# Comparing Reports with Actual Missing Persons' Footwear

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## ABSTRACT

Search and rescue resources conduct missions for tens of thousands of persons annually. Visual trackers constitute one of many resources involved in searches for missing persons. Original research compares report details with actual find characteristics of 428 missing persons' footwear (or lack thereof) from 1970 to 2024. Footwear report details such as type, brand, color, and size proved correct for 78%, 87%, 88%, and 91%, respectively, when missing persons were found. Paradoxical undressing, voluntary and involuntary removal, and cognitive impairments contributed to 25% of all subjects being found unshod. Data forms and a database were created to collect misper footwear information. A case study illustrates the beneficial application of footwear investigations. This new research provides a unique foundational understanding of how footwear information can be applied to search missions.

**KEY WORDS:** *Search and Rescue, Tracking, Shoe, Boot, Barefoot, Unshod, Signcutting*

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## INTRODUCTION

This study took aim at several goals including conducting original research to gather and compare report and found footwear data, constructing a foundational database of footwear information for more research, communicating results of findings, providing motivation for pursuing subject footwear information, demonstrating the application of footwear information at a search, providing a foundation for developing tracking tools, and suggesting improvements, including a new document for footwear investigations.

In 2023, the United States (U.S.) population was estimated at 335 million (USCB, 2024), and that population is expected to purchase a wide variety of footwear types, colors, styles, and sizes. From 2010 through 2019, U.S. citizens purchased over two billion pairs of shoes annually from 2010 through 2019 (Statista, 2024). William Bodziak (2017, p. 294) observes, "The large number of shoes sold per year combined with shoes purchased in prior years equates to many billions of shoes in the US." Regarding the evolution of the human foot and footwear, Hawes and Sovak (1994, p. 1213) note, "The human foot has evolved from a

generalized grasping organ to an organ specialized for weight-bearing and locomotion. To facilitate these functions, man has clad the foot in a variety of coverings to afford protection and warmth. In today's society, these foot coverings have become increasingly specialized for a variety of tasks..."

Though a small portion of the entire population, hundreds of thousands of persons are reported missing every year in the U.S. alone and certainly more happen world-wide (GoC, 2023; NMPCC, 2022; Shalev & Humer, 2022). The Federal Bureau of Investigation's (FBI) National Crime Information Center annual statistics for 2015 through 2022 recorded between 521,705 and 651,226 missing persons reports (FBI, 2016, 2017, 2018, 2020a, 2020b, 2021, 2022, 2023) resulting in an annual mean of 595,873. Though not all reports result in organized search efforts for missing persons (also referred to herein as subjects or mispers), search resource deployments occur thousands of times every year in the U.S. For example, the National Park Service alone conducted an average of 4090 search and rescue operations per year from 1992 through 2007 (Heggie & Amundson, 2009).

Similar trends occur in other countries as well. For example, England and Wales (E&W) receive over 300,000 calls regarding missing persons, and initiate approximately 250,000 incidents per year (NCA, 2014, 2015, 2016, 2017, 2019a, 2019b, 2020, 2021, 2022, 2023; NPIA, 2011; SOCA, 2013). Additional countries experience a similar high volume of misper calls to policing agencies (GoC, 2023; NMPCC, 2022; Shalev & Humer, 2022).

One of the first tasks in a methodical search and rescue (SAR) mission is gathering subject information. Koester (2008, p. 4) writes "Investigation is the tool that helps determine the specifics of an individual." Subject information includes reports of clothing (including footwear), belongings, and other items that might inform searchers about potentially relevant clues. While common sense dictates that one's footwear is the most common contact point between a person and the ground, missing person investigations don't always gather footwear information. Focusing attention to that person-ground interface can accelerate the find. Due to the lack of ability to find or interpret them, tracks are often overlooked or undervalued at searches. Bodziak (2017, p. 6) suggests, "What is not looked for will not be found."

This research lays the foundation for perpetual SAR tracking tools development. Visual tracking resources (trackers) endeavor to find, interpret, and follow the missing person's tracks. In addition to other types of clues, trackers and searchers often find footwear impressions or footprints during search efforts. Research is being conducted on clues found during search efforts. Preliminary findings from 503 searches indicate that subjects' tracks were found on 84 (17%) of those searches. Of those 84 searches, trackers found tracks on 67% of them and non-trackers found tracks on 19%. After a footprint is found, trackers must assess relevance to the subject. Whether the missing subject moves shod or unshod, information about their footwear (e.g., nominal size, model, or dimensions) can assist searchers in track interpretation by increasing accuracy, confidence, and ability to articulate track interpretation. Through processes of comparison and elimination, subjects' tracks can be distinguished from searchers' tracks or others that

were not made by the subject. Reducing the vast possibilities to a narrow window of usable characteristics, including outsole dimensions and tread pattern, challenges even the best trackers. Without any information about the subject's footwear, interpreting tracks can be difficult.

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## LITERATURE REVIEW

A literature search was conducted in an attempt to locate any publications relevant to footwear (or lack thereof) worn by mispers. Search terms including combinations and variations or synonyms of missing person, footwear, reports, and comparisons in Google, Google Scholar, Google Books, JSTOR, Heinonline, ScienceDirect, PubMed, Semantic Scholar, and ResearchGate yielded no results on the topic. Related publications found in those resources discussed paradoxical undressing, color blindness, and tracking. Many studies also published experiment results related to visual working memory and object recall accuracy. Those experiments studied people's abilities to recall object shapes, positions and colors on a screen or in enclosed environments (Dave et al., 2021; Geißler et al., 2023; Hu & Jacobs, 2021; Sims et al., 2022); they were not conducted in field conditions where searches occur.

While there are plenty of manuscripts on footwear types (Hsu et al., 2008, p. 328), brands (Abbas et al., 2020), colors (Banerjee et al., 2014), and sizing (Sterling, n.d.; Zupko, 1977), none of them relate to missing persons. Bodziak's (2017, p. 208) observation "Most forensic case examinations involve athletic shoes…" was the closest to any footwear description of a specific population found in the review. No research on misper footwear descriptions was found, and likewise, no writings comparing reports of subject footwear with found descriptions were discovered. The value of this research is highlighted by the originality of this study.

