace	143	1.40	0.70	3.50	96.50
		Swab	10	0.00	0.00	0.00	100.00
		Tapelift	133	1.50	0.75	3.76	96.24
	Brick/paver	Swab (blood)	17	35.29	76.47	5.88	23.53
		All trace	129	8.53	3.88	10.08	89.92
		Swab	13	0.00	0.00	0.00	100.00
		Tapelift	116	9.48	4.31	11.21	88.79
Clip-seal plastic bag		All trace	150	12.67	4.67	14.67	83.33
		Swab	125	12.00	4.00	13.60	84.00
		Tapelift	25	16.00	8.00	20.00	80.00

Bedding		All	968	25.72	27.79	22.62	58.68
		Excised	241	25.31	40.25	19.50	48.96
		Scraping	276	22.83	34.42	10.87	65.22
		Other	253	32.41	11.07	38.74	60.08
		Swab (blood)	56	26.79	55.36	23.21	35.71
		All trace	142	19.72	12.68	22.54	69.01
		Swab	5	0.00	40.00	20.00	60.00
		Tapelift	137	20.44	11.68	22.63	69.34
	Mattress	All	88	14.77	22.73	12.50	72.73
	Mattress protector	All	63	11.11	11.11	11.11	100.00
	Sheets	All	679	32.78	28.25	25.57	53.40
	Blanket	All	403	17.01	28.91	19.39	63.27
	Pillow	All	179	21.26	24.41	22.05	62.20

Table 3. Comparison of percentage success in DNA sampling between porous and non-porous items/surfaces from Table 2.

Surface	Collection method	Total results	Percentage suspect identification	Percentage full profile	Percentage partial/mixed profile	Percentage no DNA
Non-porous	All trace	13290	9.15	5.83	11.58	85.98
	Swab	7243	7.17	5.16	8.61	88.30
	Tapelift	6047	11.17	6.51	14.60	83.62
Porous	All trace	2000	17.57	8.09	24.74	71.02
	Swab	97	16.27	7.21	24.77	70.25
	Tapelift	1903	18.54	8.75	24.73	71.60

Table 4. Comparison of Queensland DNA profiling success data for specific items against equivalent data from the literature.

Exhibit category	Profile / Collection	This study	Netherlands[6]	Singapore[7]	Switzerland[4]	Switzerland[9]	New Zealand[3]	New South Wales[8]
		Full	Single	Single	Full/partial>5 loci	Single	Full	Full/partial>12 loci
Cigarette butt	Excised	54	84	81		70.6		
Hat/cap	Swab	3	42					
	Tapelift	8					25	
Collar	Swab	0*	34					
Glove (inside)	Swab	5	25a	11		18.8b		
	Tapelift	5					25	
Torch	Swab	12	27					
Drinking vessels	Swab	38	57	34		55.6	21c	
Knife handle	Swab	3*	19					
Lighter	Swab	2	17					
Firearm grip	Swab	5	6					
Firearms (other)	Swab	3*						15
Handle motorcycle	Swab	0*	9					
Cartridge cases	Swab	4*	6					
Tape	Swab	7	9	16				
Keys	Swab	1*	12					
Hair	Excised	31		21.1				
Drug apparatus	Swab	12		15			21c	
Thrown stones	Swab	0*			7	7.5		
Cables/power cords	Swab	0*			29	12.2		
Tools	Swab	5*d	5e	10	22			15

Clothing	Swab	8f		5		18.8b		
	Tapelift	9g					15h	
	Excised	32i						
Blood	Swab	71	68			87.5		
Dataset average	All trace	9j	25k	12		12k	16	14

*greater percentage full profiles from tapelifts where relevant
a combined here from latex & fabric glove results
b combined category clothing/gloves
c combined category drinking vessels/drug pipes
d averaged over all tools analysed in Table 2
e combined here from screwdriver/crowbar/hand-tools (other)
f averaged over hat/cap/underwear/waistband shorts/pants in Table 2
g averaged over beanie/balaclava/helmet/hat/cap/underwear/waistband shorts/pants in Table 2
h combined here from underwear/socks/upper garments results
i averaged over underwear/waistband shorts/pants in Table 2
j average profiling success for trace samples only (i.e., excludes biological fluids, hair, cigarette butts)
k included bloodstain profiling results

Archived: Thursday, 24 March 2022 12:52:19
From: Australian Journal of Forensic Sciences
Sent: Thursday, 2 April 2020 14:18:48
To: Krosch.MattN[OSC]
Subject: Australian Journal of Forensic Sciences - Decision on Manuscript ID TAJF-2020-0058
Sensitivity: Normal

02-Apr-2020

Dear Dr Krosch:

Your manuscript entitled "Variation in forensic DNA profiling success rate among sampled items and collection methods: a Queensland perspective" which you submitted to Australian Journal of Forensic Sciences, has been reviewed. The reviewer comments are included at the bottom of this letter.

The reviews are in general favourable and suggest that, subject to minor revisions, your paper could be suitable for publication. Please consider these suggestions, and I look forward to receiving your revision.

When you revise your manuscript please highlight the changes you make in the manuscript by using the track changes mode in MS Word or by using bold or coloured text.

To submit the revision, log into CTPI and enter your Author Centre, where you will find your manuscript title listed under "Manuscripts with Decisions." Under "Actions," click on "Create a Revision." Your manuscript number has been appended to denote a revision. Please enter your responses to the comments made by the reviewer(s) in the space provided. You can use this space to document any changes you made to the original manuscript. Please be as specific as possible in your response to the reviewer(s).

Alternatively, once you have revised your paper, it can be resubmitted to Australian Journal of Forensic Sciences by way of the following link:

*** PLEASE NOTE: This is a two-step process. After clicking on the link, you will be directed to a webpage to confirm. ***

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IMPORTANT: Your original files are available to you when you upload your revised manuscript. Please delete any redundant files before completing the submission.

Because we are trying to facilitate timely publication of manuscripts submitted to Australian Journal of Forensic Sciences, your revised manuscript should be uploaded as soon as possible. If it is not possible for you to submit your revision in a reasonable amount of time, we may have to consider your paper as a new submission.

Once again, thank you for submitting your manuscript to Australian Journal of Forensic Sciences and I look forward to receiving your revision.

Sincerely,
Sch4p4(6)
Sch4p4(6) Australian Journal of Forensic Sciences
Sch4p4(6)

Reviewer(s)' Comments to Author:

Reviewer: 1

Comments to the Author
This is a very well written report and the authors should be commended for the comprehensive comparison of such extensive data.
This reviewer only has a few minor points, many of which can be undertaken at the discretion of the authors.
Page 3 line 10: suggest rewriting as 'the relative successful allelic amplification from items'. This is not really a rate (although it reads well. There are a few cases where the term 'rate' is used when really it is one data set rather than a comparison or two or more data sets to create a rate).
Page 3, line 11: again suggest 'Such amplification success should be'
Page 3, line 18: suggest 'comparing data between'
Page 3, line 55: not really suggesting a change, rather a comment whether the victim profiles most likely came from a wearer?
Page 4, line 7: suggest 'successful allelic amplifications were'
Page 4, line 24: suggest adding a colon as a list follows: 'included: swabbing'
Page 4, line 27: then: Australia); excision ……..butts); and scrapping.'
Page 4, line 43: really should add a space between number and unit: 0.0088 ng (see next line as well)
Page 4, line 50: ideally should be 'Data were extracted' (I assume there is more than one datum?)
Page 4, line 57: is it worth any comment that this is 42 STR alleles? – I assume amelogenin is not included).
Page 5, line 13: 'data were included.'
Page 5, line 18: 'DNA success. Percentages'
Page 6, line 7: stating ~72% is fine but would it help if in brackets after was n=x? (se also 40% in line 11). This is in a table but just makes reading easier.
Page 6, line 40 & 45: perhaps these are two different things (seatbelt buckles line 40, and seatbelt straps & buckles) but seems confusing that swabs were more successful for line 40 and tapes more successful for line 45. Please clarify.
Page 7, line 41 (and line 58): perhaps 'granularity' is clear to the authors – is there a better term as not clear perhaps to all readers.
Page 8, line 14 & 18: just sems a little contradictory to state that data were similar in one sentence then results were poorer than that reported previously. Perhaps rephrase.
Page 8, line 23: introduced SAIK – perhaps in full or rephrase.
Table 2: this provides comprehensive data – a note really to the editor as not sure how this can be typeset and fit on one page.

