

Glass particles in footwear of members of the public in south-eastern Australia — a survey

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Abstract

A total of 776 pairs of shoes collected from random members of the public in south-eastern Australia were examined for the presence of glass fragments. From the samples collected a total of 110 fragments were recovered from 57 pairs of shoes (7.3% of the pairs examined). This study shows that the prevalence of glass fragments in footwear is dependent upon the area of the shoe from which the fragments were recovered. A much higher percentage of shoes were found to have fragments embedded in the sole (5.9%) than in the upper area of the shoe (1.9%). These shoes were also more likely to have multiple fragments from multiple sources of glass. Only a very small percentage of shoes contained fragments in both the upper and the sole (0.3%). These findings and their significance for the interpretation of glass evidence involving footwear are discussed in this study. © 2001 Elsevier Science Ireland Ltd. All rights reserved.

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1. Introduction

Glass is a common form of trace evidence routinely analysed by forensic scientists worldwide. Glass evidence has been used successfully in a wide variety of cases, for example, hit and run cases, where headlamp or windshield glass is present. Burglaries, which frequently involve the breaking of window glass, and violent crimes such as assault, in which bottles may be used are other examples of cases where glass evidence may be encountered. In Australia, approximately 235

glass cases are analysed per annum, one-third of which involves footwear. In the absence of a physical fit the significance of such glass evidence has however been challenged due to the possibility of a natural occurrence of glass in clothing and footwear.

Problems associated with the interpretation of glass evidence have attracted a great deal of interest over the past few years, in part due to the development of the Bayesian model as an aid for the interpretation of forensic evidence. Investigation of this model [1–3] expanded existing research and prompted new projects needed to find some basis for quantifying the probabilities of transfer and persistence [4–13] and the natural occurrence of glass fragments on selected populations [14–20].

Surveys investigating the prevalence of glass fragments provide very useful data helping to answer the

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question “what is the probability of finding the evidence given that the defendant was not at the scene?” The majority of published surveys concentrated on outer garments [14–19] with few considering the footwear of the subjects [16,17]. The only comprehensive published study on the occurrence of glass fragments in footwear is that performed in 1977 by Davis and DeHaan on subjects in Sacramento, California [20]. There is an obvious lack of data in this area which is in conflict with its need and relevance to casework in Australia and around the world.

The aim of this study was to investigate the occurrence of glass fragments in the footwear of randomly selected people from south-eastern Australia in order to generate data assisting the interpretation of glass evidence.

2. Materials and method

2.1. Sample collection

Samples were collected from a total of nine Bowling alleys throughout the Canberra and Sydney Metropolitan areas, respectively during January and September 1999. Bowling Alleys were chosen as an area of sample collection because this was thought to provide a diverse sample population and the patrons were not unnecessarily inconvenienced by the removal of their footwear. This was also thought to be the best way of gathering significant data in a reasonable time frame. In addition, it also enables a direct comparison with data on the occurrence of glass fragments on upper garments available for the same geographical area [19]. Samples were also collected from the University and two shopping centres.

People at each location were approached and asked to participate in the study. Each pair of shoes was examined visually without magnification, and any material that resembled glass was removed and transferred onto pieces of A4 paper, which was then folded, labelled and packaged appropriately. Particular attention was paid to separate particles coming from the uppers and from the soles of the shoes. Similarly, the grooves and cracks in each shoe were examined in detail. Shoes were also shaken with considerable force over a sheet of paper and dislodged trace material was collected and as described above. The collection

method corresponds to the standard procedure used in casework.

The participants were then asked to supply information on their sex, age and occupation. Details of the type and size of the shoe, material of the shoe sole, and the last time the shoes were cleaned were also recorded.

Samples were also taken from the pavement area surrounding the collection venues by sweeping.

2.2. Examination of collected samples

All collected samples were initially examined under a low power stereomicroscope (6–40× magnification), and any material resembling glass was isolated for subsequent microscopic examination. Potential glass fragments were then viewed under a Leica DM-LSP polarising light microscope (25–400× magnification) to distinguish between the isotropic and non-isotropic fragments. Isotropic fragments were confirmed to be glass if they did not dissolve in water and organic solvents.