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## METHODS

The intention of this research was collecting and analyzing foundational data to provide informational tools for searchers looking for clues including footwear and footprints to assist in finding a misper. If there was a fair likelihood that the misper traveled on foot at some point while missing, those incidents were included. By moving on foot, subjects leave tracks which are potential clues for searchers.

Retrospective data from missing person incidents were gathered by interviewing reporting parties, subjects' families, searchers, subjects, or reading media reports. Gathered data included footwear information from two stages of searches: (1) before the subject was found, and (2) after the subject was found. If details of the subject's alleged footwear were available before the subject was found, the recorded information

included: type, color, brand, model, size, U.S. size classes (men, women, youth), and width. After the search concluded with a find, researchers then sought the same details about the subject's actual footwear (or lack thereof). When available, additional recorded information included the following: anonymized database number, source (searcher or media) code, unique case or mission number, jurisdiction/locality, state, country, FIPS code, date of search, Lost Person Behavior (LPB) category (Koester, 2008), footwear descriptive terms, alternative reports, additional comments, removal method and distance information for footwear found apart from the misper.

**Exclusions**

If a missing person unlikely traveled on foot while missing, they were excluded from this study. Examples of excluded searches consisted of movement other than on foot (e.g., airplane, wheeled transportation) or beyond the subject's control (e.g., abduction, entrapment, natural disasters, and water [flood, boating, drownings, etc.]). The screening excluded 15 searches with reported footwear information for reasons mentioned in the last sentence, and another 19 because the missing person remained at large on the date of submitting this paper. Although "search and rescue" is the common phrase, rescues that lacked a search component were excluded because two guiding principles for this research were subjects for whom a search was initiated and those who moved on foot. Due to the lack of documented footwear information, countless searches could not be included in this research.

**Inclusions**

Searches were filtered for organized search efforts for subjects who traveled on foot (e.g., hunters, hikers, despondents, children). All search subjects included in this research were located; none were still missing. One author (RS) assisted with search efforts for 273 (64%) of the incidents included in this study. Other searchers who participated in searches provided information for 100 (23%) of the incidents. Media reports with photos, video, or written descriptions accounted for 54 (13%) of the incidents.

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## RESULTS

An International Missing Person Footwear Database (IMPFD) was created to store research data. Footwear details of 428 missing persons incidents were catalogued based on observations of 413 search missions (13 incidents involved multiple subjects) from 1970 to 2024 (Figure 1). These searches occurred predominantly (81%) in Virginia, with most remaining cases in states depicted in Figure 2, and six searches (1.4%) from other countries. Collected data were stored in a Google Sheet. Python, R-studio, and the Plotly visualization library were used to create the graphics.

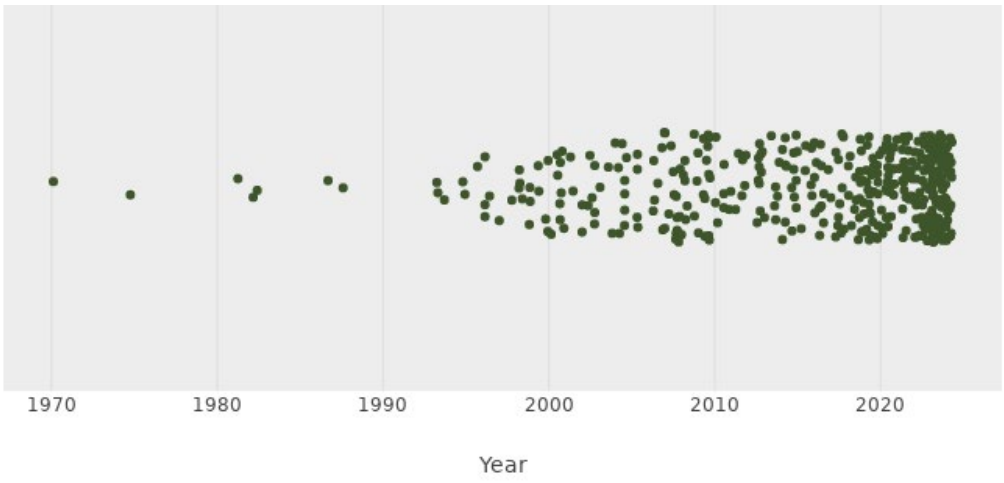


*Figure 1. A Jittered Time Series Plot Showing Year of Each Case in the IMPFD*

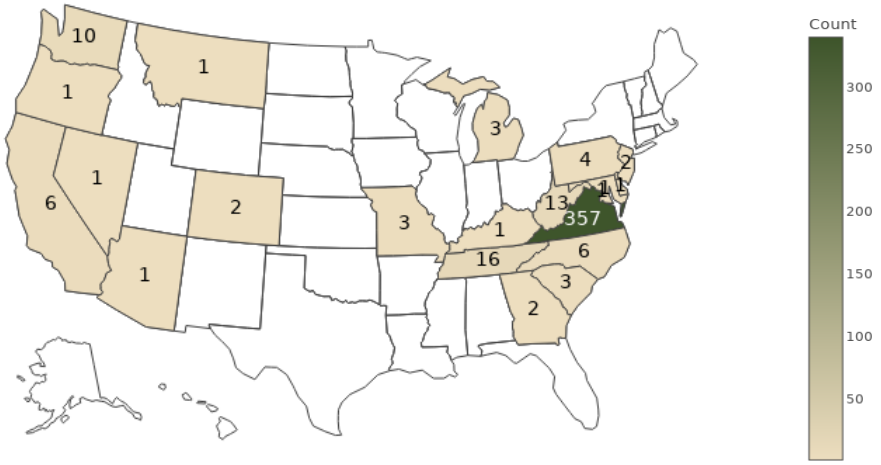


*Figure 2. A Map of the U.S. Showing Quantities of Cases in the IMPFD*

The observation unit (Ott & Longnecker, 2016, p. 26) of this retrospective research is an individual missing person. Outliers in individual occurrences include going missing more than once (four cases) and an individual exhibiting different footwear conditions between their two feet (11 cases). Data sorted into two categories originated from search mission briefings and/or interviews with family, friends, caretakers, or other reporting parties such as law enforcement officers. Though kept anonymous in the database, if any incidents involved a person that was the subject of multiple searches, each occurrence is considered individually and independently. The two categories used to segment the data, and overlap between the two, follow:

