The population of coloured textile fibres in domestic washing machines

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A population survey was carried out to analyse examples of the coloured fibre population that may be expected to exist in both front- and top-loading domestic washing machines during Spring, in Sydney, Australia. White cotton T-shirts were washed both individually, and with a normal household wash load, then taped to recover extraneous fibres transferred during the wash cycle. Twelve thousand one hundred and seventy-eight fibres were classified according to length, colour and generic class. Cotton fibres were most prevalent (69.4%), followed by man-made fibres (24.2%). The most common colour/generic class combinations were black/grey cotton (27%), blue cotton (20%) and red cotton (15.6%). Other combinations generally represented under 2% of the total fibre population. Two thirds (65.9%) of the recovered fibres were under 2 mm in length, the proportion of fibres decreasing with increasing fibre length. Variations in machine type did not affect the distribution of fibres with respect to fibre type, colour or length.

Une étude de population a été menée pour analyser des exemples d'une population de fibres colorées que l'on peut retrouver dans des machines à laver domestiques à chargement avant ou à chargement par le haut, durant le printemps à Sydney, en Australie. Des t-shirts en coton blanc ont été lavés individuellement avec une charge normale d'une lessive d'un ménage, passés ensuite au ruban adhésif pour récolter toutes fibres étrangères transférées durant le cycle de lavage. 12178 fibres ont été classées selon leur longueur, couleur et leur classe générique. Les fibres de coton étaient prévalentes (69.4%), suivies par des fibres fabriquées (24.2%). Les combinaisons les plus communes de couleurs et de classes génériques étaient le coton noir/gris (27%), le coton bleu (20%) et le coton rouge (15.6%). D'autres combinaisons constituaient généralement moins de 2% de la population totale des fibres. Deux tiers (65.9%) des fibres récoltées avaient une longueur inférieure à 2mm, la proportion de fibres diminuant avec l'augmentation de la longueur de la fibre. Les différences de types de machines n'ont pas affecté la distribution des fibres selon le type de fibre, la couleur ou la longueur.

Eine Populationsstudie wurde durchgeführt, um Beispiele aus der Population farbiger Fasern zu analysieren, die in Front- und Toplader-Waschmaschinen in Sydney, Australien, im Frühjahr zu erwarten sein können. T-Shirts aus weißer Baumwolle wurden sowohl alleine als auch zusammen mit anderen Textilien gewaschen. Anschließend wurden die dabei übertragenen Fremdfasern mittels Klebeband gesichert. 12.178 Fasern wurden bezüglich ihrer Länge, Farbe und des Materials klassifiziert. Baumwollfasern waren mit 69,4% weit häufiger als Chemiefasern mit 24,2%. Die häufigsten Kombinationen bezüglich Farbe und Material waren schwarze/graue, blaue und rote Baumwolle mit 27%, 20% bzw. 15,6%. Andere Kombinationen repräsentierten jeweils weniger als 2% des gesamten Faseraufkommens. Zwei Drittel (65,9%) der gesicherten Fasern waren weniger als 2 mm lang; mit steigender Faserlänge wurden die Anteile immer kleiner. Unterschiedliche Maschinentypen hatten keinen Einfluss auf die Faserverteilung bezogen auf Fasertyp, -farbe oder -länge.

Se realizó un estudio de población para analizar ejemplos de poblaciones de fibras coloreadas que pueden encontrarse en primavera en lavadoras tanto de carga vertical como de carga frontal en Sidney (Australia). Se lavaron camisetas blancas de algodón primero por separado y después con otra ropa de lavado doméstico normal. Despues se pasaron por cinta adhesiva para recuperar las fibras extrañas que se hubieran adherido en el proceso de lavado. Se clasificaron 12.178 fibras en función de la longitud, color y género: Las más prevalentes fueron las de algodón (69,4%) seguidas de las artificiales (24,2%). Las combinaciones color/género más frecuentes fueron algodón negro/gris (27%), algodón azul (20%) y algodón rojo(15,6%). Otras combinaciones representaban por lo general menos del 2% de la población de fibras. Dos tercios (65,9%) de las fibras recobradas medían menos de 2 milimetros siendo menos frecuentes a medida que eran más largas. Las variaciones en el tipo de lavadora usada no tuvieron influencia en la distribución de las fibras en lo que se refiere al tipo, color o longitud.

