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TECHNICAL NOTE

Criminalistics; General

Environmental assessment of gunshot residue particles in the public domain of the United Kingdom

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Abstract

Only limited data currently exists on the inadvertent transfer of gunshot residue (GSR), or GSR-like particles through contact with public places. In this study, an assessment occurrence of GSR in public environments in England, UK was undertaken. Utilizing a stubbing sampling technique over 260 samples were collected from areas accessible to the public, including buses, trains, taxis, and train stations. Stub analysis was performed by Scanning Electron Microscopy with Energy Dispersive X-ray Analysis (SEM-EDX). The results showed no characteristic GSR particles were detected on any of the 262 samples taken. From these samples, a total of four indicative/consistent particles were identified on one train seat (2× BaAl, 2× PbSb). Although geographical location and firearm association is likely to influence GSR occurrence, the data suggests that the potential for inadvertent GSR transfer through contact with public transport and associated communal areas is insignificant. Further research assessing environmental background levels of GSR in additional geographical locations is critical in an evaluation of the potential for GSR transfer from the environment.

KEYWORDS

environmental particles, persistence, prevalence of gunshot residue, SEM-EDX, transfer

Highlights

- Environmental assessments of gunshot residue particles (GSR) public environments in the UK.
- No characteristic GSR particles detected in over 260 samples.
- GSR transfer through contact with publicly accessible locations appears to be insignificant.

1 | INTRODUCTION

Gunshot residue (GSR) is a chemical cocktail of compounds produced when a firearm is discharged. It is the collective name of the complex mixture of organic and inorganic particles and compounds originating from the firearm, the ammunition, and the combustion products thereof which are produced during the discharge of a firearm.

The presence of GSR can be used for the reconstruction of shooting incidents: to estimate firing distances, identify bullet holes, and to determine whether or not a suspect can be associated with firearms activity. Thus, there is the potential for GSR detection to establish a link between the shooter, the firearm, the victim, and/or the crime scene; however, this requires careful interpretation of the gunshot residue evidence. A characteristic GSR particle is typically composed of the elements Pb, Ba and Sb. The detailed classification and interpretation of GSR materials has been covered in publications elsewhere [1].

Research on the fate and behavior of GSR has refined the view that the presence of GSR on an individual's hands may, among several possibilities, be attributed to contact with a recently contaminated surface [2]. Key findings indicate that distinction between a shooter and secondary contamination/ bystander deposition must consider the contextual circumstances surrounding a case [3, 4].

Large numbers of people, from a variety of professions and geographical locations, come into regular contact with public transport. Legitimate access to firearms and firearm material is possible among some members of the public in the UK; theoretically, these individuals may act as an indirect source of GSR materials [5]. Particularly where numbers of GSR particles detected are low, suspects may argue that despite GSR existing on their persons, they have had no direct exposure to firearms or firearms material. The presence of GSR in the general environment is assumed to be rare and would generally be detected in the vicinity of a firearm discharge and/or surfaces with direct contact shortly after discharge. Any possibility of GSR contamination via secondary contact is expected to decline as a function of time since discharge [6, 7].

The random prevalence of GSR on the hands of indiscriminately selected members of the public and individuals of varying occupations have been assessed in specific districts of Italy [8], Poland [9] and Australia [10]. Work by Stamouli et al. [11] indicated that the probability of finding at least one characteristic GSR particle (PbBaSb) for the general population and car mechanics is 0.4%; for the arresting police officers, it is 25.0%; for persons in possession of a firearm it is 42.3%. In addition, such characteristic GSR particles are also deemed to be relatively uncommon on non-firearms related clothing [12].

The direct exposure of suspects to police vehicles and facilities may increase the possibility of GSR transfer within police environments. Several studies have assessed police contamination in a variety of locations [13–18]. From this work, there is some general agreement that although GSR can exist in a police environment, GSR transfer to suspects from these locations, especially in significant quantities, is unlikely [13, 17, 19].

Although geographical location and corresponding firearm laws are likely to influence GSR occurrence, there is agreement that GSR particles are insignificant in the general environment [20]. This study further investigates the hypothesis; it is not expected that a location with no connection to firearms/firearm material would contain significant GSR materials. The primary aim was to broaden current knowledge of GSR materials in the environment, in order to assess the possibility of inadvertent GSR transfer to the public. To investigate this, samples were taken from a variety of public places to assess background levels of GSR. Few researchers have addressed the question of inadvertent GSR transfer of a suspect through contact with areas accessible to the general public. Previously, such methodologies have only been applied to traces of explosives in public places [5, 21].