Reviewer: 2

Comments to the Author
This is a very large study and equally a very useful and valuable review of success rates from trace DNA testing of casework samples. This will be of interest to other laboratories. I am impressed by the level of detail you have collated for the samples you have tested. None of my comments are major, and hopefully clarification or changes will improve your manuscript.
Abstract:
I was unable to locate the data in the tables that supported the comment- "Nevertheless trace DNA samples contributed nearly 40% of total suspect identifications (tapelifts 20.05%; swabs 18.76%)." this may also be a difficulty with your reader. Consideration of a further table with the key overall findings may assist. Or should these figures be, from Table 1: 41.63%, 24.45%, 17.18%.
Results, paragraph 1:
Referring to Table 1, it appears that tapelifts provide approximately 25% of total suspect identifications.

You currently describe this as 20%.
Also from Table 1,suspect identifications from swabs is given as approximately 17%; you currently have this as 19%.
Results, paragraph 2:
Suggest you include swabs of mobile phones in your list of no full profiles recorded, given you refer to the tapelifts of mobile phones being successful later in this same paragraph.
Results, paragraph 3:
remove seat belt buckles from the list of samples where tapelifts performed better (swabs of this sample were better). Further, did you want to include steering wheels in this list as the tapelifts performed 2x better than swabs,as too clip seal plastic bags. In this list should rocks be replaced with pavers as rocks did not perform at least 2x better as tapelfits (0.75) but pavers did (4.31).
Discussion
Paragraph 1.
Suggest the difference observed in profiling success for swabs and tapelifts from porous and non-porous is statistically assessed as it may not be significant (values are not very different). If significant then this would then provide support to your finding that these results are " opposite to conventional wisdom" or if not significant a different
wording of your conclusion would be appropriate.
Discussion, paragraph 3.
Define SAIK
Table 4:
Handle motorcycle entry is currently 3, this should be 0 in your study.

02/04/2020

Forensic Services Group
Queensland Police
Service
200 Roma Street
Brisbane, QLD, 4000

Dear Editor,

Please accept the attached manuscript as a revision of an earlier submission (TAJF-2020-0058) for consideration for publication in the *Australian Journal of Forensic Sciences*. The manuscript reports on a meta-analysis of DNA over 36,000 profiling results from Queensland for the period 22/2/18 – 11/9/19, with particular focus on trace DNA results.

The original manuscript was reviewed by two anonymous referees who provided excellent comments and picked up several minor errors. I have incorporated the majority of suggested changes into the revision (see below) and I thank the reviewers for their thorough treatment of this manuscript.

I believe that the revised manuscript is now suitable for publication.

Yours sincerely,

Dr. Matt Krosch

Research Officer
Forensic Services Group
Queensland Police Service
200 Roma Street
Brisbane, QLD, 4000

Reviewer: 1

Page 3 line 10: suggest rewriting as 'the relative successful allelic amplification from items'. This is not really a rate (although it reads well. There are a few cases where the term 'rate' is used when really it is one data set rather than a comparison or two or more data sets to create a rate).
Response: The reviewer is correct. I agonised over the use of the word rate – colloquially it is easily understood I think, but I agree that it is not a true description of the data being used. I note that there is precedent in the literature in the use of 'rate' to describe DNA profiling percentage success – see material cited in this paper. Nevertheless, I have removed the use of rate throughout and replaced with 'percentage success' or 'success statistics' where appropriate.

Page 3, line 11: again suggest 'Such amplification success should be'
Response: See above.

Page 3, line 18: suggest 'comparing data between'
Response: Not actioned.

Page 3, line 55: not really suggesting a change, rather a comment whether the victim profiles most likely came from a wearer?
Response: Added wearer in parentheses here.

Page 4, line 7: suggest 'successful allelic amplifications were'
Response: See above.

Page 4, line 24: suggest adding a colon as a list follows: 'included: swabbing'
Response: Actioned.

Page 4, line 27: then: Australia); excision ……..butts); and scrapping.'
Response: Actioned.

Page 4, line 43: really should add a space between number and unit: 0.0088 ng (see next line as well)
Response: Actioned.

Page 4, line 50: ideally should be 'Data were extracted' (I assume there is more than one datum?)
Response: Actioned.

Page 4, line 57: is it worth any comment that this is 42 STR alleles? – I assume amelogenin is not included).
Response: This is implied already as the sentence is referring to categorisation of STR profiling results.

Page 5, line 13: 'data were included.'
Response: Actioned.

Page 5, line 18: 'DNA success. Percentages'
Response: Actioned.

Page 6, line 7: stating ~72% is fine but would it help if in brackets after was n=x? (se also 40% in line 11). This is in a table but just makes reading easier.

Response: I think there are already so many numbers cited in the text that to add more will just be more cluttered and confusing. Those data are all present in tables if readers need to see sample sizes and I don't believe repeating information contained in tables assists in readability.

Page 6, line 40 & 45: perhaps these are two different things (seatbelt buckles line 40, and seatbelt straps & buckles) but seems confusing that swabs were more successful for line 40 and tapes more successful for line 45. Please clarify.
Response: Apologies, this was an error – '& buckles' has been removed.

Page 7, line 41 (and line 58): perhaps 'granularity' is clear to the authors – is there a better term as not clear perhaps to all readers.
Response: Replaced with 'resolution'.

Page 8, line 14 & 18: just sems a little contradictory to state that data were similar in one sentence then results were poorer than that reported previously. Perhaps rephrase.
Response: Apologies, this section was incomplete. It has been amended.

Page 8, line 23: introduced SAIK – perhaps in full or rephrase.
Response: This has now been removed.

Reviewer: 2

Abstract:
I was unable to locate the data in the tables that supported the comment- "Nevertheless trace DNA samples contributed nearly 40% of total suspect identifications (tapelifts 20.05%; swabs 18.76%)." this may also be a difficulty with your reader. Consideration of a further table with the key overall findings may assist. Or should these figures be, from Table 1: 41.63%, 24.45%, 17.18%.
Response: Apologies, this was a problem with version control with Table 1. The correct values have been inserted in the revised version.

Results, paragraph 1:
Referring to Table 1, it appears that tapelifts provide approximately 25% of total suspect identifications. You currently describe this as 20%.
Response: See above.

Also from Table 1,suspect identifications from swabs is given as approximately 17%; you currently have this as 19%.
Response: See above.

Results, paragraph 2:
Suggest you include swabs of mobile phones in your list of no full profiles recorded, given you refer to the tapelifts of mobile phones being successful later in this same paragraph.
Response: Actioned.

Results, paragraph 3:
remove seat belt buckles from the list of samples where tapelifts performed better (swabs of this sample were better). Further, did you want to include steering wheels in this list as the tapelifts performed 2x better than swabs,as too clip seal plastic bags. In this list should rocks be replaced with pavers as rocks did not perform at least 2x better as tapelfits (0.75) but pavers did (4.31).
Response: Actioned, except rocks are retained because tapelifts (0.75%) were more successful than swabs (0%).