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Introduction

The value of textile fibres as physical evidence has long been instituted. The ubiquitous nature of textile fibres facilitates their likely presence at most crime scenes. Extraneous fibres recovered from evidential items in criminal cases are subjected to an array of optical, physical and chemical analyses, and then compared to exemplars from a suspect source in order to demonstrate similarities or dissimilarities in the fibre characteristics. Textile fibres can thus be invaluable in establishing associations between people, locations and objects in a wide variety of criminal cases [1].

Whilst fibre evidence can be instrumental in forensic investigations, the common occurrence of textiles in daily life also constitutes a major source of background fibres. This is of particular importance when evidence is recovered from surfaces that are potentially in constant contact with numerous textiles. The question of commonality is often posed to the expert with regards to fibre evidence, with the aim of suggesting that the acquired evidence is not significant. Knowledge of the frequency of occurrence of fibre types in a given population is therefore required in order to assess the evidential value of finding fibres that could not be differentiated from a suspect source. In general, the more common the fibres, the lesser the value of the evidence. Conversely, fibres which are rare by virtue of an unusual morphological characteristic, specific usage, limited production or obsolescence will have strong evidential value, even when they are present in low numbers [2].

Population surveys are a type of investigation which assist in the accumulation of fibre frequency data by detailing the components of a fibre population on a chosen surface [3]. Representative samples are collected and the recovered fibres classified according to characteristics such as generic class and colour. This firstly gives an estimation as to which fibres are common, and secondly provides background data for the surface of interest [2]. This information becomes increasingly important when a Bayesian model is applied to the interpretation of fibre evidence.

Population surveys carried out in the United States and Europe have examined a variety of surfaces including garments encountered in casework, T-shirts, car seats, bus seats, human head hair, and a range of outdoor items [4–12]. In Australia, a survey of the foreign fibre population on cinema seats has been conducted and reported [13]. Overall, the results of these surveys have shown that the majority of fibres are represented by only a few colour/generic class combinations, most commonly colourless, black/grey, blue and red cotton. Other fibre types, and less-commonly coloured cotton fibres such as orange, green, purple and yellow, are relatively scarce with any given colour/generic class combination rarely accounting for more than 1% of the total fibre population.

In order for this information to be reliably applied to casework, it is important that research is both contemporary and locally relevant. Studies carried out internationally will have limitations when assessing whether certain data are relevant in Australia, as differences can be expected based on climate, fashion, and the source of textile fabrics and garments [13]. Similarly, with the passage of time, the changing of fashions and the evolution of technology, new materials will inevitably be developed and the popularity of certain textiles over others may vary.

Ultimately, the basis of any fibres case will be how the crime scene was treated and the circumstances under which the evidence was collected [3]. In the time that elapses between the commission of a crime and the retrieval of evidence for examination, garments worn by the victim or the perpetrator during the crime may be laundered. In such cases, an idea of the background fibre population that can be expected to be generated by washing machines will be important in facilitating the differentiation of crime-related fibres that are relevant to the case from background fibres that are not crime-related.

The current research involved a survey of the population of coloured textile fibres transferred to white cotton T-shirts during washing, both in top- and front-loading domestic washing machines during Spring, in Sydney, Australia. The influence of machine type on the primary transfer of fibres between garments during washing was also examined.