All fragments identified as glass were washed in an ultrasonic bath whenever practical, and then submitted to a Glass Refractive Index Measurement at 589.3 nm using a GRIM instrument (Foster and Freeman), with a Mettler FP82 HT hot stage, fastened to a Leitz diaphan microscope (100× magnification).

Refractive indices and morphological information (mainly colour) were used to determine the number and the size of glass groups present on the soles of each pair of shoes when more than one fragment was found.

3. Results and discussion

In total 776 pairs of shoes were surveyed. The sample population was as random as could be obtained. The ratio of males to females was very close to 50%, and the age of the participants ranged from young children to people in their late sixties. The most common age for those sampled was between 16 and 35. This is also the age bracket usually assigned to those who are most likely to commit crimes and is therefore a good representation of this select group without excluding other age brackets from the sample population. The breakdown by sex and age is shown in Fig. 1.

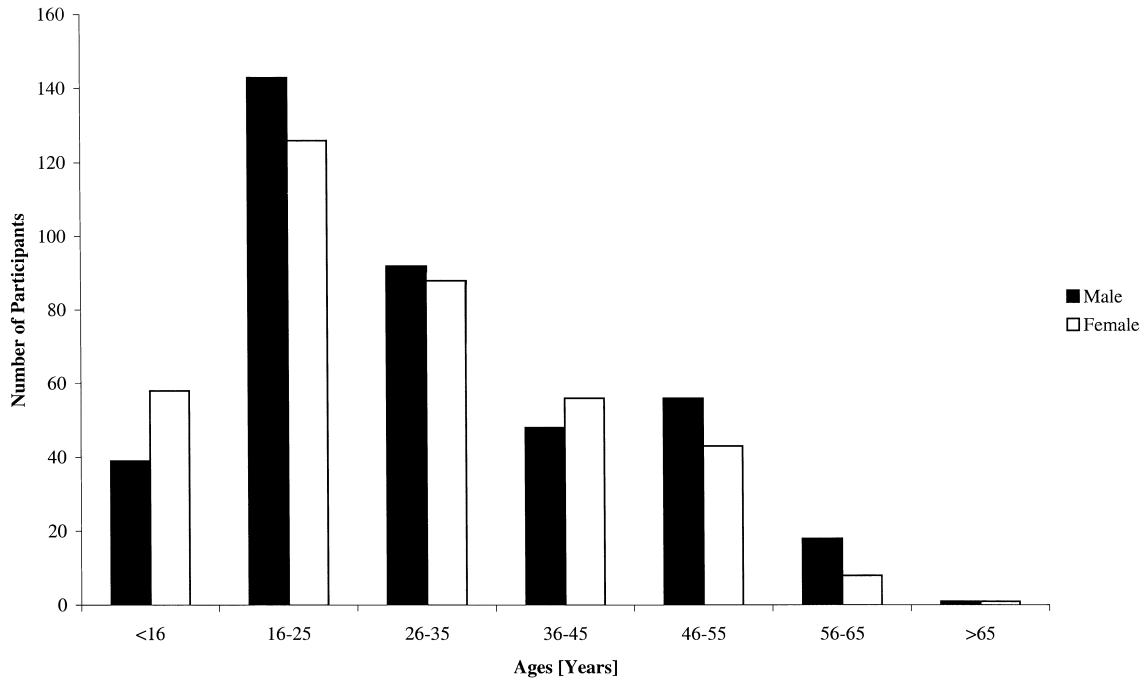


Fig. 1. Sample population by sex and age.

From these shoes, 110 glass fragments were found on 57 pairs. This represents 7.3% of the pairs examined. This result is significantly higher than the figure of 0.3% reported by Petterd et al. [19] for upper garments surveyed at the same geographical location. 95 (86.4%) of the fragments were recovered from the soles of 46 pairs of shoes, with the remaining 15 fragments (13.6%) being from the upper area of 15 pairs.

A range of colours was found, with 59 fragments (53.6%) being colourless. The other colours present were brown/amber (13 fragments, 11.8%), clear with a green tinge (5, 4.5%), green/lemon (4, 3.6%) and light blue (1, 0.9%).

The Refractive Index values for the glass fragments recovered which could be measured ranged from 1.510 to 1.524, with the main concentration being between 1.515 and 1.522 (Fig. 2).