2 | MATERIALS AND METHODS

Standard 12.5 mm diameter scanning electron microscope specimen stubs with a Leit carbon tab (Agar Scientific) were used throughout sampling. Each stub was carbon coated using Quorum Technologies Q150T ED rotary-pumped carbon coater. Samples were analyzed using SEM–EDX using a FEI Quanta™ 250 SEM with variable vacuum and a four-quadrant BSD with a working distance of 10 mm, an accelerating voltage of 25 kV, and a magnification of 250x. Automated detection and analysis software (INCAGSR; Oxford Instruments) was employed to allow automated particle search and identification; particles were classified as per ASTM E1588-17 [22] and automatically identified particles were reacquired by manual relocation and subject to confirmatory analysis.

To minimize the risk of contamination and ensure consistency, sampling kits containing IPA wipes, hand sanitiser, disposable gloves, tweezers, pre-prepared aluminium stubs, nylon bags and marker pens were employed. Prior to sampling, the sampler's hands were cleaned with 70% alcohol hand sanitiser/IPA wipes and disposable gloves were worn throughout. Once identified the area of interest was sampled using the stubbing method, whereby the whole area is stubbed until the stickiness subsides [23].

Cross contamination was avoided by replacing the plastic container immediately after sampling and storing each sample in an individual nylon bag. Control samples of the sampler's hands all tested negative for characteristic GSR and related particles.

The sampling locations varied in age, cleanliness, operating companies, origin and routes. A wide range of substrates were sampled; some locations were rigid and smooth (e.g., public benches & handrails) whereas others were fibrous, or leather coated (e.g., seats).

Samples were categorized into several sites: trains, train stations, taxis, hire cars, underground stations and tube trains and buses. For consistency the same sample locations were taken from each site (Table 1).

3 | RESULTS AND DISCUSSION

A total of 262 samples were taken from areas accessible to the general public across Manchester, Greater Manchester, Liverpool, London and Birmingham (England, UK). Despite the variety and number of individuals who have regular contact with public transport, no characteristic GSR particles were detected in any of the samples. It should be noted that all samples generally exhibited environmental particle counts in the range of hundreds to thousands.

BaAl and PbSb particles were identified in low levels (maximum of 4 particles—2 BaAl, 2 PbSb) on one single train seat back sample (Figures 1 and 2). These are classed as Indicative/consistent particles which might be associated with firearms-related sources but could also originate from other unrelated sources. Therefore, in isolation such particles have little significance in GSR interpretation

TABLE 1 Overview of the samples taken from public locations.

Location	Number of sites sampled	Total number of samples	Samples taken from location
Trains	13	91	Train carriage seat (back & base), train carriage window, train carriage windowsill, table, carpet around seat area, seat handle, arm rest
Train stations	8	48	Public bench, ticket machine screen, card machine, handrail, escalator rail, floor near seating
Taxis	3	15	Rear seat (×2), money tray, inside rear door handle (×2)
Hire cars	4	48	Boot, all seats (back & base), steering wheel, dashboard, hand brake and gear stick
Underground railway stations and 'tube' trains	6	30	Tube passenger seat (back & base), handrail, windowsill, public bench
Buses	5	30	Passenger seat (back and base) ×2, windowsill, handrail