Experimental method

The fibres in this research were collected in Spring 2003, from washing machines used in 11 households situated across Sydney, Australia. Machines comprised five top-loading washers, five front-loading washers and one combination washer/dryer (Table 1). Trends in Australia over the last decade have seen a decline in the purchase of top-loading machines, popular throughout the United States, in favour of gentler, more water-efficient front-loading machines that are common throughout Europe. Both machine types were incorporated into this study to ascertain whether this trend could pose any potential consequences for the interpretation of fibre evidence.

Garment preparation

New, white, 100% cotton T-shirts were pre-cleaned before washing using a lint remover with disposable adhesive surfaces, followed by adhesive taping. This treatment was carried out twice to remove all adhering extraneous fibres so that any coloured fibres ultimately recovered would be attributable to the washing process.

Table 1 Washing machines used in population survey.

Machine	Type	Brand	Capacity (kg)	Agitator
T1	Top-loading	Sanyo	4.0	No
T2	Top-loading	Fisher & Paykel	5.5	Yes
T3	Top-loading	Fisher & Paykel	5.0	Yes
T4	Top-loading	Simpson	9.0	Yes
T5	Top-loading	NEC	4.5	No
F1	Front-loading	LG	7.0	N/A
F2	Front-loading	Whirlpool	5.0	N/A
F3	Front-loading	Omega	4.5	N/A
F4	Front-loading	Whirlpool	5.0	N/A
F5	Front-loading	Whirlpool	5.0	N/A
C1	Washer/dryer	Bendix	6.0	N/A

Table 2 Summary of categories used for the classification of fibres.

Generic class	Colour	Length (mm)
Cotton, other vegetable (VOC), wool, other animal, man-made, unknown	Black/grey, blue, red/pink, purple, green, yellow, orange, brown	0.5–1.0, 1.1–2.0, 2.1–3.0, 3.1–4.0, 4.1–5.0, 5.1–10.0, >10.0

Cleaned T-shirts were then stored in unused plastic zip-lock bags. Control tapings of four T-shirts subjected to this procedure yielded no more than 30 coloured fibres per T-shirt, most of which were less than 0.5 mm long. This was considered an acceptable level of background noise, as this number was low in comparison to the number of fibres recovered after washing and because fibres under 0.5 mm in length were not counted in this survey.

Washing procedure

T-shirts were distributed to volunteers in sets of three with instructions for washing. Shirt "A" was washed by itself in order to investigate the population of residual fibres present in the washing machine receptacle. Shirt "B" was washed with a normal load of household washing to compare the effect of washing machine type on the primary transfer of fibres between garments during washing. Volunteers recorded the type, colour and fibre composition of accompanying garments. Shirt "C" was washed by itself directly after to assess the proportion of residual fibres that may be attributed to garments from the immediately preceding wash. This also provided a measure of the repeatability of the population frequency figures by comparing data obtained from the "A" and "C" T-shirts. Laundry detergent was added to each wash to mimic real-life cases where evidential garments are laundered. All T-shirts were hung to air-dry away from other garments to minimise the transfer of fibres to T-shirts other than during the wash cycle.

Fibre recovery and analysis

The entire outside surface of each washed T-shirt was taped using Crystal 1250 25 mm adhesive tape manufactured by Scapa Tapes to recover extraneous fibres transferred during washing. The front and back of the T-shirts were each divided into six sections – left and right sleeves, left and right upper region, left and right lower region – and a separate strip of adhesive tape was used for each section. Tape lifts were fixed onto A4 sized overhead transparencies then examined visually using a LEICA MZ6 stereomicroscope with LEICA CLS150 light source at 32× magnification. For "A" and "C" T-shirts in each set, the entire length of tape was searched. For "B" T-shirts the density of extraneous fibres on each tape lift was much greater, so a randomly selected 1.25 cm × 1.25 cm square of each tape was examined. Fibres were then examined *in situ* (without removal from the adhesive tape) using a LEICA DMR comparison microscope at 200× magnification.

