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Effect of hand sanitizer on the performance of fingermark detection techniques

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ABSTRACT

Hand sanitizers have seen a rapid increase in popularity amongst the general population and this increased use has led to the belief that hand sanitizers may have an effect on subsequent fingermark detection. Based on this hypothesis, three alcoholic and two non-alcoholic hand sanitizers were evaluated to determine the effect they had on the detection of fingermarks deposited after their use. The following fingermark detection methods were applied: 1,2-indanedione-zinc, ninhydrin, physical developer (porous substrate); and cyanoacrylate, rhodamine 6G, magnetic powder (non-porous substrate). Comparison between hand sanitized fingermarks and non-hand sanitized fingermarks showed that the alcohol-based hand sanitizers did not result in any visible differences in fingermark quality. The non-alcoholic hand sanitizers, however, improved the quality of fingermarks developed with 1,2-indanedione-zinc and ninhydrin, and marginally improved those developed with magnetic powder. Different parameters, including time since hand sanitizer application prior to fingermark deposition and age of deposited mark, were tested to determine the longevity of increased development quality. The non-alcoholic hand sanitized marks showed no decrease in quality when aged for up to two weeks. The time since sanitizer application was determined to be an important factor that affected the quality of non-alcoholic hand sanitized fingermarks. It was hypothesized that the active ingredient in non-alcoholic hand sanitizers, benzalkonium chloride, is responsible for the increase in fingermark development quality observed with amino acid reagents, while the increased moisture content present on the ridges resulted in better powdered fingermarks.

1. Introduction

Hand sanitizers are effective microbial killing liquids, gels or foams that are used to disinfect and cleanse hands without the need for soap and water. Hand sanitizers have been a growing commodity ever since their introduction in 1966, with hand sanitizer sales peaking to over 15 million sales in a single week in 2009 – (coinciding with the news of a H1N1 outbreak) [1]. These products were originally alcohol-based, with ethanol or isopropanol as the active ingredient. At concentrations between 60–95% [2], alcohols are effective against most bacteria and fungi, and many viruses, killing these organisms by denaturing their proteins, dissolving their lipids, and subsequently interfering with their metabolism and cell lysis [3]. The harsh nature of alcohol, however, can lead to dryness and skin irritations [4]. This resulted in the development of non-alcoholic alternatives, in which the main active anti-bacterial ingredient is benzalkonium chloride (BAC). BAC falls into the category of quaternary ammonium compounds (QACs). The mechanism of bactericidal action involves the QAC, integrating into the bacterial hydrophobic membrane core, disrupting and denaturing structural proteins and enzymes [5]. BAC has been shown to have a long duration of action (in comparison to alcoholic hand sanitizers, whose action ceases as soon as the alcohol has evaporated [3,4]), where some companies claim their product continues to have anti-bacterial effects for a period of time after application [3,6]. Hand sanitizers also contain a range of other ingredients, including thickening agents, humectants, stabilizers, fragrances, emollients, moisturisers, emulsifiers, water, and plant-sourced essential oils – some of which remain on the skin following evaporation of the active ingredient. This is of particular interest in the field of fingermark detection as the hand sanitizer components may persist on the friction ridge skin and be transferred onto the surface during

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deposition. These exogenous compounds may then inhibit or enhance the subsequent fingermark development techniques.

Latent fingermarks occur when secretions and environmental contaminants present on the tips of the fingers are deposited onto a surface by direct contact, resulting in an impression of the friction ridges being left behind. Each fingermark contains a complex mixture of chemical compounds [7,8]. The precise chemical composition of the natural secretions that may be present in a fingermark is variable and dependent on many factors, including the donor's age, diet, metabolism, recent activities and genetic factors. The composition can also change over time due to environmental factors. Current detection methods generally target a group of compounds (e.g., amino acids, proteins, lipids) rather than a specific compound. Therefore, the presence of exogenous compounds such as cosmetics, hand creams or hand sanitizers may impact on the quality of latent fingermark development. It is hypothesized that the application of a hand sanitizer prior to fingermark deposition will have an effect on the subsequent development of latent fingermarks. This view is supported by reports that alcoholic hand sanitizers strip away the sebum and lipids that are present on the skin surface [4]. Due to their widespread use, it would be of concern if the application of hand sanitizers could be used to inhibit fingermark detection during the commission of a crime.