Discussion
Paragraph 1.
Suggest the difference observed in profiling success for swabs and tapelifts from porous and non-porous is statistically assessed as it may not be significant (values are not very different). If significant then this would then provide support to your finding that these results are " opposite to conventional wisdom" or if not significant a different wording of your conclusion would be appropriate.
Response: I'm not inclined to perform formal statistics of this data as the comment is made as a general observation that there was no substantial difference between collection methods across two surface types. I've modified the wording to make this conclusion clearer.

Discussion, paragraph 3.
Define SAIK
Response: This has now been removed.

Table 4:
Handle motorcycle entry is currently 3, this should be 0 in your study.
Response: Actioned.

Variation in forensic DNA profiling success ~~rate~~ among sampled items and collection methods: a Queensland perspective.

Matt N. Krosch[a*]

[a]*Quality Management Section, Forensic Services Group, Queensland Police Service, 200 Roma Street, Brisbane, QLD 4000*

Corresponding author: CTPI @police.qld.gov.au, Ph +61 7 CTPI, ORCID 0000-0003-0354-8189

Field Code Changed

Variation in forensic DNA profiling success ~~rate~~ among sampled items and collection methods: a Queensland perspective.

Understanding the relative success ~~rates~~ of recovering DNA profiles from different touched evidentiary items/substrates, and between different methods of collection, is critical for optimal targeting of forensic sample collection and triaging for analysis. Further, reporting of such success ~~rates~~ statistics allows comparison between jurisdictions that can drive improvements and prompt discussion between stakeholders. This study analysed success ~~rates~~ statistics for ~~of~~ DNA sampling from major and volume crimes attended by the Queensland Police Service, Australia, from February 2018 to September 2019. In total, 36 416 total records were analysed, representing the most comprehensive analysis of its kind to date. Percentage ~~S~~successes ~~rates~~ were determined for various sample types and items, including those that are commonly encountered or have high probative value. Results suggested that, overall, around 9.5% of trace DNA samples returned full profiles, but with some disparity between swabs (13.48%) and tapelifts (6.02%). Nevertheless, trace DNA samples contributed nearly 40% of total suspect identifications (tapelifts 20.05%; swabs 18.76%). Substantial variation in profiling success among items/substrates was observed, as there was between swabs and tapelifts taken from the same item. These data contribute significantly to our understanding of DNA prevalence and recovery and provide a critical evidence base to inform changes to operational procedures.

Keywords: swabs, tapelifts, full profile, mixed profile, suspect identification

Introduction

DNA sampling, particularly of touched objects and surfaces, has become an increasing focus for forensic analysts globally[1,2]. Resolution of DNA profiles from such items can be highly probative and thus understanding the relative success ~~rates~~ of recovering profiles from items is important for targeting sample collection and triaging for analysis. Such success ~~rates~~ statistics should be considered in the context of the specific collection and analysis methods used by a given jurisdiction. Comparing data generated from different extraction and profiling methods may not necessarily represent a like-for-like comparison and must be considered with some caution. Nevertheless, there can be great value in comparing between jurisdictions to determine whether substantial differences are apparent and where improvements could be made. Moreover, sampling of putatively touched items can be a point of friction between investigators and forensic scientists who may have contrasting anecdotal experience concerning a questioned item. Finally, where jurisdictions use multiple collection methods for similar items (because of officer preference or simply what consumables are available at the time), it is important to assess whether one method outperforms another to ensure operational procedures follow best practice. Therefore, there is a need for additional data to inform decision-making and assist forensic scientists in optimally targeting sampling effort.

There have been sporadic attempts over the last twelve years to address this issue in a range of national and state jurisdictions from New Zealand[3], Switzerland[4], Canada[5], Netherlands[6], Singapore[7], and Australia[8], including a comparative analysis of experimental and casework samples from Western Switzerland[9]. These studies analysed success ~~rates~~ statistics for various types of casework samples; either those most commonly collected, restricted to volume crime cases, or other items of interest. Generally speaking, these studies were consistent in suggesting that, as expected, biological fluid traces (blood, saliva, semen) provided the greatest proportions of full profiles (up to 87.5%[9]), whereas touch samples were far less successful overall (<30%). Worn or touched items that often returned above average proportions of full profiles include hats/caps, gloves, adhesive tape, clothing, door handles and steering wheels[3-9], though in some cases these may represent victim (wearer) profiles.

This study aimed to analyse success ~~rates~~ statistics of DNA sampling from major and volume crime for the Queensland Police Service, Queensland, Australia over a period of roughly 20 months. Percentage ~~S~~successes ~~rates~~ were determined for sample types over the entire period, as well as broken down to selected items of interest, including those that are commonly encountered or have high probative value. Queensland data are then discussed in the context of previous literature.

Methods

Samples included in this analysis were collected from exhibits related to both major and volume crime between the 22nd February 2018 and 11th September 2019. Methods of collection included: swabbing with a rayon swab (Medical Wire, UK) pre-moistened with 70% ethanol;~~,~~ tapelifting with a custom 3M adhesive tape kit (Lovell Surgical Supplies, Australia);~~,~~ excision (e.g., fabric, cigarette butts);~~,~~ and scraping. All samples were processed at Queensland Health Forensic Scientific Services (QHFSS) following standard procedures: DNA extraction conducted using either the DNA IQ™ Casework Pro Kit for Maxwell®16 (Promega Corp., Melbourne, Australia) on a Maxwell® 16 MDx (Promega Corp.) or DNA Investigator Kit (Qiagen, Melbourne, Australia) on a QIASymphony (Qiagen); quantification using Quantifiler® Trio (ThermoFisher Scientific, Melbourne, Australia) on the 7500 Real Time PCR System (Applied Biosystems™, ThermoFisher Scientific), and STR amplification using PowerPlex® 21 (Promega Corp.). DNA quantification results determined progression to profiling, according to QHFSS standard procedures: samples of concentration <0.0088 ng/µL were considered to have insufficient DNA and were thus categorised as 'no DNA'. Samples that yielded sufficient DNA (>0.0088 ng/µL) proceeded to STR profiling.

Data w~~as~~ere extracted from the in-house laboratory information management system (LIMS) for all DNA samples sent for processing between the 22nd February 2018 and 11th September 2019. The LIMS was queried in such a way to return sample type (e.g., swab/tapelift) and exhibit description information, as well as STR profiling results categorised as 'full' (all 42 alleles present), 'partial/mixed' (less than 42 alleles, or more than one contributor), or 'no DNA' (insufficient DNA quantity for profiling, or unsuccessful profiling). In some cases, sample results were classified in multiple categories; for example,

full+partial/mixed profile results may indicate full suspect profiles deconvoluted from mixtures, or no DNA+full or partial/mixed where samples were amplified and genotyped more than once. Profiles were also recorded for whether they matched a suspect/offender reference sample. This master spreadsheet was queried using Windows Powershell to extract lines in which the exhibit description matched specific text strings. All resulting sub-sheets were manually reviewed to ensure only relevant data wereas included. Despite this, inconsistencies in spelling and terminology in the exhibit description limited the completeness of the analysis; however, this is unlikely to impact dramatically on the interpretation of DNA success ratesstatistics. Percentages of each profile result category were calculated for the total dataset, each collection method across all items, and then broken down for collection method from each selected item. Percentage Ssuccesses rates were also assessed for porous versus non-porous substrate surfaces. Sample metadata allowed separation of swabs from biological fluid stains (blood, saliva, semen) to be separated from those taken from putative touched areas or handled objects.