Fibres were categorized by colour, generic class and length (Table 2). Fibre colour was determined subjectively under the stereomicroscope. Red and pink fibres were grouped together in one colour class as difficulties arose in distinguishing pink fibres from light/faded red fibres. For the same reason, black and grey fibres were also grouped into the one category. Length was measured by comparison with a millimetre scale under the stereomicroscope. Fibres less than 0.5 mm in length were not included, as they were generally difficult to classify by microscopy and the analysis of control T-shirts indicated that cleaning techniques were not efficient at eliminating all contaminant fibres of this length. Frequency figures were then calculated for colour, generic class, colour/generic class combinations and length for the fibre population as a whole and for the populations recovered from front- and top-loading washing machines.

Results

Twelve thousand one hundred and seventy-eight coloured fibres recovered from the washed T-shirts were analysed. Multivariate analysis showed that washing machine type gave no significant[1] variation in the number of fibres recovered from washed T-shirts, nor the distribution of these fibres in terms of generic class, colour and length. No correlation was evident between the number of fibres recovered from washed T-shirts and the number of garments included in the wash load or the capacity of the washing machine.

Fibre type and colour

The generic class distribution for fibres recovered from the full complement of T-shirts is shown in Figure 1. Cotton fibres made up the greatest portion (69.4%), followed by man-made fibres (24.2%). Other vegetable fibres, wool and other animal fibres (mainly human hairs, some cat and some rabbit fibres) constituted only a small proportion of the overall fibre population (2.3, 1.7, 1.7% respectively). Less than 1% of fibres were unidentified as to class, the majority of these being shorter fibres that were difficult to classify definitively as being either cotton or other vegetable fibres. The distribution of fibre types was almost identical for top- and front-loading washing machines (Figure 2). The combination washer/dryer did not yield significantly different background fibre populations.

The predominant colours for all fibres recovered and classified were black (41.9%), blue (28.2%) and red (19.2%), accounting for almost 90% of the total fibre population examined. Brown fibres constituted 5.6% of analysed fibres, with other colours each representing less than 2% (Figure 3). The distribution of fibre colour/generic class combinations reflected the popularity of individual fibre classes and colours. Black/grey cotton was the most common (26.9%) followed by blue cotton (20.2%) and red cotton (15.6%). Collectively, these three combinations accounted for almost two thirds of all fibres recovered. Only six of the remaining 36 colour/generic class combinations frequented more than 1% (Figure 4). These were black man-made fibres (12.2%), blue man-made fibres (7.1%), brown cotton (3.0%), red man-made fibres

[1] All significant results were at the 1% level.

Figure 1 Total fibre population by generic class ($N = 12,178$).

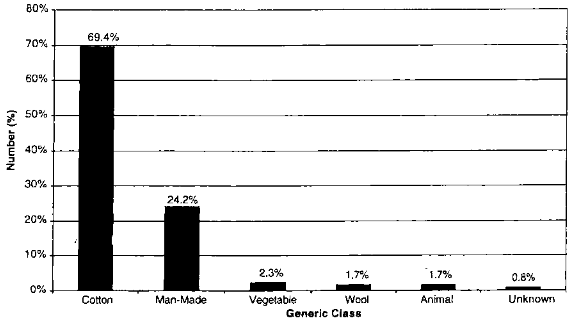


Figure 2 Generic class distribution for top- and front-loading washing machines ($N_T = 6,524$, $N_F = 4,695$).