The number of fragments recovered from the soles of each pair varied from 1 to 7 (Fig. 3), with the most common number being 1–2 fragments only. There were no multiple fragments recovered from the uppers of any of the shoes. The latter were also smaller fragments, approximately 1 mm³ or less, in compa-

parison to sizes ranging from 1 to 7 mm³ for fragments recovered from the soles.

The number of groups recovered from the soles of each pair varied from 1 to 4 (Fig. 4), and each group contained only a limited number of fragments (Fig. 5). A typical pair of shoes contained only one or two groups of one or two fragments on the sole.

Only two pairs of shoes sampled contained glass fragments in both the upper and the sole. This represents less than 0.3% of the sample population and indicates that finding glass fragments in both the upper and the sole of a pair of shoes is highly significant. In addition, examination of the refractive index data showed that none of the shoes examined contained matching glass in both the upper and the sole of the shoe, making the occurrence of such a situation extremely rare.

The discrepancy between the results obtained for the sole and for the upper area of the shoes is most likely due to the fact that glass fragments become embedded in the sole of the shoe, whereas they simply sit on the surface of the upper area. Hence, once glass fragments enter the sole material they persist for long periods of time, unlike the upper of the shoe, which is expected to lose fragments quickly. This can lead to

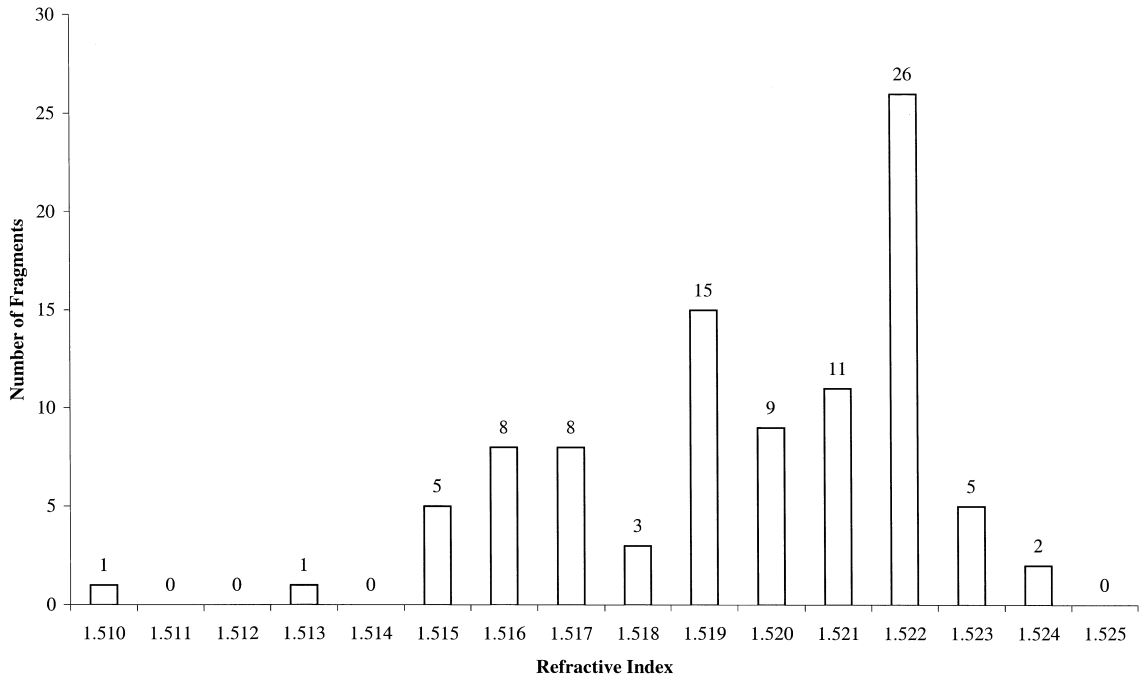


Fig. 2. Dispersion of refractive indices.

