

Blakey, L, Sharples, GP, Chana, K and Birkett, JW

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

<https://researchonline.ljmu.ac.uk/id/eprint/20461/>

Article

Citation (please note it is advisable to refer to the publisher's version if you intend to cite from this work)

Blakey, L, Sharples, GP ORCID logoORCID: <https://orcid.org/0000-0003-0492-0253>, Chana, K and Birkett, JW ORCID logoORCID: <https://orcid.org/0000-0002-5682-512X> (2023) Environmental assessment of gunshot residue particles in the public domain of the United Kingdom.

LJMU has developed **LJMU Research Online** for users to access the research output of the University more effectively. Copyright © and Moral Rights for the papers on this site are retained by the individual authors and/or other copyright owners. Users may download and/or print one copy of any article(s) in LJMU Research Online to facilitate their private study or for non-commercial research. You may not engage in further distribution of the material or use it for any profit-making activities or any commercial gain.

The version presented here may differ from the published version or from the version of the record. Please see the repository URL above for details on accessing the published version and note that access may require a subscription.

For more information please contact researchonline@ljmu.ac.uk



Expand your NPS screening capabilities using the vMethod application for forensic toxicology screening

vMethod applications from SCIEX are designed to help labs implement challenging new applications with ease and be ready for validation with minimal method development

The updated vMethod application for forensic toxicology screening adds 130 novel psychoactive substances (NPS) to the original screening method for 664 drugs of abuse. It makes full use of the unique data independent acquisition (DIA) capabilities of SWATH DIA with confirmation through full-spectral MS/MS library entries.

A complete standard operating procedure (SOP) provides details on:

- Sample preparation for human whole blood and urine
- Comprehensive LC-MS/MS methods that employ either SWATH DIA or data dependent acquisition (DDA) for analysis
- Reliable data processing for quantification and confirmation of over 790 analytes with meaningful reporting tools

Download your content pack now >



TECHNICAL NOTE

Criminalistics; General

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

Lauren Blakey PhD¹ | George P. Sharples PhD¹ | Kal Chana GRSC² |
Jason W. Birkett PhD¹¹Faculty of Science, School of Pharmacy and Biomolecular Sciences, Liverpool John Moores University, Liverpool, UK²Cellmark Forensic Services, Oxfordshire, UK**Correspondence**Jason W. Birkett, School of Pharmacy and Biomolecular Sciences, Liverpool John Moores University, James Parsons Building, Byrom Street, Liverpool, L3 3AF, UK.
Email: j.w.birkett@ljmu.ac.uk**Funding information**

Liverpool John Moores University

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,

This is an open access article under the terms of the [Creative Commons Attribution-NonCommercial-NoDerivs](https://creativecommons.org/licenses/by-nc-nd/4.0/) License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

© 2023 The Authors. *Journal of Forensic Sciences* published by Wiley Periodicals LLC on behalf of American Academy of Forensic Sciences.

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 (x2), money tray, inside rear door handle (x2)
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) x2, windowsill, handrail

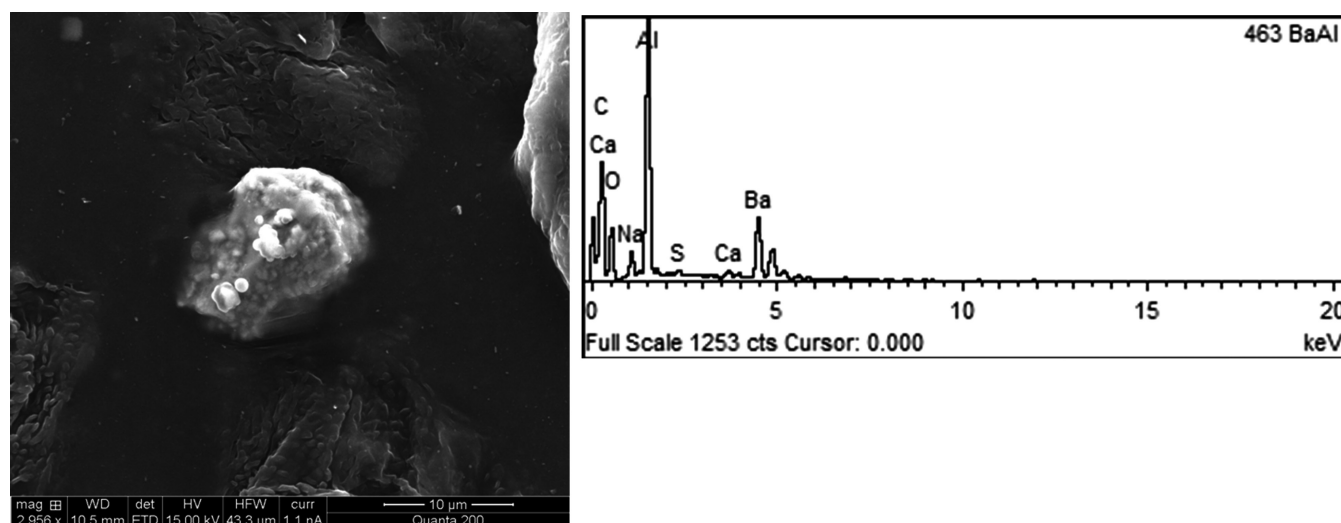


FIGURE 1 SEM-EDX image and spectra of a BaAl particle at 2956x magnification identified on one single train seat back sample.

