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1 **The effects of various household cleaning methods on DNA persistence on**
2 **mugs and knives**

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9 **Abstract**

10 With the prevalence of forensic science in popular media, offenders are becoming
11 more forensically aware and can employ precautionary methods, such as cleaning
12 used items or rubbing away fingermarks, to reduce their traces left at a crime scene.
13 This study examined the effects of various cleaning methods on DNA persistence on
14 commonly encountered casework exhibits, specifically knives and mugs. Aliquots of
15 acellular DNA were added to the knife handles or mug rims, allowed to dry, and then
16 the substrates were either sampled directly or were cleaned and then sampled. The
17 plastic- and wood-handled knives were cleaned with a cloth in a sink of water, diluted
18 dish washing liquid or diluted household bleach, whereas the ceramic, glass and steel
19 mugs were cleaned with a dry or wet cloth, or by wiping with a cloth after applying a
20 cleaning product (dish washing liquid or household bleach spray) directly into the mug
21 and then rinsing it with water. DNA samples were collected with wet and dry swabs, in
22 triplicate, and extracted and quantified. In both experiments, DNA was not detected
23 on items after cleaning with dish washing liquid or household bleach, irrespective of
24 the differences in amounts of DNA initially deposited, substrates, and cleaning
25 methods. Even without a cleaning product, rubbing with a dry cloth decreased DNA
26 recovery from the mugs, regardless of the mug substrate. These results contribute to
27 our understanding of the impact of various cleaning methods on DNA recovery at the
28 crime scene and will help inform DNA recovery strategies.
29

30 **Keywords**

31 Trace DNA; DNA persistence; Cleaning; DNA-TPPR
32

33 **1. Introduction**

34 With the prevalence of forensic science in popular media, offenders are becoming
35 more forensically aware and can employ precautionary methods to reduce their traces
36 left at a crime scene. Not limited to DNA evidence, perpetrators can remove traces
37 through various ways such as through fires [1], use of bleach [2], painting over stains
38 [3] or rubbing away of fingermarks. Washing of body fluid stained clothes has also
39 been shown to reduce DNA persistence to varying degrees (as reviewed by van
40 Oorschot *et al.* 2019 [4]) and rubbing an item during cleaning can transfer DNA to
41 other parts of the item [5]. Here, we investigate the effects of various cleaning methods
42 on DNA persistence on commonly encountered casework exhibits, specifically knives
43 and mugs.

44

45 **2. Materials and Methods**

46 Kitchen knives with plastic (n=12) and lacquered wooden (n=12) handles, and single-
47 handled 300 ml mugs made of glass (n=15), ceramic (n=15) and stainless steel (n=15)
48 were initially cleaned with MicroSol 3+ or 25% bleach, rinsed with DNA-free water and
49 UV-irradiated to remove any extraneous DNA present (as confirmed by negative
50 controls taken from each substrate). Stock solutions of acellular human DNA were
51 prepared from buccal swabs of a consenting volunteer.

52

53 Aliquots of DNA were added to the substrates (3 µl of 300 ng DNA to the knife handles,
54 10 µl of 50 ng to the rims of the mugs), allowed to dry, and then the substrates were
55 either sampled directly (positive controls) or were cleaned and then sampled. The
56 knives were cleaned with a cloth in a sink containing 1.5 L water, either as water alone,
57 or with 10 ml dish washing liquid or 36 ml household bleach diluted in the water. The
58 mugs were cleaned with a dry or wet cloth (soaked with water), or by wiping with a
59 cloth after applying a cleaning product (0.7 ml dish washing liquid or two sprays of
60 household bleach spray) directly into the mug and then rinsing it with water. DNA
61 samples were collected with wet and dry swabs in triplicate for each substrate, for both
62 positive controls and each cleaning method.

63

64 DNA was extracted from each pair of surface swabs, and individual buccal swabs,
65 using the swab protocol of the QIAamp® DNA Investigator Kit. During the extraction
66 process, an incubation of 1 hr was used for the knife samples, whereas an overnight
67 (~16 hr) incubation was used for the mug samples; this was due to a change in the
68 standard operating procedures of the research laboratory between the two
69 experiments. The concentrations of DNA in the extracts were determined using the
70 Quantifiler® Human DNA Quantification Kit and then multiplied by the elution volume
71 (35 µl) to give the total amounts of DNA recovered in each sample.