Results

In total, 36 416 total records (representing 35 722 unique exhibits) were analysed, the majority of which were swabs or tapelifts (Table 1). Swabs collected from biological fluids represented a much smaller proportion than those from touched areas/objects. Overall, 25.60% of samples returned full profiles: the greatest proportion of full profiles was obtained from samples of obvious stains of biological fluids, with the most successful being swabs of bloodstains (71.15%, Table 2). Partial/mixed profiles were rarely obtained from swabs of semen stains (2.86%), but otherwise ranged up to 30.02% of DNA results from other sample types. Percentages of suspect identifications ranged from 13.14% (hair) to 39.37% (blood swabs). Both swabs and tapelifts of touched objects/surfaces returned suspect identifications from ~14% of samples, but there was a significant disparity between full profile results (swabs = 13.48%; tapelifts = 6.02%). Despite this, tapelifts provided 20% of total suspect identifications compared with nearly 19% for trace swabs (Table 1), suggesting that the success of tapelifting is often reliant on partial profiles or deconvolution of mixtures.

Individual items/surfaces showed great variation in their percentage success (Table 2). The greatest success for exhibits where no visible stain was observed was for clippings from fingernails, which produced full profiles in ~72% of samples taken. Chewing gum, excisions from cigarette butts, bedding and waistbands of lower garments, all samples from drinking straws, and fingernail scrapings all produced full profiles in >40% of samples. The least successful items (no full profiles recorded) included swabs of rocks and pavers, helmets, mobile phones, firearm barrels, shirt collars, power cords, rubber, metal and plastic key handles, and several tools; tapelifts of cigarette lighters, firearm handles, and several tools; and both swabs and tapelifts of public phones, fingermarks, glovemarks, external car door handles, sweat smears on cars, and axe handles. Despite this, many of these items did return suspect identifications based on partial profiles (either single source or deconvoluted mixtures); including, external car door handles, shirt collars, and mobile phones. Among sexual assault-related samples, breast swabs identified the greatest percentage of suspects after penis swabs (suspect reference samples); no suspect identifications were recorded from perineum samples. The highest percentage of full profiles were reported from oral swabs (most likely complainant profiles, though 6.57% were identified a suspect), whereas the lowest proportion of full profiles were from breast swabs.

Some distinct differences in the recovery of full profiles from swabs and tapelifts of trace samples were observed for specific items. Swabs were at least twice as successful as tapelifts for seatbelt buckles, adhesive tapes, cigarette lighters, window frames/sills, drinking vessels, firearm handles, knife blades, sledgehammers, mattock/pickaxes, torches, and bedding. In contrast, tapelifts were more successful for discharged car airbags, steering wheels, gearsticks, seatbelt straps ~~& buckles~~, motorcycles (including handlebars), power cords, keys, clip seal plastic bags, cartridge cases (both discharged and live), firearm barrels, sweat smears on buildings, mobile phones, shirt collars, helmets, hats, rocks, pavers, and several tools. In contrast to conventional wisdom, tapelifts of non-porous surfaces recovered slightly more full profiles than swabs, and did so also from porous surfaces (Table 3). Furthermore, porous surfaces returned a greater percentage of full profiles and suspect identifications than non-porous surfaces.

Data caveats

A small number of samples were recorded as returning results in more than one category: 106 records were categorised as both partial/mixed and full (likely representing full profiles deconvoluted from mixtures), representing 1.4% of partial/mixed records and 1.1% of full profile results; 339 samples were categorised as both partial/mixed and no DNA, representing 1.5% of no DNA results and 4.4% of partial/mixed results; 2103 samples were categorised as both no DNA and full, representing 9.6% of no DNA results and 22.5% of full profile results; and 23 samples were categorised across all three categories. The bulk of such multiple categorisations were due to samples being reworked, either by concentrating dilute samples that initially fell below the quantification threshold to proceed to profiling, or by reamplification of partial/failed genotyping runs. In the context of the total dataset these multiple categorisations are not considered to substantially impact on the interpretation of profiling success ~~rates~~statistics. Manually reviewing every record was outside the scope of this project.

Discussion

The analysis presented here of nearly 18 months of DNA sampling data, representing more than 36 000 individual exhibits, from the Queensland Police Service has revealed some interesting patterns that can inform operational procedures. Averaged over all items/surfaces, trace swabs recovered more full profiles than tapelifts; however, there was substantial variation noted among exhibit types, including many for which tapelifts were the more successful method of collection. Increasing the ~~granularity~~ resolution of the analysis therefore provided a deeper insight into DNA profiling success ~~rates~~ among items and methods of collection. Interestingly, percentage profiling successes for swabs and tapelifts from porous and non-porous surfaces were ~~opposite~~ highly similar, in apparent contradiction of ~~to~~ conventional wisdom that swabs are more successful for non-porous surfaces whereas tapelifts are better for porous surfaces.

It is difficult to compare the data presented here with previous studies from other jurisdictions. The specifics of collection technique, consumables, DNA extraction and STR

profiling procedures and kits between organisations and over time are likely to have significant influence on profiling success. In addition, there has been variation across studies in the exhibit categorisation strategy used and hence granularity of data analysed. For example, some studies lump all clothing samples together[4,7,9], whereas others separate them into subcategories for specific clothing types[3,5,6]. Further, some studies were deliberately restricted to samples taken from volume crime scenes[8,9], whereas others either were from all crime scenes or did not specify[3-7]. This limits the ability to make truly like-for-like comparisons between studies. Nevertheless, some general trends deserve discussion.

Overall, full profile recovery from trace DNA ~~success~~ samples was ~~similar~~ slightly lower ~~for~~ in Queensland ~~as~~ than reported from other ~~for most~~ jurisdictions compared here (Table 4). Interestingly, profiling success for many items included in the comparison was also poorer than that reported from other jurisdictions, despite the current use in Queensland of a more sensitive DNA profiling kit than that used in many of these previous studies. This increased sensitivity may have resulted in increased mixed profile recovery in Queensland. ~~suggests that there were many other more successful items sampled by Queensland that made up the shortfall (possibly including SAIK swabs, for example).~~ Alternatively, ~~it~~ the observed differences could be because of different collection, storage, submission, triage or laboratory procedures in other regions, or a factor of analysing total sample data rather than smaller, selected subsets. For example, the dataset used here included both major and volume crime samples, which are treated in different ways both at collection (only one sample per volume crime occurrence is allowed to be submitted, whereas major crime samples are unlimited) and in the laboratory (major crime samples are automatically reworked, whereas volume crime samples are not). Such inconsistencies between datasets render the comparison indicative only. Nevertheless, trace DNA profile success was relatively high for items from cars (airbags, seatbelts), drinking straws, chewing gum, cartridge cases, underwear and waistbands, and bedding. The majority of comparisons with previous literature related to swabbed items (Table 4); however, tapelift sampling of many of these items in fact returned more full profiles than swabs (9 out of 19 items). Perhaps the most striking discrepancies were for swabs from hats/caps, inside of gloves, and collars compared with the results of Mapes et al[6]. Within the Queensland data, clear differences in profiling success were

observed between collection methods which will contribute toward updated operational procedures.

These data provide valuable insight into DNA profiling success of one of Australia's largest police jurisdictions. Additional research is required to determine whether differences between Queensland and other published data stem from consumables used, collection technique, environmental effects (e.g., increased degradation), or some other factor. Some recent work has suggested that rayon swabs are not ideal for recovering maximum DNA from collected samples[10], although this appears to contradict other research that supports rayon as among the most effective swab materials[11,12]. Additional research is still required here to inform better consumables choice for forensic practitioners. Pleasingly, there is good support in the data presented here for the efficacy of forensic tapelifts, particularly in preference to swabs for many non-porous items. This accords with existing literature that supports tapelifting as a highly effective collection method[13,14], including for the specific tape product used by QPS forensic officers[15]. Future research and reporting by other agencies into their success ~~rates~~ statistics would benefit from a consistent approach to item and profile success categorisation, to maximise comparability between studies. This study demonstrates that increasing the granularity of data captured can reveal important trends that can inform best practice at the crime scene and laboratory.