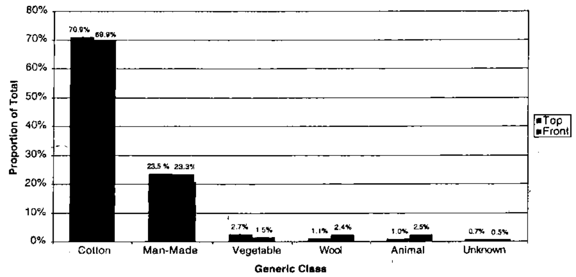
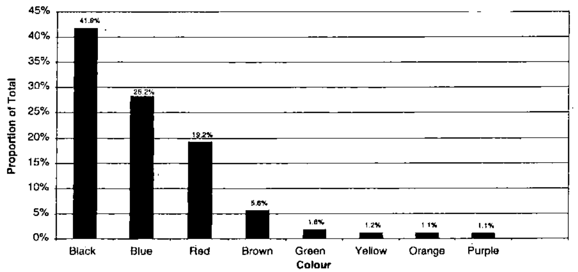


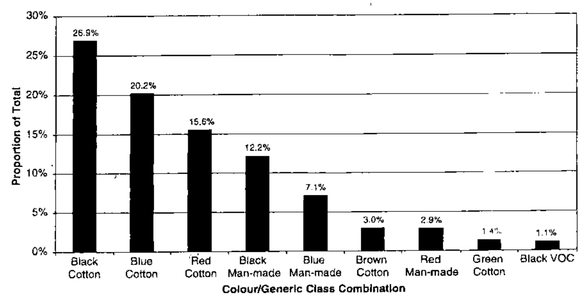
Figure 3 Total fibre population by colour ($N = 12,178$).



(2.9%), green cotton (1.4%) and black vegetable fibres, other than cotton (1.1%).

When one considers that fibres within each colour category are not identical but include a wide range of colours, whose individual frequencies will be much lower, the significance of finding fibres of colours in the less-common categories in casework is increased. Similarly, the further classification of man-made fibres by polymer type can be expected to reduce the frequencies of individual fibre types.

Figure 4 Frequencies for the most common colour/generic class combinations ($N = 12,178$).



Length

The majority of recovered fibres analysed (65.9%) were shorter fragments, less than 2 mm in length. The most common fibre length was 1–2 mm (37.2%), followed by fibres of length 0.5–1 mm (28.7%). After these two categories, the proportion of the total fibre population generally decreased with increasing fibre length (Figure 5). Machine type did not appear to influence the fibre length distribution (Figure 6). For cotton, other vegetable,

Figure 5 Fibre population by fibre length ($N = 12,171$). Seven fibres were curled up or coiled into a tuft such that the fibre length could not be estimated.

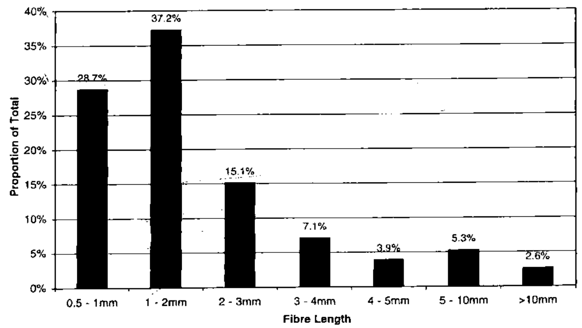


Figure 6 Fibre length distribution for top- and front-loading machines.

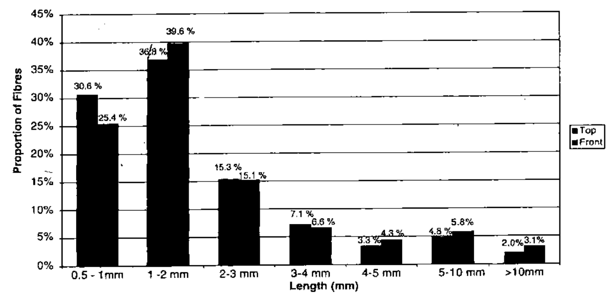
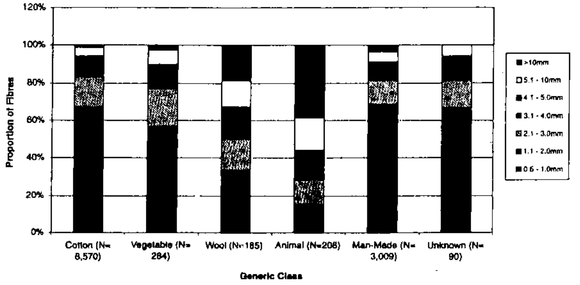