(1) Reports of footwear information before the subject was found

(2) Details of footwear (or lack thereof) donned by the subject when found
(3) Subjects for whom information was noted both before and after the person was found

"Reported" information included any details about the mispers' footwear conveyed to searchers before the search ended. "Found" information presents details gathered about the mispers' footwear after being found. Included cases contained 428 descriptions of footwear either before and/or after the subject was located. Research encountered footwear information reports for 347 (81%) incidents and examined footwear information for 265 (62%) subjects after being discovered (see Figure 3).

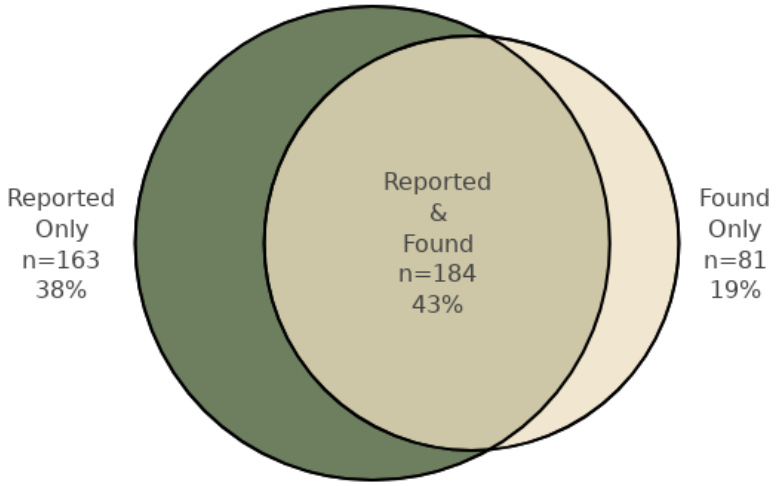


*Figure 3. Venn Diagram Showing Numbers of Subjects and Report Types of Footwear Information*

Data for reported and found details of the mispers' footwear were divided into four main descriptive characteristics (type, color, brand, size). Type is the most general characteristic of missing persons' footwear, and it can provide searchers with limited information. With additional data, it can be divided into additional categories or subcategories. Missing person footwear brands can assist trackers in narrowing the tread pattern possibilities to a few manageable options. Footwear colors can assist searchers in confirming clue assessment. The nominal size of a subject's footwear can aid searchers in interpreting the dimensions of tracks. Figure 4 shows characteristic comparison quantities for reported, found, and overlapping (both) search phases. As an example of interpreting the frequency table in Figure 4, the bottom row shows that type, color, brand, and size were documented for both reports and found conditions (179, 99, 61, and 35 times, respectively).

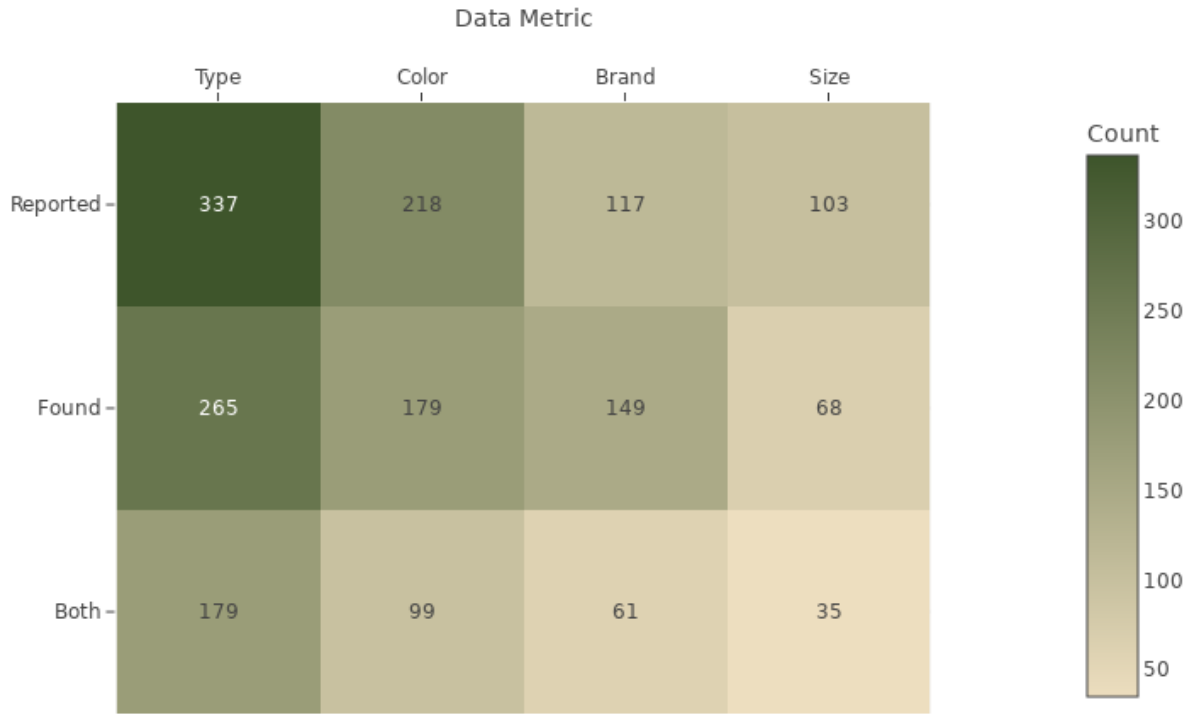


*Figure 4. A Heatmap Showing Quantities of Documented and Comparable Footwear Characteristics*

**Footwear Types**

The database organized footwear type into five categories: Boots, Shoes, Minimal shoes, Unshod, and Mixed. The first category defines boots as: “a fitted covering (as of leather or rubber) for the foot that usually reaches above the ankle” (Merriam-Webster, 2024). This paper adds a distinction to the “boot” definition: the top of the footwear is five or more centimeters above the ankle (e.g., hunting or hiking boots). The second database category defines shoes as footwear that typically stops at the ankle (e.g., tennis shoes, sneakers) and includes high-top sneakers. Next, the subcategory of minimal shoes includes open-toed or open-heeled shoes and shoes with outsoles measuring one centimeter or less compared to the insole length (e.g., flip flops, sandals). The unshod type describes subjects wearing just socks or those reported to be barefoot and/or found barefoot. If a person was reported or, more commonly, found wearing a combination of any two of the first four categories, they were designated as mixed.