Acknowledgements:

The author would like to thank Inspectors David Keatinge and David Neville (QPS), and Allison Lloyd and Cathie Allen (QHFSS) for their review of the manuscript and valuable comments and discussion. Tim Middleton (QPS) assisted extraction of DNA results from the LIMS.

Disclosure Statement:

The author declares no conflict of interest.

References

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Tables

Table 1. Number of records included for analysis separated into major sample types (minor sample types or those not subsequently analysed are not shown). Percentages of total records, suspect identifications, full or partial/mixed profiles, and no DNA records provided for each sample type.

Sample type	Number of exhibit records	Percentage of total records	Percentage of total suspect identifications (N=8263)	Percentage of total full profiles (N=9323)	Percentage of total partial/mixed profiles (N=7698)	Percent total no (N=21
Cigarette butts	15462633	4.254.29	7.507.46	8.919.16	6.406.31	1.91
Fabric	10501865	2.883.04	4.444.56	4.345.00	3.383.83	2.37
Hair	205289	0.560.47	0.330.27	0.690.52	0.230.21	0.61
Scraping	709922	1.951.50	2.942.28	3.252.34	0.830.82	1.94
Swab (blood)	436172 48	11.9811.82	20.7821.10	33.2833.81	10.079.05	4.63
Swab (saliva)	26884769	7.387.77	12.4512.93	11.3912.17	10.4810.46	4.86
Swab (semen)	3551	0.100.08	0.100.10	0.090.09	0.010.01	0.13
Swab (trace)	10372 16518	28.4826.93	18.7617.18	15.0014.01	21.7120.24	35.65
Tapelift	12184 22576	33.4636.76	20.0524.45	7.879.97	33.1338.40	42.46
All trace	22556 39067	61.9463.69	38.8141.63	22.8723.99	54.8358.64	78.11

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Table 2. DNA profiling results for samples collected by QPS forensic officers between 22 February 2018 and 11 September 2019.

Item		Collection method	Total results	Percentage suspect identification	Percentage full profile	Percentage partial/mixed profile	Percentage no DNA
	All	All	36416	22.69	25.60	21.14	60.19
		Fabric	1050	34.95	38.57	24.76	49.43
		Hair	205	13.14	31.22	8.78	65.37
		Scrapings	709	34.27	42.74	9.03	60.08
		Swab (blood)	4361	39.37	71.15	17.77	23.25
		Swab (saliva)	2688	38.28	39.51	30.02	39.62
		Swab (semen)	35	22.86	22.86	2.86	82.86
		All trace	22556	14.22	9.45	18.71	75.90
		Swab	10372	14.94	13.48	16.11	75.34
		Tapelift	12184	13.60	6.02	20.93	76.39
Cars	Steering wheel	Swab (blood)	20	60.00	60.00	25.00	35.00
		All trace	1934	12.62	4.55	21.04	76.78
		Swab	431	10.67	2.55	18.10	80.74
		Tapelift	1503	13.17	5.12	21.89	75.65
	Airbags	Swab (blood)	37	67.57	81.08	16.22	16.22
		Excised	9	33.33	66.67	22.22	44.44
		All trace	130	26.92	15.38	25.38	70.00
		Swab	8	12.50	0.00	12.50	87.50
		Tapelift	122	27.87	16.39	26.23	68.85
	Gear stick	Swab (blood)	4	50.00	100.00	0.00	25.00
		All trace	371	8.36	3.77	14.82	83.02
		Swab	113	5.31	0.00	9.73	90.27
		Tapelift	258	9.69	5.43	17.05	79.84

	All doors	Swab (blood)	69	60.87	73.91	11.59	27.54
		All trace	99	7.07	2.02	8.08	89.90
		Swab	60	8.33	1.67	8.33	90.00
		Tapelift	39	5.13	2.56	7.69	89.74
	Internal door handle	Swab (blood)	33	60.61	69.70	12.12	36.36
		All trace	61	6.56	3.28	6.56	90.16
		Swab	35	8.57	2.86	8.57	88.57
		Tapelift	26	3.85	3.85	3.85	92.31
	External door handle	Swab (blood)	20	70.00	80.00	20.00	15.00
		All trace	28	3.57	0.00	7.14	92.86
		Swab	17	0.00	0.00	0.00	100.00
		Tapelift	11	9.09	0.00	18.18	81.82
	Seatbelt strap	Swab (blood)	1	0.00	100.00	0.00	100.00
		Fabric	1	0.00	0.00	0.00	100.00
		All trace	85	4.71	3.53	9.41	88.24
		Swab	3	0.00	0.00	33.33	66.67
		Tapelift	82	4.88	3.66	8.54	89.02
	Seatbelt buckle	All trace	63	9.52	4.76	11.11	87.30
		Swab	20	5.00	10.00	0.00	90.00
		Tapelift	43	11.63	2.33	16.28	86.05
Motorcycles		Swab (blood)	4	100.00	100.00	0.00	0.00
		All trace	39	5.13	5.13	7.69	92.31
		Swab	12	0.00	0.00	0.00	100.00
		Tapelift	27	7.41	7.41	11.11	88.89
	Handlebars	Swab (blood)	-	-	-	-	-
		All trace	34	5.88	5.88	8.82	91.18
		Swab	10	0.00	0.00	0.00	100.00
		Tapelift	24	8.33	8.33	12.50	87.50
Cigarette butt		Excised (majority)	1546	40.10	53.75	31.89	27.04

Cigarette packet		Swab (blood)	5	40.00	100.00	0.00	0.00
		Tapelift	4	25.00	25.00	75.00	100.00
Cigarette lighter		All trace	110	3.64	1.82	8.18	90.00
		Swab	88	4.55	2.27	7.95	89.77
		Tapelift	22	0.00	0.00	9.09	90.91
Bindings		All	229	9.17	10.48	17.03	77.73
	Rope	Tapelift (majority)	57	3.51	14.04	22.81	70.18
	Zip/cable ties	All trace	29	13.79	13.79	6.90	82.76
		Swab	16	6.25	12.50	0.00	93.75
		Tapelift	13	23.08	15.38	15.38	69.23
	Power cords	Swab (blood)	4	25.00	50.00	25.00	75.00
		All trace	86	9.30	5.81	11.63	84.88
		Swab	45	2.22	0.00	6.67	93.33
		Tapelift	41	17.07	12.20	17.07	75.61
	Tapes	All trace	92	9.78	5.43	10.87	89.13
		Swab	58	10.34	6.90	13.79	86.21
		Tapelift	34	8.82	2.94	5.88	94.12
	Deceased scenes	Tapelift (majority)	32	3.13	28.13	37.50	59.38
Door handles (premises)		Swab (blood)	38	57.89	65.79	28.95	28.95
		All trace	252	2.78	2.78	7.14	90.87
		Swab	136	2.21	2.94	5.15	93.38
		Tapelift	116	3.45	2.59	9.48	87.93
Window frames/sills		Swab (blood)	113	48.67	76.11	14.16	18.58
		All trace	61	13.11	9.84	8.20	85.25
		Swab	38	13.16	13.16	7.89	84.21
		Tapelift	23	13.04	4.35	8.70	86.96
Flyscreen mesh		Swab (blood)	20	45.00	70.00	10.00	25.00
		Excised	1	100.00	100.00	0.00	0.00
		All trace	611	4.42	3.93	9.17	88.22