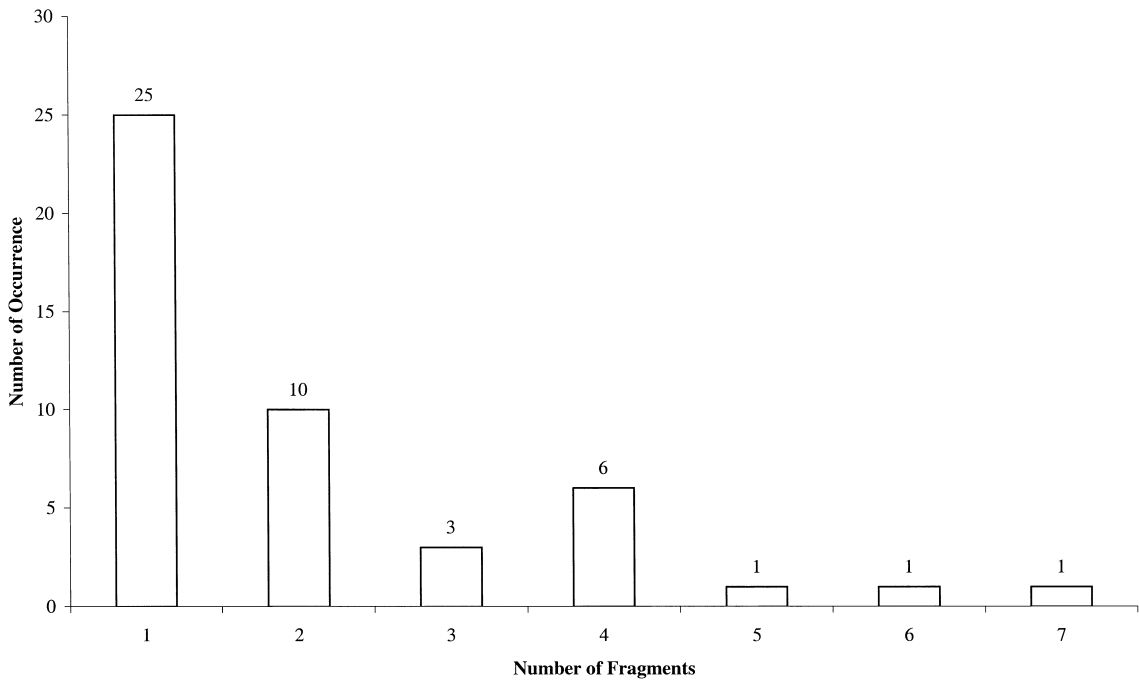


Fig. 3. Number of fragments recovered from the soles of each pair.