Figure 5 shows percentages of footwear reports for 337 subjects and find types for 265 subjects. Subjects’ reported and found footwear conditions included all five types. Shod subjects comprised the vast majority (93%) of reports, but fewer (70%) subjects were actually found shod on both feet. Footwear (or lack thereof) status observations at the conclusion of the search (265 subjects) noted 25% of them as unshod on both feet. Subjects found unshod represented several LPB categories, as shown in Table 1. Table 1 shows LPB

category and quantities of subjects reported and found unshod; children and people with dementia were the most numerous. Eleven persons found with mixed footwear conditions included three that were reported mixed, and the other eight consisted of those found with different footwear on each foot or one foot shod and one unshod.

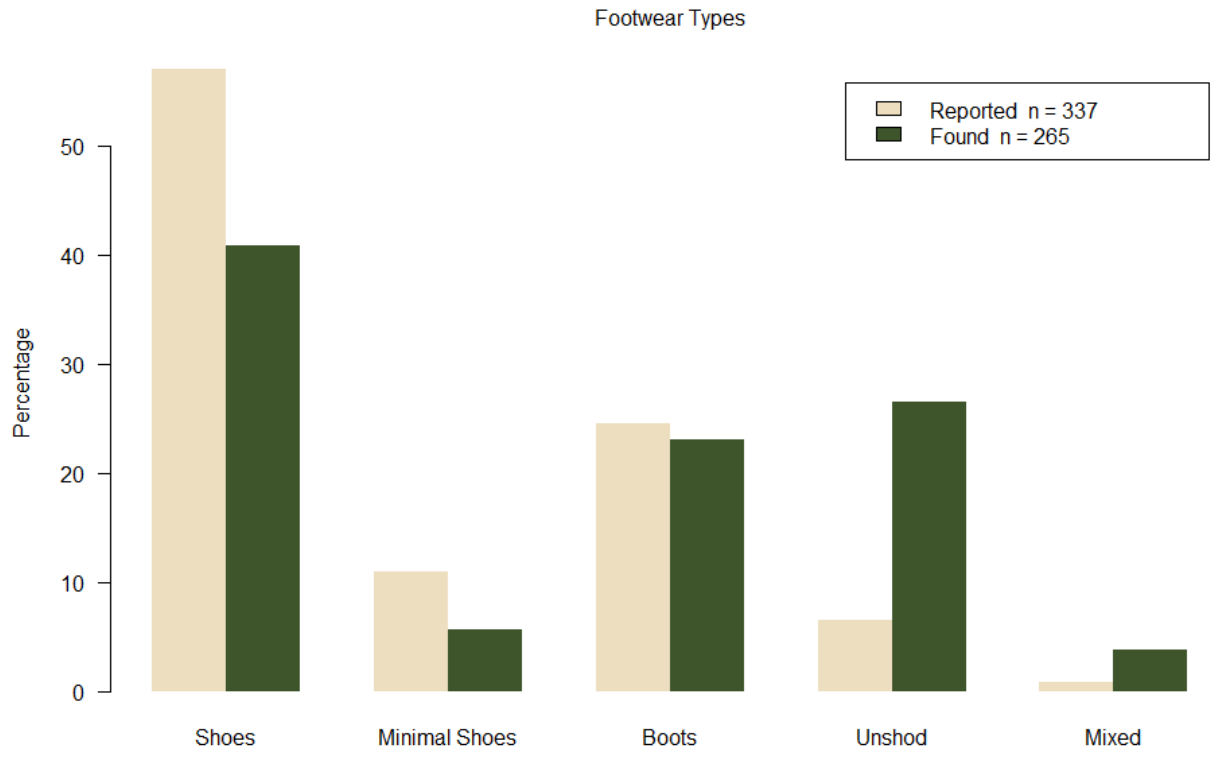


*Figure 5. A Bar Chart Comparing Relative Proportions of Missing Persons Footwear Types*

| LPB Category | Reported (n = 24) | Found (n = 71) |
|---|---|---|
| Dementia | 21% | 28% |
| Despondent | 8% | 13% |
| Children (age 1 – 15) | 46% | 21% |
| Mental illness | 4.2% | 8.5% |
| Hiker | 8.3% | 11% |
| Autism | 4.2% | 7.0% |
| Abandoned Vehicle | 4.2% | 5.6% |
| Camper | -- | 1.4% |
| Substance Intoxication | -- | 4.2% |
| Unknown | 4.2% | -- |
| **Total** | **100%** | **100%** |

**Footwear Colors**

*Table 1. Lost Person Behavior Categories and Percentages of Subjects Reported or Found Unshod*

Footwear reports involved color descriptions for 218 subjects, or 63% of footwear reports. Of those reports, 20% were for boots, 77% for shoes, and 3% for subjects with mixed types. Found footwear accounts included color for 78% of 187 subjects found shod with the same footwear on both feet. Colors were noted for 12 items of footwear worn by ten individuals with mixed footwear conditions; one mispers wore two different colors of footwear, and another was found wearing two different brands of white shoes. As a result of finding footwear separated from the subject, colors were determined for footwear of 22 subjects found with both feet unshod. Figure 6 shows the more common quantities of footwear colors distinguished by reported and found shoes and boots. The six colors reported only once, and the five colors found only once, were omitted from Figure 6.