		Swab	94	0.00	2.13	4.26	94.68
		Tapelift	517	5.22	4.26	10.06	87.04
Mouth/rim of drinking vessel		All trace	2525	34.93	37.43	28.83	42.85
		Swab	2450	35.67	38.33	29.14	41.63
		Tapelift	75	10.67	8.00	18.67	82.67
Drinking straw		Excised	33	54.55	48.48	36.36	30.30
		All trace	311	47.91	45.98	29.26	38.26
		Swab	305	47.87	45.90	29.51	38.36
		Tapelift	6	50.00	50.00	16.67	33.33
Drug pipe/bong		Swab (majority)	118	28.81	11.86	35.59	56.78
Chewing gum		Whole item (majority)	16	12.50	62.50	18.75	43.75
Keys		All trace	223	4.04	1.79	12.11	87.89
		Swab	134	1.49	0.75	5.97	94.78
		Tapelift	89	7.87	3.37	21.35	77.53
	Rubber	All trace	6	0.00	16.67	0.00	100.00
		Swab	1	0.00	0.00	0.00	100.00
		Tapelift	5	0.00	20.00	20.00	100.00
	Metal	All trace	93	2.15	1.08	7.53	92.47
		Swab	68	1.47	0.00	5.88	94.12
		Tapelift	25	4.00	4.00	12.00	88.00
	Plastic	All trace	87	4.60	2.30	12.64	86.21
		Swab	41	2.44	0.00	4.88	95.12
		Tapelift	46	6.52	4.35	19.57	78.26
Cartridge cases		All trace	130	3.08	5.38	3.85	93.08
		Swab	75	2.67	1.33	1.33	97.33
		Tapelift	55	3.64	10.91	7.27	87.27
	Discharged	All trace	47	4.26	12.77	4.26	87.23
		Swab	25	4.00	4.00	0.00	96.00

		Tapelift	22	4.55	22.73	9.09	77.27
	Live	All trace	77	2.60	1.30	2.60	97.40
		Swab	46	2.17	0.00	2.17	97.83
		Tapelift	31	3.23	3.23	3.23	96.77
Firearm		Swab (blood)	8	12.50	75.00	25.00	25.00
		All trace	499	8.02	2.40	8.82	89.98
		Swab	308	7.79	2.60	9.09	90.26
		Tapelift	191	8.38	2.09	8.38	89.53
	Handle	All trace	129	8.53	2.33	10.85	88.37
		Swab	60	8.33	5.00	11.67	86.67
		Tapelift	69	8.70	0.00	10.14	89.86
	Barrel	All trace	13	0.00	7.69	7.69	92.31
		Swab	7	0.00	0.00	14.29	100.00
		Tapelift	6	0.00	16.67	0.00	83.33
	Trigger	All trace	164	7.93	3.05	7.93	89.63
		Swab	121	8.26	3.31	9.09	88.43
		Tapelift	43	6.98	2.33	4.65	93.02
Knife		Swab (blood)	218	33.49	47.25	37.16	27.52
		All trace	769	15.34	6.11	19.25	77.89
		Swab	491	13.85	6.31	18.13	78.82
		Tapelift	278	17.99	5.76	21.22	76.26
	Handle	All trace	578	15.74	3.81	19.55	79.24
		Swab	330	13.94	3.03	17.58	81.82
		Tapelift	248	18.15	4.84	22.18	75.81
	Blade	All trace	138	13.04	12.32	21.74	69.57
		Swab	132	12.88	12.88	21.21	69.70
		Tapelift	6	16.67	0.00	33.33	66.67
Gloves		Swab (blood)	8	37.50	25.00	37.50	37.50
		Excised	7	71.43	0.00	71.43	28.57

		All trace	1003	15.05	4.49	22.33	75.27
		Swab	228	7.02	3.95	13.16	85.09
		Tapelift	775	17.42	4.65	25.03	72.39
	Inside surfaces	All trace	640	14.22	4.69	23.28	74.22
		Swab	139	7.91	5.04	13.67	83.45
		Tapelift	501	15.97	4.59	25.95	71.66
Fingermarks		Swab (blood)	6	16.67	33.33	33.33	33.33
		All trace	67	4.48	0.00	7.46	92.54
		Swab	58	5.17	0.00	8.62	91.38
		Tapelift	9	0.00	0.00	0.00	100.00
Glovemarks		All trace	64	0.00	0.00	0.00	100.00
		Swab	60	0.00	0.00	0.00	100.00
		Tapelift	4	0.00	0.00	0.00	100.00
Sweat smears	Premises	All trace	73	5.48	4.11	2.74	95.89
		Swab	67	4.48	2.99	2.99	97.01
		Tapelift	6	16.67	16.67	0.00	83.33
	Cars	All trace	20	0.00	0.00	5.00	95.00
		Swab	18	0.00	0.00	5.56	94.44
		Tapelift	2	0.00	0.00	0.00	100.00
Phones	Mobile phone	Swab (blood)	19	52.63	57.89	42.11	21.05
		All trace	81	19.75	2.47	22.22	75.31
		Swab	63	15.87	0.00	22.22	77.78
		Tapelift	18	33.33	11.11	22.22	66.67
	Public phone	Swab (blood)	2	100.00	100.00	0.00	100.00
		All trace	8	0.00	0.00	0.00	100.00
		Swab	5	0.00	0.00	0.00	100.00
		Tapelift	3	0.00	0.00	0.00	100.00
Keypad (eg., safe/alarm)		Swab (majority)	18	5.56	11.11	11.11	83.33
Computer keyboard		Swab (blood/trace)	2	50.00	50.00	0.00	50.00

Fingernails		Scrapings	357	53.50	41.46	44.26	32.21
		Clippings	47	17.02	72.34	25.53	19.15
Condom		Swab (majority)	205	50.24	17.56	49.27	46.83
Sexual assault-related		All	3428	22.35	45.92	22.58	42.68
		High vaginal	478	26.78	50.42	31.59	32.64
		Low vaginal	473	20.93	50.95	25.79	34.46
		Hymen	8	12.50	62.50	12.50	37.50
		Vaginal other	55	30.91	61.82	23.64	18.18
		Vulval	756	17.59	51.59	19.97	38.23
		Labial	158	15.19	61.39	20.25	32.28
		Perineum	12	0.00	58.33	0.00	41.67
		Perianal	319	14.73	34.17	19.75	55.17
		Anal	111	8.11	36.94	9.91	63.06
		Rectal	176	9.66	39.77	11.36	57.95
		Breast	33	39.39	9.09	42.42	66.67
		Oral	213	6.57	67.61	6.10	35.68
		Penis	320	55.63	27.19	34.06	52.19
Clothing	Collar	Swab (blood)	2	100.00	50.00	50.00	50.00
		Fabric	10	30.00	40.00	20.00	50.00
		All trace	256	24.61	5.86	31.64	66.80
		Swab	11	27.27	0.00	36.36	63.64
		Tapelift	245	24.49	6.12	31.43	66.94
	Beanie	Tapelift (majority)	65	33.85	3.08	40.00	60.00
	Balaclava	Tapelift (majority)	56	26.79	17.86	16.07	73.21
	Helmet	Swab (blood)	6	66.67	100.00	0.00	33.33
		All trace	89	25.84	4.49	31.46	67.42
		Swab	8	0.00	0.00	0.00	100.00
		Tapelift	81	28.40	4.94	34.57	64.20
	Hat/cap	Swab (blood)	27	59.26	40.74	40.74	33.33