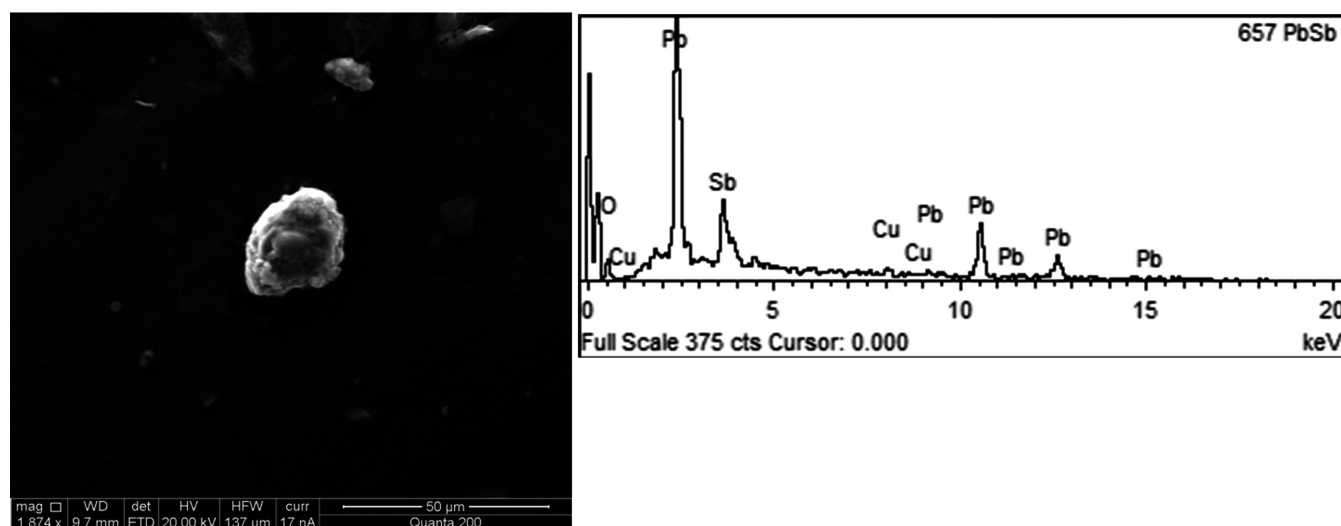


FIGURE 2 SEM-EDX image and spectra of a PbSb particle at 1874x magnification identified on one single train seat back sample.

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.

FUNDING INFORMATION

Funding provided by the School of Pharmacy and Biomolecular Sciences at Liverpool John. Moores University and Cellmark Forensic Services through the Faculty of Science PhD. Studentship Scheme.