The use of hand sanitizers will alter the condition of a donor's friction skin, especially with respect to the amount of moisture and the types of residues present on the skin surface. A previous study examined the effect of 'Liquid Gloves' (a product that when applied to the skin provided protection from a range of chemicals) on latent fingermark detection [9]. This study found there was no effect on fingermark development for a range of porous and non-porous techniques. However this particular product acts as a protective layer and does not claim to remove any components on the surface of the skin. Hand sanitizers however may remove components, making it difficult to detect fingermarks if target compounds are no longer present, or add compounds that may either degrade or enhance the performance of fingermark detection methods. In addition, the altered composition of the deposit may change the way the fingermarks age. The research presented here aimed to evaluate a range of different hand sanitizers to determine whether or not the application of a hand sanitizer, prior to fingermark deposition, has an effect on the subsequent physical and chemical detection of fingermarks. The effects of time between hand sanitizer application and fingermark deposition and the effects of ageing the deposits were also investigated.

2. Materials and methods

2.1. General approach

In order to determine the potential effect of hand sanitizer application on fingermark residue, five hand sanitizers were evaluated, three alcoholic – Dettol® Instant Hand Sanitizer Original, Purell® Advanced Hand Sanitizer Refreshing Gel, and Squeakie® 100% Natural Hand Sanitizer – and two non-alcoholic – Deb® InstantFoam™ and EcoHydra® Antibacterial Hand Sanitizer Alcohol Free Foam. The potential effect of hand sanitized fingermarks was examined using the most common fingermark detection techniques: 1,2-indanedione-zinc (IND-Zn), ninhydrin (NIN) and physical developer (PD) (porous surfaces); and magnetic powdering, cyanoacrylate fuming and rhodamine 6G staining (non-porous surfaces). For each of three donors, six hand sanitized and six non-hand sanitized fingermarks were deposited either on Reflex® Ultra White Paper (A4, 80 GSM) for each porous technique or Livingstone® premium plain pathology grade glass microscope slides for each non-porous substrate technique. Developed fingermarks were imaged using the ideal conditions for each technique and the development quality was assessed using the UK Home Office Centre for Applied Science & Technology (CAST) scale [10]. Experimental considerations for number of fingermarks, donors and surfaces were done in accordance to the International Fingerprint Research Guidelines [11].

2.2. Fingermark deposition

The following method was repeated for each development technique and for each hand sanitizer tested.

Natural non-hand sanitized (NHS) fingermarks were collected from three donors known to produce strong, medium and weak fingermarks, respectively. Each donor was asked to rub their hands together and mimic the application of hand sanitizer before depositing fingermarks, so that the conditions between NHS and hand sanitized (HS) fingermarks were constant. Donors were asked to use six different fingers to deposit six NHS fingermarks (Fig. 1), by pressing each finger against the substrate with a light pressure and brief contact time. The donors then applied one squirt/pump of hand sanitizer and rubbed the liquid into their hands until the volatile components had evaporated (20–30 s). This corresponds to the normal usage of a hand sanitizer in real life. Donors then immediately deposited six HS fingermarks directly above their

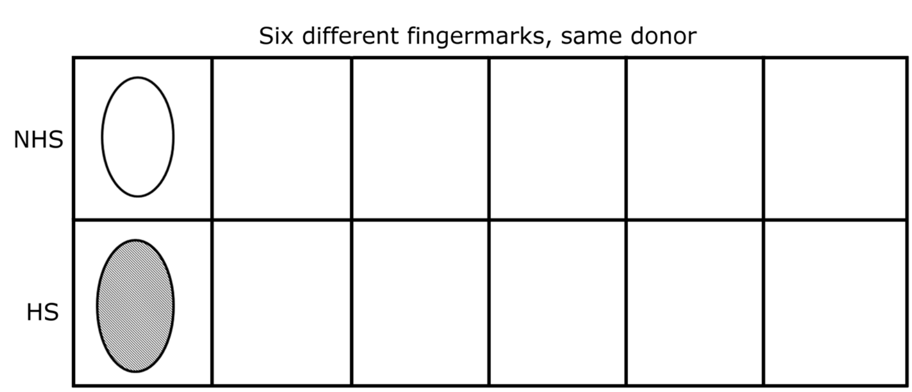

Fig. 1. Schematic diagram of porous substrate set-up for fingermark deposition.