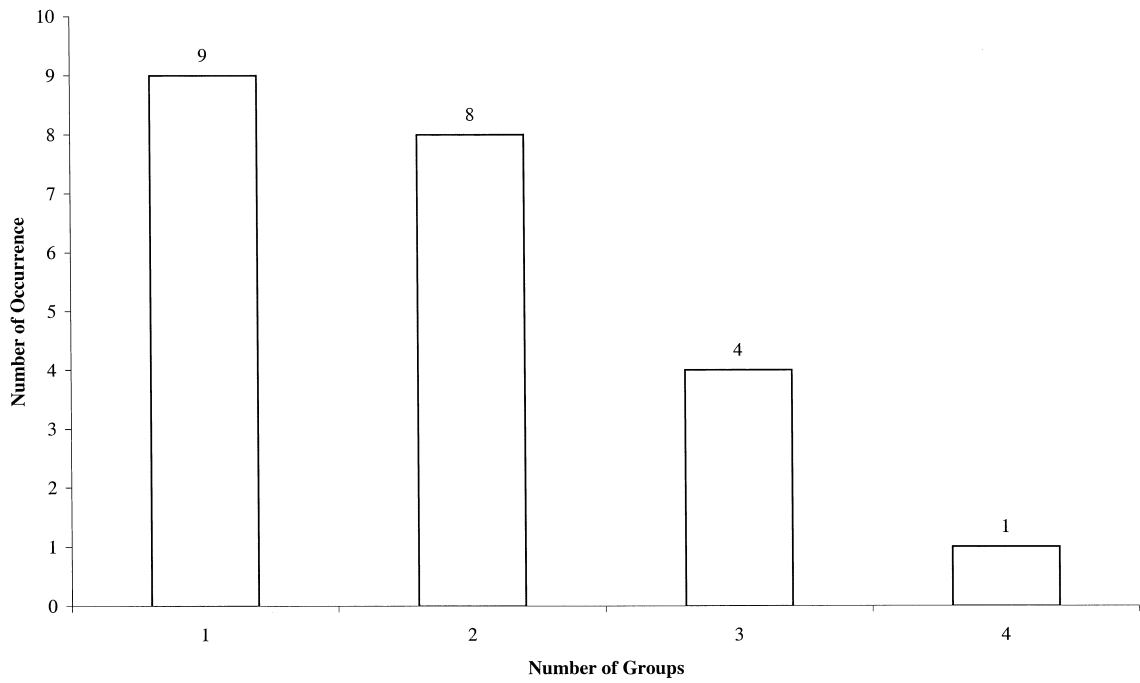


Fig. 4. Number of groups recovered from the soles of each pair.

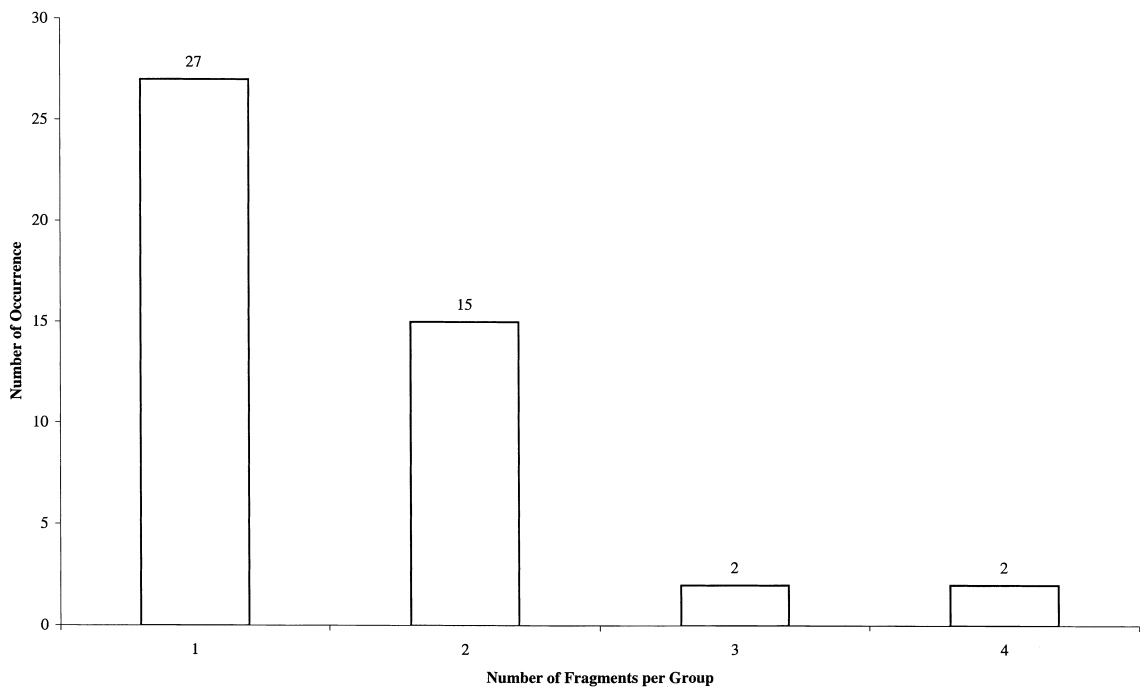


Fig. 5. Number of fragments recovered in each group.

Table 1
Comparison of results from previous surveys

	Target population	No. of shoes sampled	No. of fragments recovered	No. of shoes with glass	Percentage of footwear with glass (%)	No. with glass recovered from sole (%)	No. with glass recovered from upper (%)	No. with glass recovered from both the upper and sole (%)
[17]	High school students	213 pairs	11	Eight pairs	4.8	4.8	0.0	0.0
[20]	Shoes from second-hand stores	1300 individual shoes	Not available	355 individual shoes	27.3	Not available	Not available	Not available
This study	Random population	776 pairs	110	57 pairs	7.3	5.9	1.9	0.3

the build up of fragments over a period of time rather than from recent contact with broken glass. This is supported by the fact that the largest number of fragments recovered from the soles with a likely single source was four fragments. This was the only sample, with more than two fragments, where all the glass fragments recovered appeared to be from the same source. These results also indicate that the finding of a large number of glass fragments from a single source in the sole of footwear worn by a suspect would be significant, although the mere finding of glass in a sole is not rare.