REFERENCES

1. SWGGSR. Guide for primer gunshot residue analysis by scanning electron microscopy/energy dispersive X-ray spectrometry 11-29-11. SWGGSR. 2011. <https://www.crime-scene-investigator.net/GSRanalysisguide.pdf>. Accessed 12 Apr 2023.
2. Blakey L, Sharples GP, Chana K, Birkett JW. Fate and behavior of gunshot residue—a review. *J Forensic Sci.* 2018;63(1):9–19. <https://doi.org/10.1111/1556-4029.13555>
3. Blakey L, Sharples GP, Chana K, Birkett JW. Fate and behavior of gunshot residue: recreational shooter vehicle distribution. *J Forensic Sci.* 2019;64(6):1668–72. <https://doi.org/10.1111/1556-4029.14126>
4. French J, Morgan R. An experimental investigation of the indirect transfer and deposition of gunshot residue: further studies carried out with SEM-EDX analysis. *Forensic Sci Int.* 2015;247:14–7. <https://doi.org/10.1016/j.forsciint.2014.10.023>
5. Cullum HE, McGavigan C, Uttley CZ, Stroud HE, Warren DC. A second survey of high explosive traces in public places. *J Forensic Sci.* 2004;49(4):684–90. <https://doi.org/10.1520/jfs2003237>
6. French J, Morgan R, Davy J. The secondary transfer of gunshot residue: an experimental investigation carried out with SEM-EDX analysis. *X-Ray Spectrom.* 2014;43(1):56–61. <https://doi.org/10.1002/xrs.2498>
7. Blakey LS, Sharples GP, Chana K, Birkett JW. The fate and behaviour of gunshot residue: recreational shooter distribution. *Aust J Forensic Sci.* 2019;51(Suppl 1):S176–9. <https://doi.org/10.1111/1556-4029.14126>
8. Garofano L, Capra M, Ferrari F, Bizzaro GP, Di Tullio D, Dell'Olio M, et al. Gunshot residue – further studies on particles of environmental and occupational origin. *Forensic Sci Int.* 1999;103(1):1–21. <https://doi.org/10.1016/j.forsciint.2004.01.019>
9. Brožek-Mucha Z. On the prevalence of gunshot residue in selected populations – an empirical study performed with SEM-EDX analysis. *Forensic Sci Int.* 2014;237:46–52. <https://doi.org/10.1016/j.forsciint.2014.01.020>
10. Lucas N, Brown H, Cook M, Redman K, Condon T, Wrobel H, et al. A study into the distribution of gunshot residue particles in the random population. *Forensic Sci Int.* 2016;262:150–5. <https://doi.org/10.1016/j.forsciint.2016.02.050>
11. Stamouli A, Niewohner L, Larsson M, Colson B, Uhlhig S, Fojtasek L, et al. Survey of gunshot residue prevalence on the hands of individuals from various population groups in and outside Europe. *Forensic Chem.* 2021;23:100308. <https://doi.org/10.1016/j.forc.2021.100308>
12. Hannigan TJ, McDermott SD, Greaney CM, O'Shaughnessy J, O'Brien CM. Evaluation of gunshot residue (GSR) evidence: surveys of prevalence of GSR on clothing and frequency of residue types. *Forensic Sci Int.* 2015;257:177–81. <https://doi.org/10.1016/j.forsciint.2015.08.003>
13. Berk RE, Rochowicz SA, Wong M, Kopina MA. Gunshot residue in Chicago police vehicles and facilities: an empirical study. *J Forensic Sci.* 2007;52(4):838–41. <https://doi.org/10.1111/j.1556-4029.2007.00457.x>
14. Brožek-Mucha Z. A gunshot following the stopping of passenger car by police—reconstruction of an event on the basis of case files and gunshot residue examinations. *Probl Forensic Sci.* 2002;51:119–36.
15. Charles S, Geusens N. A study of the potential risk of gunshot residue transfer from special units of the police to arrested suspects. *Forensic Sci Int.* 2012;216(1–3):78–81. <https://doi.org/10.1016/j.forsciint.2011.08.022>
16. Gerard RV, Lindsay E, McVicar MJ, Randall ED, Gapinska A. Observations of gunshot residue associated with police officers, their equipment, and their vehicles. *Can Soc Forensic Sci J.* 2012;45(2):57–63. <https://doi.org/10.1080/00085030.2012.10757183>
17. Gialamas D, Rhodes E, Sugarman L. Officers, their weapons and their hands: an empirical study of GSR on the hands of non-shooting police officers. *J Forensic Sci.* 1995;40(6):1086–9. <https://doi.org/10.1520/jfs13882j>
18. Grima M, Hanson R, Tidy H. An assessment of firework particle persistence on the hands and related police force practices in relation to GSR evidence. *Forensic Sci Int.* 2014;239:19–26. <https://doi.org/10.1016/j.forsciint.2014.03.002>

19. Lucas N, Cook M, Kirkbride KP, Kobus H. Gunshot residue background on police officers: considerations for secondary transfer in GSR evidence evaluation. *Forensic Sci Int*. 2019;297:293–301. <https://doi.org/10.1016/j.forsciint.2019.02.017>
20. Dalby O, Butler D, Birkett JW. Analysis of gunshot residue and associated materials – a review. *J Forensic Sci*. 2010;55(4):924–43. <https://doi.org/10.1111/j.1556-4029.2010.01370.x>
21. Crowson CA, Cullum HE, Hiley RW, Lowe AM. A survey of high explosive traces in public places. *J Forensic Sci*. 1996;41(6):980–9. <https://doi.org/10.1520/jfs14035j>
22. ASTM International. ASTM – E1588-17 a. standard practice for gunshot residue analysis by scanning electron microscopy/energy dispersive X-ray spectrometry. West Conshohocken, PA: ASTM International; 2017.
23. Reid L, Chana K, Bond JW, Almond MJ, Black S. Stubs versus swabs? A comparison of gunshot residue collection techniques. *J Forensic Sci*. 2010;55(3):753–6. <https://doi.org/10.1111/j.1556-4029.2010.01332.x>
24. Birkett JW, Bradley D, Clews J, Goldstone C, Humphreys C, Mulvihill D, et al., editors. *Understanding ballistics – a primer for courts*. London, UK: The Royal Society; 2021.

How to cite this article: Blakey L, Sharples GP, Chana K, Birkett JW. Environmental assessment of gunshot residue particles in the public domain of the United Kingdom. *J Forensic Sci*. 2023;68:1330–1334. <https://doi.org/10.1111/1556-4029.15267>