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73 **3. Results and Discussion**

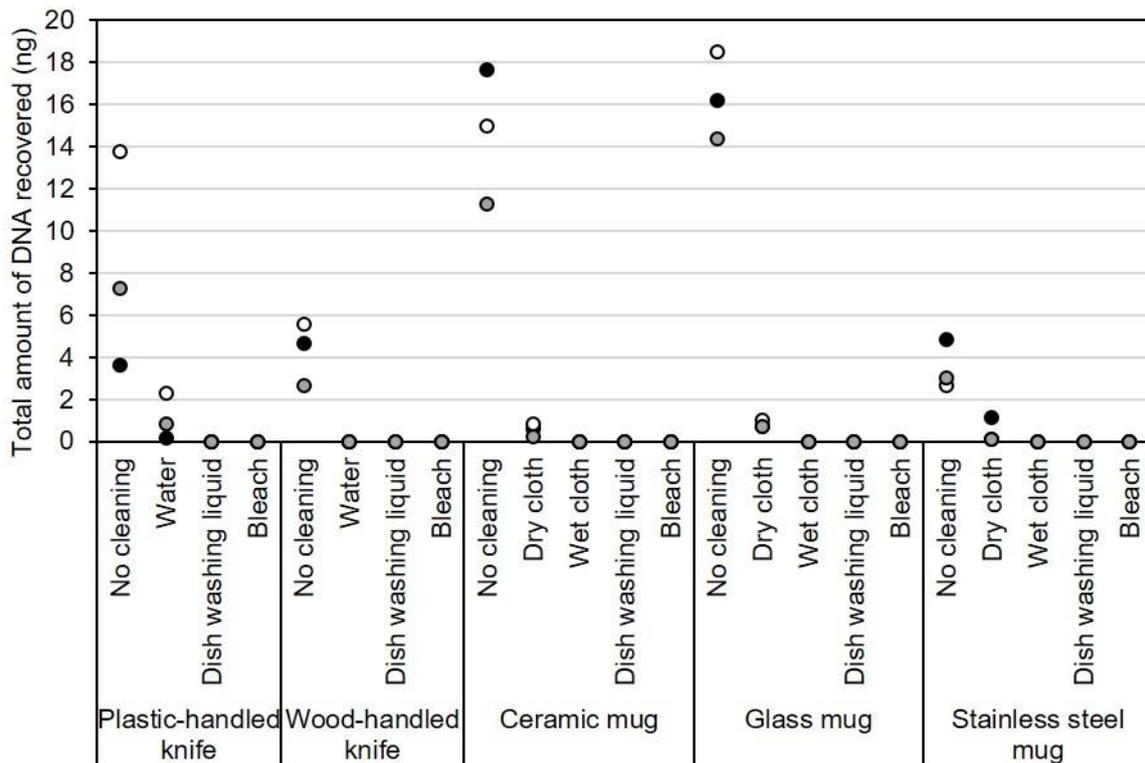
74 The total amounts of DNA recovered from each substrate for each replicate are shown
75 in Fig. 1. For the no cleaning positive controls, more DNA tended to be recovered from
76 the plastic-handled knives than the wood-handled ones, and consistently more DNA
77 was recovered from the ceramic and glass mugs than the stainless steel mugs (Fig. 1).
78 This is in agreement with the accepted view that substrate type impacts the quantity
79 of DNA recovered [4]. More DNA was generally also recovered from the ceramic and
80 glass mugs, than both types of knife, which was surprising given that a larger quantity
81 of DNA was initially deposited on the knife handles than on the mug rims. This
82 difference in efficiency of DNA recovery between the items could be due to the
83 aforementioned difference in extraction incubation and/or due to varied swabbing
84 experience between the two researchers, who were each responsible for the knives
85 or mugs experiment. Increasing extraction incubation time has been shown to increase
86 DNA yield [6] and swabbing experience has been suggested to affect DNA recovery
87 efficiency [7].

88

89 For the knives, only cleaning with a cloth in a sink of water allowed DNA to persist, but
90 at a consistently lower level than without any cleaning, and cleaning in diluted dish
91 washing liquid and household bleach resulted in no detectable DNA (Fig. 1). For the
92 mugs, simply cleaning with a dry cloth reduced the amount of DNA recovered and the
93 other cleaning methods resulted in no detectable DNA (Fig. 1). These observations
94 support the recent findings that wiping an object can redistribute DNA and that chloric

95 agents tend to render surfaces DNA-free [5]. Non-chloric cleaning agents appeared to
 96 have a larger effect on DNA persistence in the experiments described herein than
 97 observed by Helmus *et al.* [5], which could be due to differences in cleaning methods,
 98 use of smaller quantities of DNA and/or the use of acellular DNA; these variables need
 99 to be investigated further.

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104 **Fig. 1.** Quantities of DNA recovered from substrates before or after cleaning; data presented from three
 105 replicates of each substrate (white, grey and black dots).

106
 107

108 **4. Conclusion**

109 For both knife handles and mug rims, DNA was not recovered after cleaning the items
 110 with dish washing liquid or household bleach, irrespective of the differences in
 111 substrates, amounts of DNA initially deposited, and method of cleaning. Even without
 112 a cleaning product, rubbing with a dry cloth decreased DNA recovery from the mugs,

113 regardless of the mug substrate. These results contribute to our understanding of the
114 impact of various cleaning methods on DNA recovery at the crime scene and will help
115 inform DNA recovery strategies when it is suspected that cleaning has taken place.
116

116

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120

121 **Conflict of interest statement**

122 None.

123

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