		All trace	509	25.54	7.86	34.97	62.48
		Swab	29	13.79	3.45	20.69	75.86
		Tapelift	480	26.25	8.13	35.83	61.67
	Underwear	Excised/scraped	193	29.02	21.76	22.80	64.25
		All trace	308	25.32	14.94	43.18	49.35
		Swab	14	42.86	21.43	50.00	28.57
		Tapelift	294	24.49	14.63	42.86	50.34
	Waistband shorts/pants	Excised/scraped	12	33.33	41.67	8.33	83.33
		All trace	120	20.00	4.17	35.83	64.17
		Swab	4	50.00	0.00	50.00	50.00
		Tapelift	116	18.97	4.31	35.34	64.66
Screwdriver		All trace	498	9.24	2.41	16.06	83.13
		Swab	253	8.70	2.37	13.44	85.38
		Tapelift	245	9.80	2.45	18.78	80.82
Sledge hammer		Swab (blood)	3	0.00	66.67	0.00	66.67
		All trace	35	11.43	2.86	11.43	85.71
		Swab	10	10.00	10.00	0.00	90.00
		Tapelift	25	12.00	0.00	16.00	84.00
Hammer		Swab (blood)	17	35.29	64.71	17.65	58.82
		All trace	183	7.10	2.73	11.48	86.89
		Swab	60	5.00	3.33	10.00	86.67
		Tapelift	123	8.13	2.44	12.20	86.99
Spanner		Swab (blood)	4	25.00	100.00	0.00	0.00
		All trace	57	3.51	3.51	3.51	94.74
		Swab	32	0.00	3.13	0.00	100.00
		Tapelift	25	8.00	4.00	8.00	88.00
Chisel		All trace	30	13.33	3.33	10.00	90.00
		Swab	17	0.00	0.00	0.00	100.00
		Tapelift	13	30.77	7.69	23.08	76.92

Shovel		Swab (blood)	1	0.00	100.00	0.00	100.00
		All trace	45	13.33	2.22	11.11	86.67
		Swab	19	10.53	0.00	10.53	89.47
		Tapelift	26	15.38	3.85	11.54	84.62
Crow bar		All trace	158	5.70	3.16	6.33	93.04
		Swab	59	3.39	3.39	3.39	96.61
		Tapelift	99	7.07	3.03	8.08	90.91
Axe		Swab (blood)	1	100.00	100.00	0.00	100.00
		All trace	60	8.33	0.00	13.33	86.67
		Swab	14	0.00	0.00	7.14	92.86
		Tapelift	46	10.87	0.00	15.22	84.78
Mattock/Pickaxe		All trace	18	0.00	5.56	5.56	88.89
		Swab	5	0.00	20.00	0.00	80.00
		Tapelift	13	0.00	0.00	7.69	92.31
Torch		All trace	212	17.92	8.49	19.81	75.47
		Swab	100	16.00	12.00	15.00	80.00
		Tapelift	112	19.64	5.36	24.11	71.43
Brick/rock		All	298	6.71	8.39	6.71	87.25
	Rock	Swab (blood)	9	11.11	66.67	11.11	22.22
		All trace	143	1.40	0.70	3.50	96.50
		Swab	10	0.00	0.00	0.00	100.00
		Tapelift	133	1.50	0.75	3.76	96.24
	Brick/paver	Swab (blood)	17	35.29	76.47	5.88	23.53
		All trace	129	8.53	3.88	10.08	89.92
		Swab	13	0.00	0.00	0.00	100.00
		Tapelift	116	9.48	4.31	11.21	88.79
Clip-seal plastic bag		All trace	150	12.67	4.67	14.67	83.33
		Swab	125	12.00	4.00	13.60	84.00
		Tapelift	25	16.00	8.00	20.00	80.00

Bedding		All	968	25.72	27.79	22.62	58.68
		Excised	241	25.31	40.25	19.50	48.96
		Scraping	276	22.83	34.42	10.87	65.22
		Other	253	32.41	11.07	38.74	60.08
		Swab (blood)	56	26.79	55.36	23.21	35.71
		All trace	142	19.72	12.68	22.54	69.01
		Swab	5	0.00	40.00	20.00	60.00
		Tapelift	137	20.44	11.68	22.63	69.34
	Mattress	All	88	14.77	22.73	12.50	72.73
	Mattress protector	All	63	11.11	11.11	11.11	100.00
	Sheets	All	679	32.78	28.25	25.57	53.40
	Blanket	All	403	17.01	28.91	19.39	63.27
	Pillow	All	179	21.26	24.41	22.05	62.20

Table 3. Comparison of percentage success in DNA sampling between porous and non-porous items/surfaces from Table 2.

Surface	Collection method	Total results	Percentage suspect identification	Percentage full profile	Percentage partial/mixed profile	Percentage no DNA
Non-porous	All trace	13290	9.15	5.83	11.58	85.98
	Swab	7243	7.17	5.16	8.61	88.30
	Tapelift	6047	11.17	6.51	14.60	83.62
Porous	All trace	2000	17.57	8.09	24.74	71.02
	Swab	97	16.27	7.21	24.77	70.25
	Tapelift	1903	18.54	8.75	24.73	71.60

Table 4. Comparison of Queensland DNA profiling success data for specific items against equivalent data from the literature.

Exhibit category		This study	Netherlands[6]	Singapore[7]	Switzerland[4]	Switzerland[9]	New Zealand[3]	New South Wales[8]
	Profile / Collection	Full	Single	Single	Full/partial>5 loci	Single	Full	Full/partial>12 loci
Cigarette butt	Excised	54	84	81		70.6		
Hat/cap	Swab	3	42					
	Tapelift	8					25	
Collar	Swab	0*	34					
Glove (inside)	Swab	5	25a	11		18.8b		
	Tapelift	5					25	
Torch	Swab	12	27					
Drinking vessels	Swab	38	57	34		55.6	21c	
Knife handle	Swab	3*	19					
Lighter	Swab	2	17					
Firearm grip	Swab	5	6					
Firearms (other)	Swab	3*						15
Handle motorcycle	Swab	~~30~~0*	9					
Cartridge cases	Swab	4*	6					
Tape	Swab	7	9	16				
Keys	Swab	1*	12					
Hair	Excised	31		21.1				
Drug apparatus	Swab	12		15			21c	
Thrown stones	Swab	0*			7	7.5		
Cables/power cords	Swab	0*			29	12.2		
Tools	Swab	5*d	5e	10	22			15

Clothing	Swab	8f		5	18.8b		
	Tapelift	9g				15h	
	Excised	32i					
Blood	Swab	71	68		87.5		
Dataset average	All trace	9j	25k	12	12k	16	14

*greater percentage full profiles from tapelifts where relevant
a combined here from latex & fabric glove results
b combined category clothing/gloves
c combined category drinking vessels/drug pipes
d averaged over all tools analysed in Table 2
e combined here from screwdriver/crowbar/hand-tools (other)
f averaged over hat/cap/underwear/waistband shorts/pants in Table 2
g averaged over beanie/balaclava/helmet/hat/cap/underwear/waistband shorts/pants in Table 2
h combined here from underwear/socks/upper garments results
i averaged over underwear/waistband shorts/pants in Table 2
j average profiling success for trace samples only (i.e., excludes biological fluids, hair, cigarette butts)
k included bloodstain profiling results

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Reviewer: 1

Page 3 line 10: suggest rewriting as 'the relative successful allelic amplification from items'. This is not really a rate (although it reads well. There are a few cases where the term 'rate' is used when really it is one data set rather than a comparison or two or more data sets to create a rate).
Response: The reviewer is correct. I agonised over the use of the word rate – colloquially it is easily understood I think, but I agree that it is not a true description of the data being used. I note that there is precedent in the literature in the use of 'rate' to describe DNA profiling percentage success – see material cited in this paper. Nevertheless, I have removed the use of rate throughout and replaced with 'percentage success' or 'success statistics' where appropriate.

Page 3, line 11: again suggest 'Such amplification success should be'
Response: See above.

Page 3, line 18: suggest 'comparing data between'
Response: Not actioned.

Page 3, line 55: not really suggesting a change, rather a comment whether the victim profiles most likely came from a wearer?
Response: Added wearer in parentheses here.

Page 4, line 7: suggest 'successful allelic amplifications were'
Response: See above.

Page 4, line 24: suggest adding a colon as a list follows: 'included: swabbing'
Response: Actioned.

Page 4, line 27: then: Australia); excision ……..butts); and scrapping.'
Response: Actioned.

Page 4, line 43: really should add a space between number and unit: 0.0088 ng (see next line as well)
Response: Actioned.