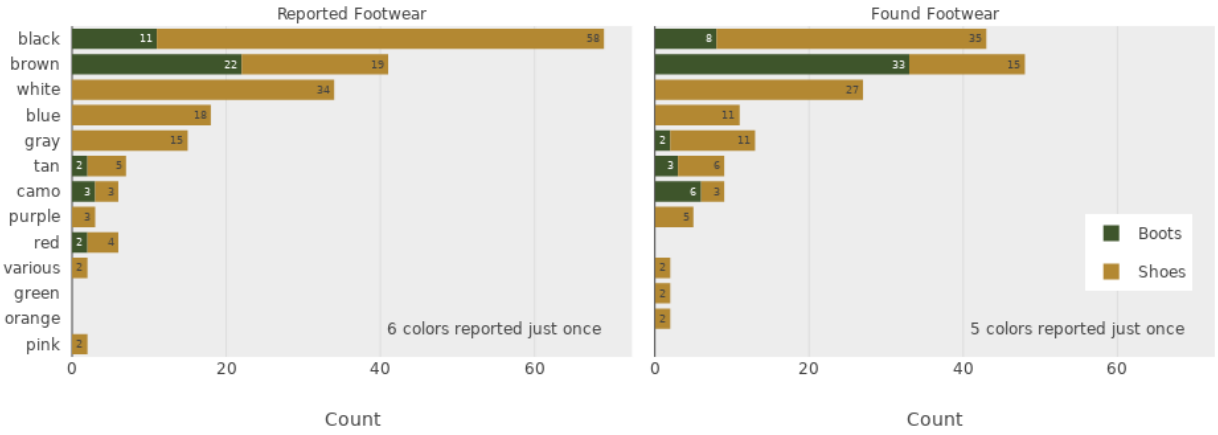


*Figure 6. Common Color Quantities of Two Types of Reported and Found Footwear*

**Footwear Brands**

Footwear descriptions included brand names for 117 subjects or 34% of footwear reports. Found footwear accounts included brand determinations for 64% of 188 subjects found shod by the same footwear on both feet. Brands were determined for ten items of footwear worn by eight individuals with mixed footwear conditions; two mispers wore two different brands of footwear. As a result of finding separated footwear during the search, brands were determined for 30% of subjects found unshod on both feet.

Figure 7 shows breakdowns of brands by type (shoe vs. boot) and search phase (report or found). Individual reports or finds – 11 brands reported only once, and 27 brands found only once – were omitted from Figure 7. Shoes comprised a majority (78%) of footwear brand reports. Nike was the most commonly reported shoe brand, followed by Crocs. Boots comprised a minority (21%) of footwear brand reports. Five brands were reported twice each, with an additional 15 brands being reported only once. Brahma, Rocky, and Timberland tied for the most commonly found boot brands on three subjects (11%) each.