Figure 7 Length distribution within each generic class for total fibre population ($N = 12,171$).



man-made and unclassified fibres, which collectively comprised 97% of all fibres analysed, the length distribution within each class was not significantly different to that for the total population with fibres under 2 mm being the most common and longer fibres much less frequent (Figure 7). In contrast, wool and other animal fibres showed much greater proportions of longer fibres.

Washes with accompanying garments

The major effect of including additional garments in the wash load with the T-shirts was to increase the number of extraneous fibres transferred to the T-shirts during washing. Whilst the fibre populations were not affected in terms of the colour and generic class distributions, differences in the fibre length distributions were observed between T-shirts washed individually and T-shirts washed with other items (Figure 8).

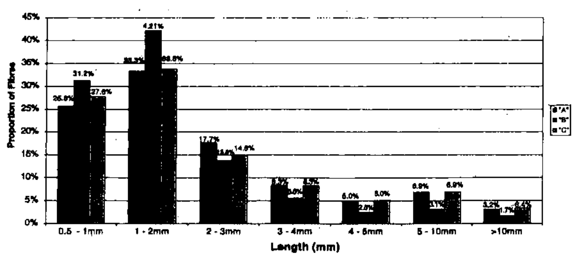
For all T-shirts, the order of fibre lengths – most common to least common – was the same. However, a significantly higher proportion of shorter fibres (0.5–1 and 1–2 mm) were recovered from T-shirts washed with additional garments (73%) compared to T-shirts washed individually (59% "A", 61% "C").

In only two cases could all of the fibres recovered from the "B" shirt be potentially attributed to garments present in the wash load with respect to colour and fibre type, with up to 32% (53/164) of fibres being unaccounted for in some washes. Similarly, between 1% (4/660) and 43% (32/75) of fibres recovered from each "C" shirt could not be attributed to any recorded garments from the immediately preceding wash. In one case, black cotton fibres constituted 25% of the fibres recovered from "B" and "C" T-shirts, the most common fibre type recovered from each shirt, where no garments washed in this machine were reported to have contained black cotton fibres.

Discussion

The results of this research correlate well with the findings of previous studies. Cantrell et al. [13] reported an almost identical proportion of cotton (69.7%) in a survey of fibres recovered from cinema seats in Sydney, with man-made fibres the second most popular fibre class and other vegetable fibres and non-wool animal fibres also in similar proportions. The most common fibre colours, black/grey and blue were consistent between the two Australian studies. The hierarchy of fibre colour/class combinations was also similar, the only notable differences were higher proportion of black wool fibres and lower proportion of red cotton fibres recovered from cinema seats. Wool fibres comprised a lesser proportion of fibres from washing machines (1.7%) compared to cinema seats (8.4%). The survey of cinema seats was conducted during Winter, so it could be expected that a high proportion of warmer garments would have been worn at the particular venue. In contrast, the current research was conducted during the warmer months of Spring. This was reflected in the garments included in

Figure 8 Fibre length distribution for "A", "B" and "C" T-shirts – all machines.



the household washing loads, in which only 12% were warmer items of clothing such as jackets and trousers. Of these, only one pair of trousers was reported to contain wool. This could account for the slightly higher relative occurrence of wool fibres reported by Cantrell compared to the current research. Differences in colour groupings (purple/pink rather than red/pink) could have contributed to the differences in the frequency of red fibres.