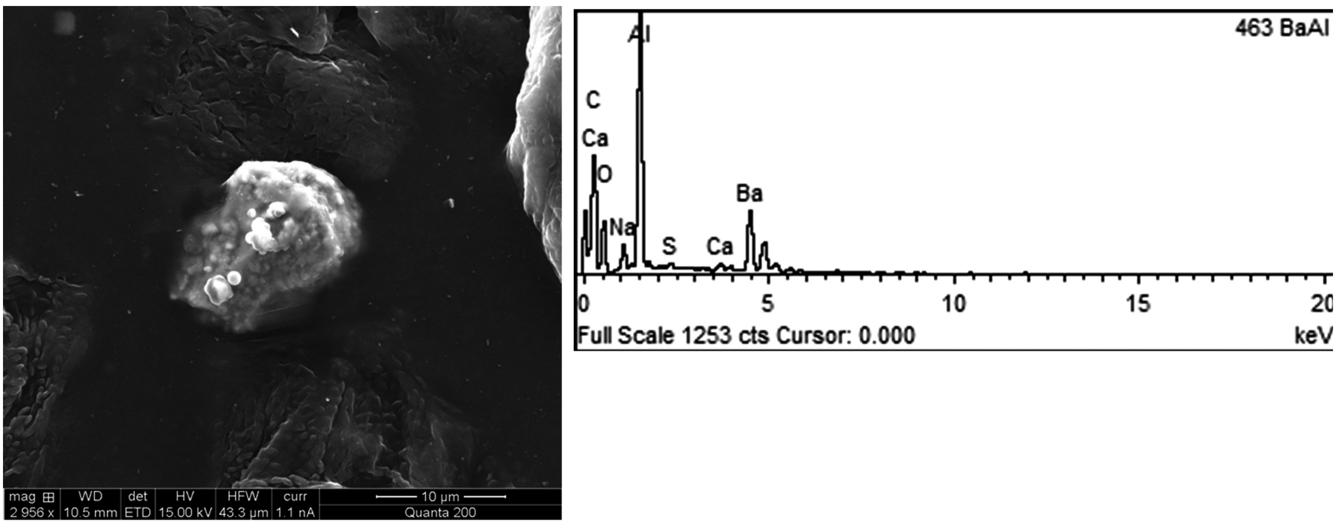

FIGURE 1 SEM–EDX image and spectra of a BaAl particle at 2956× magnification identified on one single train seat back sample.

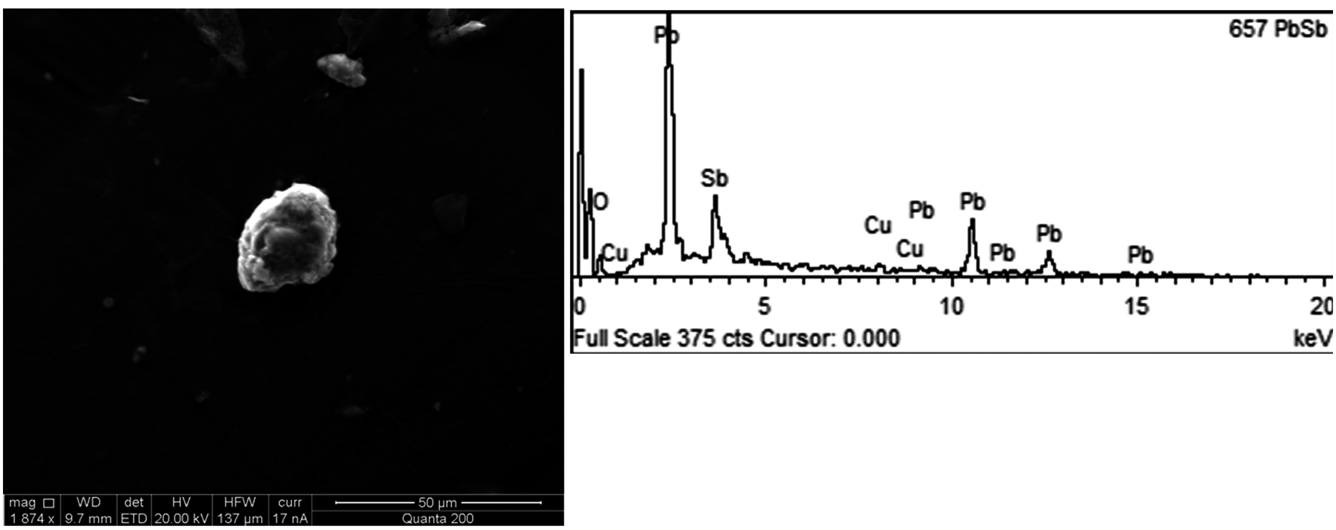

FIGURE 2 SEM–EDX image and spectra of a PbSb particle at 1874× magnification identified on one single train seat back sample.

as these particle types can originate from sources unrelated to firearms activity [1]. Specific source apportionment of these particles is not possible due to the unknown throughput of the public. One explanation is that these particles are present as a result of natural environmental particulate matter.

These particles were found among a variety of fibers and microscopic environmental debris also deposited on the stub during sampling (e.g. fine vegetable matter). This debris was a common theme throughout analysis of all samples. Nothing unusual was observed in any of the samples with regards to general stub debris encountered. The presence of characteristic GSR among the public is presumed to be rare. These results would infer that any GSR detected on individuals is unlikely to have originated from the general environment and would imply an association with firearms or a firearms discharge.

4 | CONCLUSION

This study investigated the background levels of GSR persisting in public transport environments in the UK. Considering the initial hypothesis proposed; 'it is not expected that a location with no connection to firearms/ firearm material would contain significant GSR materials', the results would appear to support this.

Of all the samples analyzed from public locations across England, zero characteristic GSR particles were identified. These findings indicate the potential for GSR transfer through contact with locations accessible to the public appears to be insignificant. The absence of characteristic GSR in the environments studied here serves to strengthen the support for an individual being associated with firearms or related activities, when GSR is detected on that individual. Additionally, when significant levels of GSR are detected on an individual, the support for a direct association or involvement in a firearms related activity is strengthened [24].

It is critical to note that this study focused on a select number of samples and geographical locations. Geographical locations and associated firearms laws are likely to influence the background levels of GSR in other environments. Further studies, which take additional geographical locations into account, will broaden our understanding of the potential for inadvertent GSR transfer from non-firearm related environments.

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