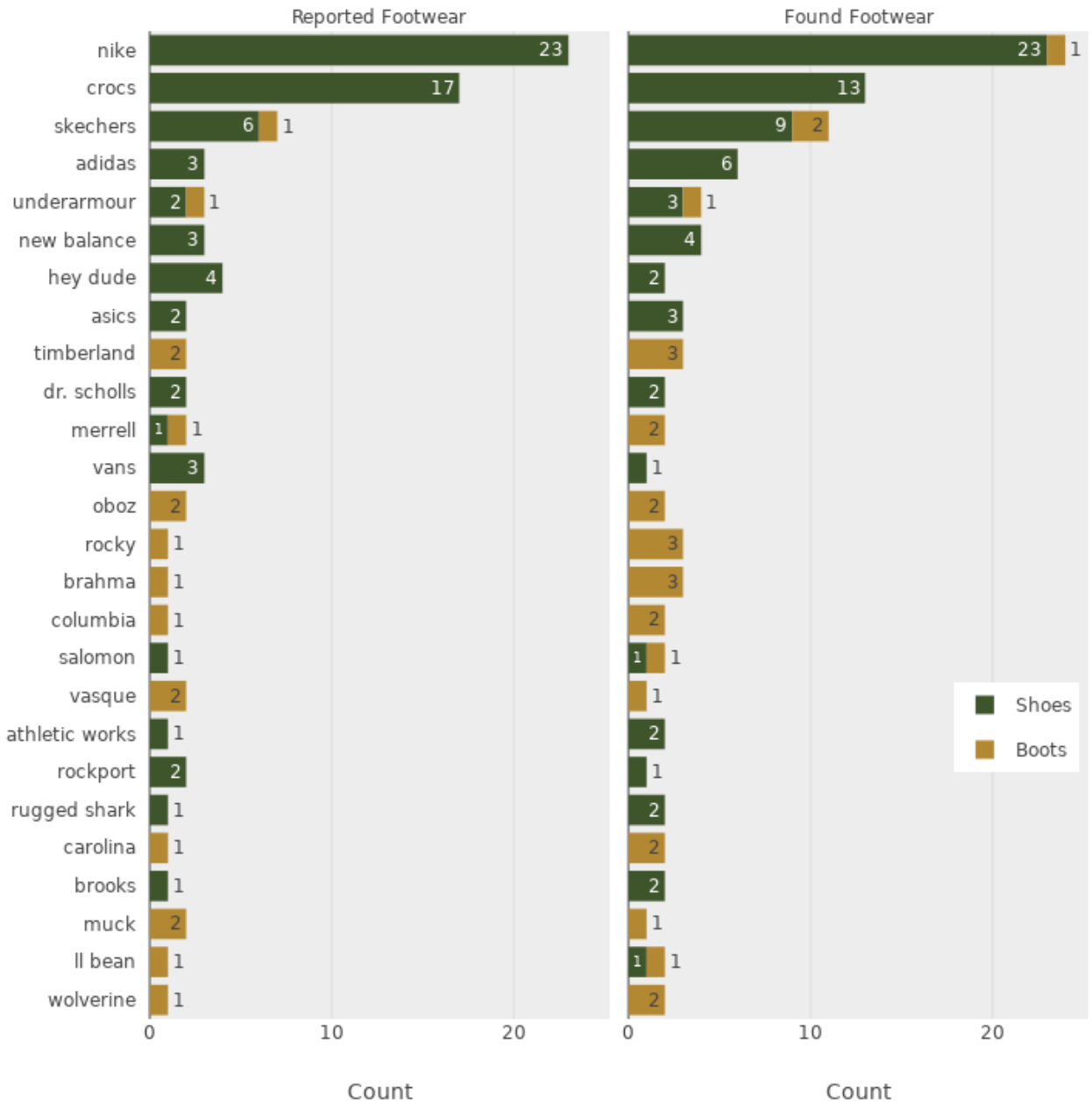


*Figure 7. Chart Showing the More Commonly Reported and Found Footwear Brands*

**Nominal Sizes**

The nominal size of footwear was the characteristic least reported (30% of 347) and least noted when found (26% of 265). Reported sizes ranged from youth 2½ to men's 15, and found sizes from youth 2 to men's 14. Of subjects' whose size was noted, 88% of reports and 71% of found footwear descriptions included additional U.S. size qualifiers (e.g., men's, women's, youth). Figures 8a and 8b show reported and found footwear sizes by gender and footwear type.

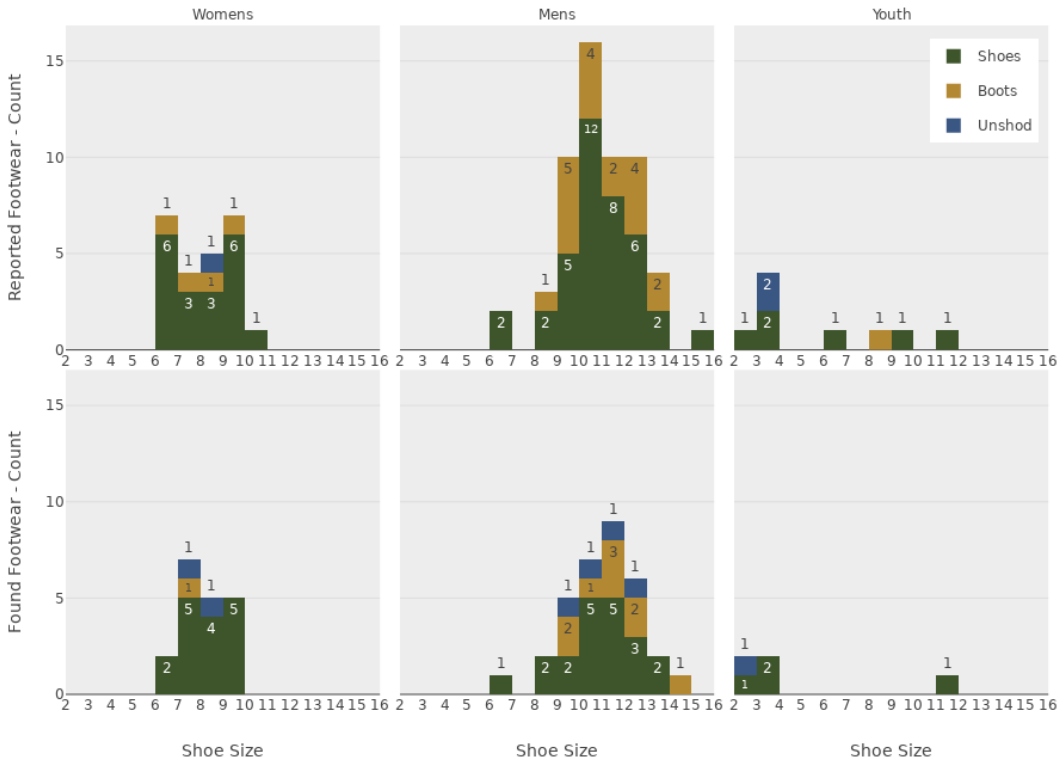


*Figure 8a. Chart Showing Quantities of U.S. Sizes Reported and Found as Arranged by Gender*

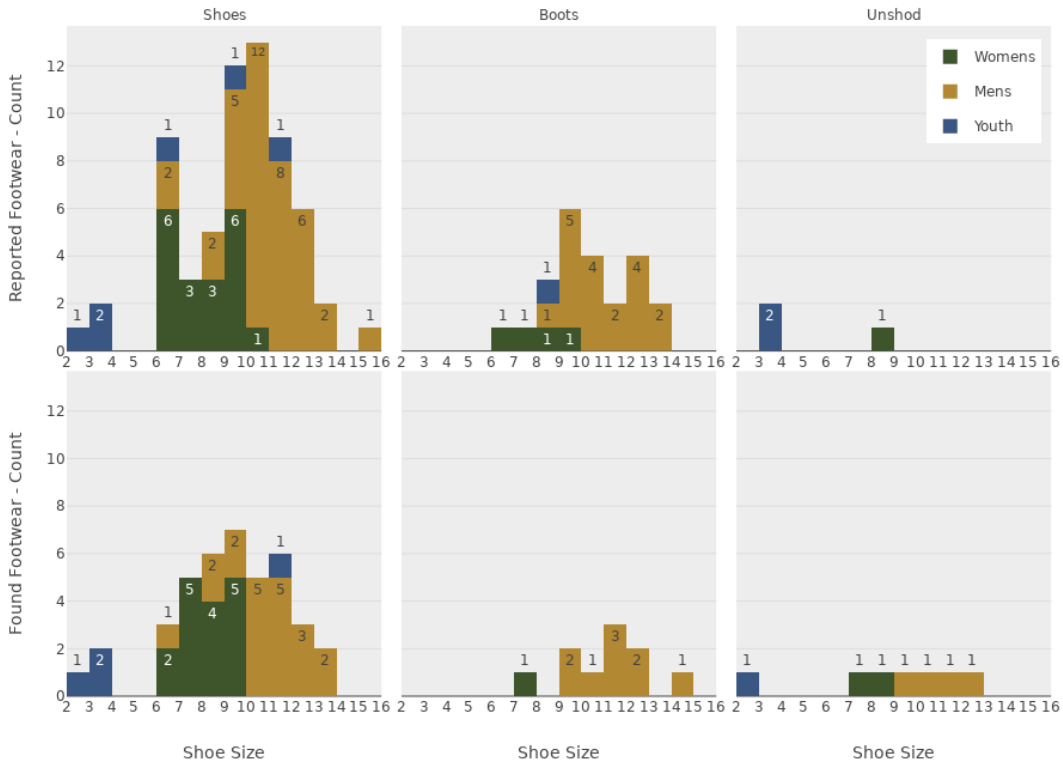


*Figure 8b. Chart Showing Quantities of U.S. Sizes Reported and Found as Arranged by Type*

## DISCUSSION

Conducting this research highlighted the difficulty in obtaining footwear information. From this study, a complete lack of any footwear information excluded hundreds of searches in which only the authors assisted, not to mention thousands of other searches that were conducted without documenting accessible footwear information.