The more contemporary overseas studies have also reported similar results to the current research with regard to the most frequent fibre types encountered. Cotton fibres have consistently been found to be the most abundant fibre type, being the most common of fibres recovered from T-shirts [7], various outdoor surfaces [9], casework undergarments [5], human head hair [12], car seats [11] and casework items of evidence [6]. Man-made fibres have constituted the next most frequent fibre type, with black/grey and blue cotton fibres the most common colour/class combinations. Discrepancies in percentages and the order of less-common fibre types and colours could generally be accounted for by climatic differences in the region of study, by variations inherent on the source of fibres for analysis or by the methodology used in alternate studies. For example, Roux and Margot [11] reported wool fibres as the second most common fibre type recovered from car seats in a study in Switzerland during Winter, comprising 35% of fibres compared to 1.7% in the current research. Seasonal effects in the composition of garments in Europe have been reported to induce an increase in wool at the expense of cotton in the Autumn/Winter season due to the variation of these fibre types in outer clothing [14]. Since outer garments are more likely to come into contact with automobile seats compared to washing machines, where all garment types receive the same exposure, it is not surprising that wool fibres form a larger proportion of the fibre population in [11]. Furthermore, wool garments are less likely to be machine washed, as manufacturer instructions often prescribe "dry clean only" or "hand wash" for wool garments.

The popularity of blue cotton fibres was higher and the prevalence of cotton fibres compared to man-made fibres was greater in the present study compared to Grieve and Dunlop's survey of fibres on casework undergarments [5]. These differences could be attributed to the exclusion of blue denim fibres by Grieve and Dunlop, which would undeniably have led to an understatement of the frequency of blue cotton fibres, and the exclusion of fibres under 1mm in length which would tend to understate the proportion of cotton fibres due to the greater propensity for cellulosic fibres to fragment compared to synthetic fibres [9]. The difference in the proportion of cotton compared to man-made fibres was smaller again in a survey of casework items by Houck [6]. In his study, fibres were selected as being appropriate to the case in question and analytically indistinguishable fibres from the same item were not considered. Since man-made fibres will generally offer greater evidential value in casework by virtue of their great diversity in morphological characteristics and sub-classes, and lower frequency of occurrence compared to cotton fibres, it is likely that a selection of "appropriate" fibres would be biased towards man-made over cotton, thereby reducing the number of cotton fibres reported and increasing the number of man-made fibres. This selection criteria could also account for the greater prevalence of brown fibres reported by Houck, as selecting fibres "appropriate" for each individual case could reasonably lead to an overstatement of the population of (ordinarily) less-common colours that would have greater evidential potential. Similarly, the exclusion of analytically indistinguishable fibres from the same textile would lead to an understatement of colours such as blue and black, which have been shown to exhibit lower differentiability [15].

Few of the previous population surveys have reported frequencies for fibre length. The length distribution of fibres recovered from car seats reported by Roux and Margot [11] closely followed that of the current study for fibres greater than 0.5 mm. Grieve and Biermann [9] also included fibre length as one of the properties analysed for fibres recovered from outdoor surfaces. Of the fibres recovered that were greater than 0.5 mm, a higher proportion of fibres were in the 0.5–1.0 mm category in the outdoor surfaces study (46%) compared to the current study (28.7%). One explanation would be the influence of hard, rough outdoor surfaces on fibres which tends to increase fragmentation, as was evidenced by the fact that a lot of the smaller fragments were damaged with frayed ends, poor scale patterns and adherent dirt particles. Palmer and Oliver [12] reported a similarly higher proportion of fibres in the 0.5–1 mm category in the population sampled from human head hair. Other fibre lengths were in comparable proportions for these studies.

Fibres transferred from garments to T-shirts during a normal wash load showed a higher proportion of shorter fibres compared to those transferred from residual fibres in the machine receptacle in subsequent washes. One explanation could be that the presence of extra garments leads to greater fibre fracture due to contact and friction between garments during washing. Furthermore, fibre persistence has been shown to decrease with increasing fibre length [16–18] such that the population of adventitious fibres on garments immediately before washing could be expected to consist of mainly shorter fragments. Thus, the population of fibres available for secondary transfer to other garments during washing would likely consist of shorter fibres.