Page 4, line 50: ideally should be 'Data were extracted' (I assume there is more than one datum?)
Response: Actioned.

Page 4, line 57: is it worth any comment that this is 42 STR alleles? – I assume amelogenin is not included).
Response: This is implied already as the sentence is referring to categorisation of STR profiling results.

Page 5, line 13: 'data were included.'
Response: Actioned.

Page 5, line 18: 'DNA success. Percentages'
Response: Actioned.

Page 6, line 7: stating ~72% is fine but would it help if in brackets after was n=x? (se also 40% in line 11). This is in a table but just makes reading easier.

Response: I think there are already so many numbers cited in the text that to add more will just be more cluttered and confusing. Those data are all present in tables if readers need to see sample sizes and I don't believe repeating information contained in tables assists in readability.

Page 6, line 40 & 45: perhaps these are two different things (seatbelt buckles line 40, and seatbelt straps & buckles) but seems confusing that swabs were more successful for line 40 and tapes more successful for line 45. Please clarify.
Response: Apologies, this was an error – '& buckles' has been removed.

Page 7, line 41 (and line 58): perhaps 'granularity' is clear to the authors – is there a better term as not clear perhaps to all readers.
Response: Replaced with 'resolution'.

Page 8, line 14 & 18: just sems a little contradictory to state that data were similar in one sentence then results were poorer than that reported previously. Perhaps rephrase.
Response: Apologies, this section was incomplete. It has been amended.

Page 8, line 23: introduced SAIK – perhaps in full or rephrase.
Response: This has now been removed.

Reviewer: 2

Abstract:
I was unable to locate the data in the tables that supported the comment- "Nevertheless trace DNA samples contributed nearly 40% of total suspect identifications (tapelifts 20.05%; swabs 18.76%)." this may also be a difficulty with your reader. Consideration of a further table with the key overall findings may assist. Or should these figures be, from Table 1: 41.63%, 24.45%, 17.18%.
Response: Apologies, this was a problem with version control with Table 1. The correct values have been inserted in the revised version.

Results, paragraph 1:
Referring to Table 1, it appears that tapelifts provide approximately 25% of total suspect identifications. You currently describe this as 20%.
Response: See above.

Also from Table 1,suspect identifications from swabs is given as approximately 17%; you currently have this as 19%.
Response: See above.

Results, paragraph 2:
Suggest you include swabs of mobile phones in your list of no full profiles recorded, given you refer to the tapelifts of mobile phones being successful later in this same paragraph.
Response: Actioned.

Results, paragraph 3:
remove seat belt buckles from the list of samples where tapelifts performed better (swabs of this sample were better). Further, did you want to include steering wheels in this list as the tapelifts performed 2x better than swabs,as too clip seal plastic bags. In this list should rocks be replaced with pavers as rocks did not perform at least 2x better as tapelfits (0.75) but pavers did (4.31).
Response: Actioned, except rocks are retained because tapelifts (0.75%) were more successful than swabs (0%).

Discussion
Paragraph 1.
Suggest the difference observed in profiling success for swabs and tapelifts from porous and non-porous is statistically assessed as it may not be significant (values are not very different). If significant then this would then provide support to your finding that these results are " opposite to conventional wisdom" or if not significant a different wording of your conclusion would be appropriate.
Response: I'm not inclined to perform formal statistics of this data as the comment is made as a general observation that there was no substantial difference between collection methods across two surface types. I've modified the wording to make this conclusion clearer.

Discussion, paragraph 3.
Define SAIK
Response: This has now been removed.

Table 4:
Handle motorcycle entry is currently 3, this should be 0 in your study.
Response: Actioned.

Archived: Thursday, 24 March 2022 12:53:09
From: Australian Journal of Forensic Sciences
Sent: Tuesday, 7 April 2020 15:48:58
To: Krosch.MattN[OSC]
Subject: Australian Journal of Forensic Sciences - Decision on Manuscript ID TAJF-2020-0058.R1
Sensitivity: Normal

07-Apr-2020

Dear Dr Krosch:

Ref: Variation in forensic DNA profiling success among sampled items and collection methods: a Queensland perspective

Our referees have now considered your paper and have recommended publication in Australian Journal of Forensic Sciences. We are pleased to accept your paper in its current form which will now be forwarded to the publisher for copy editing and typesetting. The reviewer comments are included at the bottom of this letter.

You will receive proofs for checking, and instructions for transfer of copyright in due course.

The publisher also requests that proofs are checked and returned within 48 hours of receipt.

Thank you for your contribution to Australian Journal of Forensic Sciences and we look forward to receiving further submissions from you.

Sincerely,
Sch4p4(6)
Sch4p4(6) Australian Journal of Forensic Sciences
Sch4p4(6)

Reviewer(s)' Comments to Author:

Archived: Thursday, 24 March 2022 13:13:59
From: Sch4p4(6)
Sent: Thursday, 16 December 2021 11:09:51
To: Krosch.MattN[OSC]
Cc: Neville.DavidH[OSC]
Subject: Re: Some Further Analysis from your Paper
Sensitivity: Normal

Hi Matt,

Thank you for your response and clarifying the sexual assault samples. I understand your comments about not using the data to make comment about the lab's efficiency, and will respect your position on that. There are some very interesting results in there that may indicate there are issues in the lab though. The breast, oral and penis swabs are essentially clinical samples (taken from either the victim or offender by a GMO). To get such high amounts of 'no DNA' from those swabs is a concern (eg 52% of penis swabs getting no DNA, when you would expect to always at least get the donor).

Sch4p4(6)

Sch4p4(6)

From: Krosch.MattN[OSC] CTPI @police.qld.gov.au>
Sent: Thursday, December 16, 2021 9:14 AM
To: Sch4p4(6)
Cc: Neville.DavidH[OSC] CTPI @police.qld.gov.au>
Subject: RE: Some Further Analysis from your Paper

Dear Sch4p4(6),

Thank you for your inquiry. Regarding your specific questions, sexual assault sample results included both fractions (where relevant), and I am not sure about AP/microscopy results for the semen swabs. More broadly, however, the purpose of the paper was to provide some insight for crime scene examiners about the likelihood of generating a useable profile from a particular sample type based on the substrate and collection technique and thereby inform their decision-making at the point of collection. The study was not designed to evaluate the efficacy of the testing laboratory and it would be inappropriate to use the data for that purpose. Any attempt to do so would be significantly flawed. There are numerous caveats around these data and the appropriateness or otherwise of comparing these with previous studies, many of which are discussed in the paper. It would not be appropriate for me to comment more broadly on these matters.

Kind regards,
Matt

Dr Matt Krosch
Research Officer
Quality Management Section
Forensic Services Group
Operation Support Command
Queensland Police Service
CTPI Mobile: Sch4p4(6)
CTPI @police.qld.gov.au

Members of QMS will at times be working from home during the COVID-19 crisis. If my office phone goes unanswered, please call me on the mobile above if you need to speak with me.

From: Sch4p4(6)
Sent: Monday, 13 December 2021 11:00
To: Krosch.MattN[OSC] CTPI @police.qld.gov.au>
Subject: Some Further Analysis from your Paper

Hi Matt,

I did some further analysis from the data in your paper. Rather than doing the comparison on full profiles or single profiles, which may not include information gained from mixtures from the more sensitive PP21 kit as you have suggested, I did the comparison on 'no DNA' profiles. I used the same papers for the comparison, but some of the categories either dropped out or new ones were included depending on how sure I could be of the results (see attached), so it won't be the same as your Table 4.

Does this look right to you? There appears to be a large difference between the proportion of 'no DNA' from Qld compared to all other studies. There aren't any categories where Qld are getting better results, and Qld appear to be using the more sensitive kit, which you would think would decrease the 'no DNA' results.

Best wishes

Sch4p4(6)