The lack of reported footwear information is not due to an absence of prompting, since many missing person questionnaires exist in books (Diaz & McCann, 2013; Hurth, 2012; Koester, 2008; NASAR, 2018; Osuna, 2021, 2021; Robbins, 1977; Speiden, 2009, 2018; Stoffel & Stoffel, 2017; Taylor & Cooper, 1990, 2014; Young, 2021), and websites (EMSA, 2010; KYEM, 2022; NCMEC, 2022; NEWSAR, n.d.; UCSO, 2014). These questionnaires include reminders to document some description of footwear – typically including style, color, and size – reportedly worn by subjects. Questionnaires lacking a prompt for footwear information are rare, are typically brief, and lack many other questions (VSP, 2006). Even when most forms contain footwear prompts, several factors prevent the collection of footwear information. In the urgency of a missing person situation, footwear questions are likely discounted or ignored. While nearly all (97%) footwear reports contained information about the footwear type, fewer contained color (63%), brand (34%), or size (30%) information that is helpful while investigating clues such as footwear or associated track pattern and dimension information.

Footwear seems to be the least reported clothing item in missing person reports. A crude survey of 67 announcements found descriptions given for the head, torso, legs, and feet of missing persons in 88%, 64%, 64%, and 49%, respectively. Because an observer more readily notices clothing that is relatively larger in size and visible within their own eye level, a subject's top-wear (e.g., shirt or coat) tends to be reported more frequently than the lower-wear (e.g., pants or shorts), and footwear is reported the least. Nonetheless, footwear descriptions remain imperative to improving trackers' informed assessments. To provide trackers with pertinent information, it is recommended that more effort be given to investigating footwear descriptions.

Figure 9 is a representation of the reliability of reports. It shows quantities and percentages of reported footwear characteristics that were correct or incorrect. These results were determined by comparing information for subjects for whom both reported and found information was catalogued (see Figure 4, bottom row). An example of reading the figure is that reported and found brands were both noted for 61 persons, and 53 (86.9%) of those found were consistent with the reported brand.

Since having accurate information assists trackers in assessing tracks and other clues, it is important to know the reliability of reported information. The hashed regions represent cases where footwear type was reported, and though the subject was found unshod, their footwear was found separate of them and

compared to the reported type information. Trackers may be interested in that information because subjects who become separated from their footwear likely left shod and unshod tracks. The type rows suggest that type was reported and noted when found for 198 subjects, 140 (70.7%) of whom were wearing the reported type of footwear. An additional 16 (8.1%) subjects were found unshod, but footwear found separate of them during the search was consistent with the reports. Footwear descriptions, even if found separate from the subjects, are significant since there are likely to be tracks made when the subject was wearing the footwear; those tracks could lead to the subject.

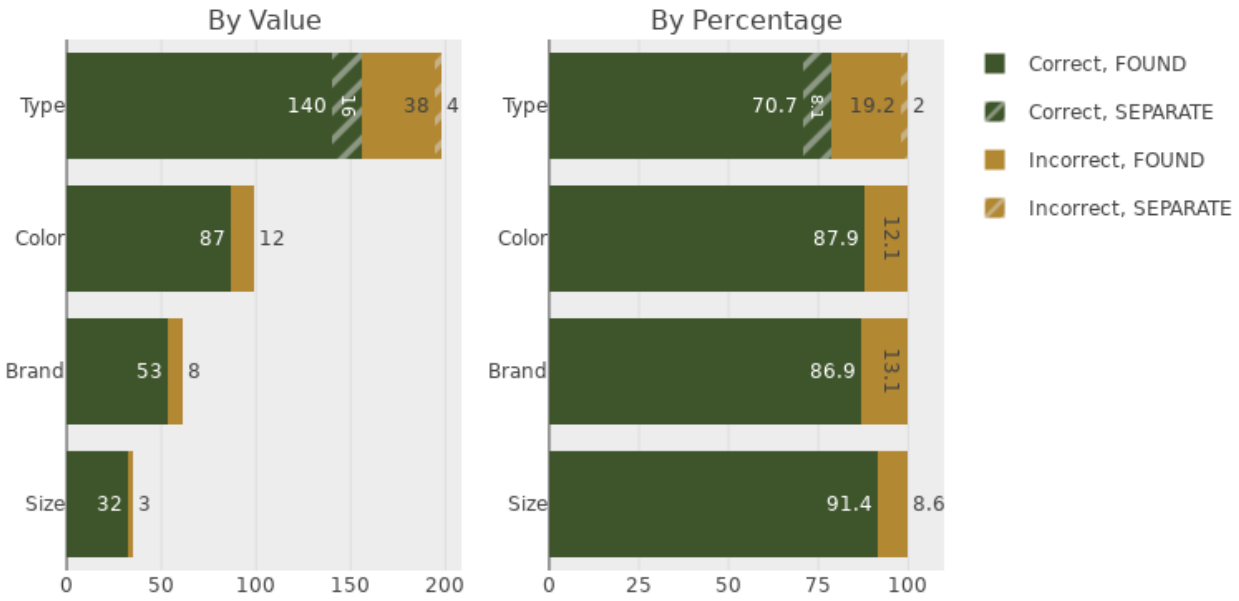


*Figure 9. Two Charts Comparing Counts and Percentages of Reports Compared to Found Characteristics for Footwear Type, Color, Brand, and Size*

**Comparing Types**

Results showed footwear type (shoe, minimal shoe, boot, unshod, and mixed) as the most common selected characteristic described in both reported and found footwear accounts. Type information was available for 79% of all subjects, and for 97% of cases with some reported footwear information. Found footwear information included type for 61% of all cases and 99.6% of cases in which any information about the subject's footwear was documented. Of the 265 subjects for whom their found footwear type was documented (Figure 4), 42% were wearing shoes, an additional 6% were wearing minimal shoes, 23% were wearing boots, 25% were found unshod, and 4% were found mixed. Some footwear styles notably absent from the database included novelty shoes and women's dress shoes (e.g., high heels and wedges).