Animal fibres, other than wool, recovered were mostly human hairs, many of which still contained the hair root. These were recovered both from T-shirts washed by themselves and from T-shirts washed in the household laundry load, indicating that hairs as well as textile fibres will remain in machine receptacles to be transferred to garments in subsequent washes and can be transferred between garments during washing. The practical implication of this is that when hairs forming evidence in a given case have been recovered from garments that are known to have been washed, the location of the hairs and the fact that they were recovered from a particular garment should be interpreted with caution.

Fibres recovered from washed "B" and "C" T-shirts that could not be attributed to any accompanying garments were most likely the result of a secondary transfer of extraneous fibres present on the surface of the garments included in the wash, rather than from fibres constituting garments in previous (unrecorded) washes remaining in the receptacle for several washes. For machine T1, brown and yellow wool fibres were recovered from both "B" and "C" T-shirts where no woollen items were included in the wash load. For this machine, the composition of garments included in each wash had been recorded for the month preceding the experimental washes and no brown or yellow woollen garments had been washed in that time. Concurrent studies in the redistribution of textile fibres during washing have confirmed that a secondary transfer of fibres does occur between garments, and that fibres tend not to persist in machine receptacles for more than one wash [19].

This can also account for the high proportion of black cotton fibres recovered from "B" and "C" T-shirts washed in machine F4 where no black cotton garments were included in the wash load. Population surveys of the fibres recovered from worn T-shirts have shown black cotton fibres to be among the most common type of extraneous fibres found [7, 8]. It would be reasonable to expect that black cotton fibres would be present on the surface of clothing included in the wash, such that a secondary transfer of these fibres to other garments (in this case, white cotton T-shirts) would occur during washing. This phenomenon accentuates the inherently precarious nature of inferring associations based on comparisons of extraneous fibres recovered from multiple evidentiary items without known source samples, a hazard that is exacerbated when it is known or suspected that the items have been laundered.

Conclusion

The current survey of domestic washing machines showed that the majority of recovered fibres were cotton (69%) with black/grey, blue and red cotton constituting two thirds of the total fibre population. Aside from black and blue man-made fibres, other colour/generic class combinations represented only very low proportions, mostly less than 2%. The practical implication is that the finding of fibres of the less-common colour/generic class combinations will carry higher potential evidential value, even when it is known that the garment under investigation has been laundered.

Two thirds of the recovered fibres were under 2 mm in length, the proportion of fibres decreasing with increasing fibre length. Variations in machine type and the presence of other garments in the wash load did not affect the distribution of fibres with respect to fibre type, colour or length. Whilst the inclusion of additional garments in the wash load increased the number of fibres recovered compared to T-shirts washed individually, the number of fibres recovered was not seen to correlate with the number of additional garments or the washing machine capacity.

The results were generally consistent with results reported for previous studies, both domestic and overseas, with regards to the most popular fibre types, colours, and colour/generic class combinations. Small discrepancies that existed could be explained by variations in climate for the locale surveyed, or by particular facets of the methodology used in alternate studies such as the exclusion of certain fibre types.

In casework, even when it is known that evidential garments have been washed, it is not likely that the other garments included in the washing load will be known. The information gained by this project is useful in providing knowledge of the likely background fibre population generated by washing machines, in order to facilitate a more meaningful interpretation of the significance of recovered fibre evidence. The results not only showed that a primary transfer of fibres occurs between garments during laundering but also that machine washing facilitates the secondary transfer of extraneous fibres present on the surface of one garment to another. These extraneous fibres, as well as constituent fibres from the included garments, can remain in the machine receptacle and be transferred to garments in subsequent washes. As such, interpretations based on the distribution of fibres recovered from garments that are known to have been laundered should be made with caution.

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