The assumption was also that areas with high levels of broken glass on the pavements would have a greater possibility of transfer (e.g. floor in a public bar), leading to the recovery of more glass fragments on participants sampled from that area. However, there seems to be little correlation between the number of glass fragments present on the pavement at each location and the number of fragments recovered from the footwear of participants sampled at those locations. It is, therefore, not viable to state that the number of fragments at a particular location will indicate a high or low level of glass fragment recovery from footwear examined in that area.

It should also be pointed out that soles of the shoes in which glass was contained were all made of rubber other than two which were synthetic. No leather soles retained glass fragments. These results are in accordance with Davis and DeHaan [20] who found that there was a prevalence for glass to become lodged in the soles which were either soft or hard rubber.

The prevalence of glass on the upper of the shoes (1.9%) is much closer to the figures quoted in [17–19] for garments. This can be explained by the fact that the upper part of a shoe has transfer and persistence qualities similar to those of clothing. For transfer to occur glass fragments would need to fall onto the shoe, as with clothing, rather than be trodden upon.

When considering the participants from whose footwear glass fragments were recovered, our results indicate that males between 26 and 35 years of age are the most likely to have glass fragments on their shoes. In general there seems to be very little correlation between the occupation of the wearer and percentage recovery, except for public servants who had no glass recovered from their shoes, and for trade persons who were more likely to have glass on the upper areas.

A comparison of the results obtained in this study with previous studies is shown in Table 1. The slight difference between the results obtained by Lau et al. [17] and the results obtained in this study is probably indicative of the limited age bracket sampled in the previous work. The study performed by Davis and DeHaan [20] shows a considerable difference in the results obtained for percentage recovery compared to the results of this study. This difference is partly explained by the sample population chosen in [20], which sampled only shoes worn by males. The results of this current study indicate that males are more likely to have glass fragments recovered from their footwear. The results of [20] however still seem relatively high compared to the current work and without more information regarding the wearer of the shoe it is difficult to determine the reason for this increased value.

The significant difference observed between the “sole” and the “upper” results are consistent amongst the studies which separated the fragments recovered from the sole and the fragments recovered from the upper area of the shoe. It is obvious that the sole contains a much higher number of glass fragments than the upper of the shoe, and that glass fragments are rarely found in both the upper and the sole of a pair of shoes. This major finding has an obvious implication for operational procedures: the soles and upper areas of shoes must be examined separately, and hence potential evidence collected in a way which allows the scientist to identify the actual location of the recovered fragment on the shoe.

This study has produced a good baseline of data in respect to the occurrence of glass fragments in footwear worn in south-eastern Australia with direct application in casework. Further research on specific target populations would bring valuable extra information and is presently being envisaged.

4. Conclusions

The collection of debris from the footwear of 776 random members of the population resulted in the recovery of 110 glass fragments from 57 individual pairs of shoes. The percentage of footwear with fragments recovered from the sole, the upper or both were quite different, indicating the prevalence of glass

fragments in the footwear of the general public is dependent upon the area of the shoe from which the fragments were recovered.

The percentage of glass recovered from the soles of the footwear sampled was high in comparison to the percentage found in the upper of the shoe or the percentages obtained from previous studies concerning glass in clothing. These samples commonly contained multiple fragments from multiple sources.

Only a very small percentage of shoes contained glass in the upper area and none contained more than one fragment. This percentage was even smaller for shoes which contained fragments in both the upper and the sole.

This indicates that the significance of finding glass fragments (from the one probable source) in the upper area, or in both the upper area and the sole, of a suspects footwear is quite high, and that this significance decreases substantially for shoes with glass embedded in the sole only, unless there are multiple fragments recovered from the one probable glass type.

There is little correlation between the wearer of the footwear and the likelihood of glass recovery, except that a larger percentage of males were found with glass in their footwear than females.

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