Figure 10 is a heatmap comparison of the data points in the "Both" row of the "Type" column of Figure 4 which shows a value of 179. An example of reading a row in Figure 10 uses the "Minimal" row, indicating that 1 + 10 + 0 + 1 + 7 = 19 subjects were reported to be wearing the footwear type minimal shoes. Of those 19, one (5.3%) subject was found wearing boots; ten (53%) were found wearing minimal shoes on both

feet; one (5.3%) were wearing shoes; and seven (37%) were found unshod. The minimal shoe report subcategory exhibits the highest percentage (47%) of subjects reported to be shod who were then found unshod. While not enough for rigorous statistical analysis, the data suggests a pattern that occurs frequently enough to factor into anticipation of tracks, sign, and clues left by the subject. The trend of minimal shoes being shed more frequently than other footwear types is reflected in the discrepancy between reported and found percentages of minimal shoes, as well as the related discrepancy between the percentages of subjects who were reported to be unshod and those found unshod. While the difference in minimal shoe percentage change does not account for the entire change in the unshod category, the change in shoe percentages does explain the unshod discrepancy, and the percentage discrepancy in the mixed category, as well. Interestingly, of the 19 subjects reportedly wearing minimal shoes, none of them were found with mixed footwear conditions. One explanation for that occurrence is just a lack of a significant amount of data.

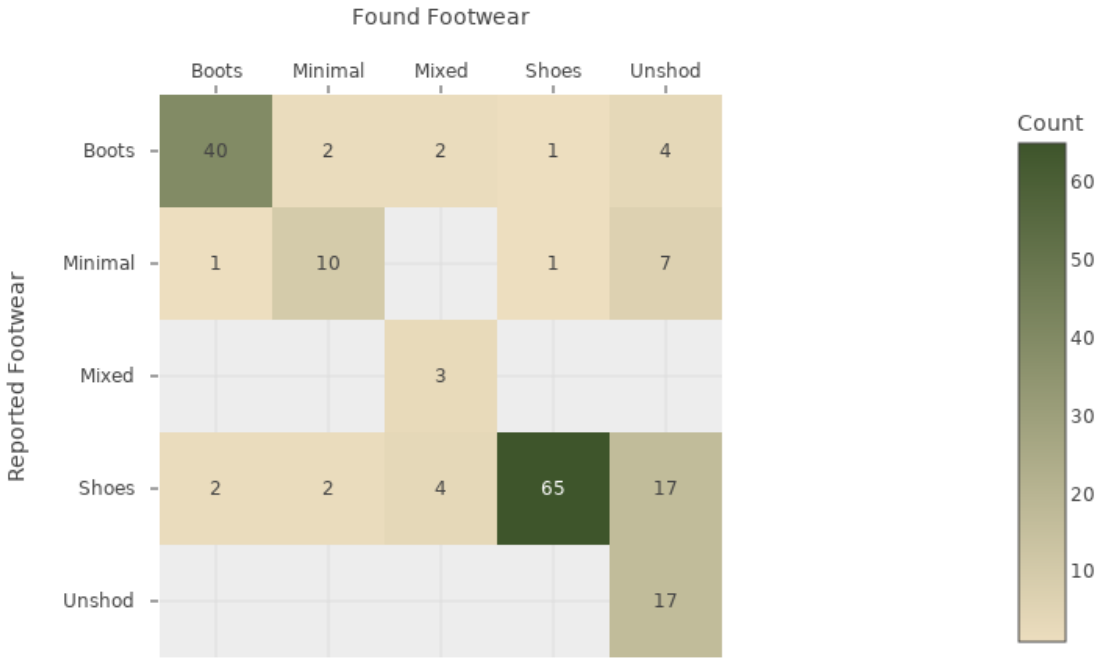


*Figure 10. A Heatmap Comparing Reports with Found Footwear Types*

The majority of subjects shown as found with their reported types of footwear or lack thereof (e.g., boots 82%, minimal 53%, mixed 100%, shoes 72%, and unshod 100%) is consistently shown across all five types as the darkest cell for each row in the Figure 10 Heatmap. The mixed and unshod proportions will likely decrease with additional data. Ironically, two subjects reported to be unshod did, in fact, wear footwear at some point while missing; their footwear was found removed, and nearby the subjects.

**Found Unshod**

While most (71%) searches involved subjects found shod, searchers found a significant portion (25%) of subjects unshod and more partially unshod. Subjects found unshod presented as either barefoot (66%), wore thin fabric such as socks or stockings (23%), had one sock and one bare foot (3%), or unknown (8%). Searchers found 50 items of footwear belonging to 26 unshod subjects. While a few subjects found with mixed results were shod with different footwear, most (73%) were shod on one foot and unshod on the other. Only 10% of subjects reported to be wearing boots were found unshod, while 19% of those reported to be wearing shoes were found unshod.

The shod category that was found unshod the most was subjects reported to be wearing minimal shoes (37%). The difference in the latter is likely due to the lack of structure in the footwear to keep them on the feet in various environmental conditions. Type reports (unshod, minimal, shoes, boots, mixed) resulting in subjects found unshod tabulated as 100%, 45%, 21%, 8.3%, and 0% of subjects, respectively. Interestingly, none of the 24 cases in which subjects reported to be unshod were found wearing footwear. Two of them, however, wore footwear while missing, but their footwear was removed and found separately during both searches. Speiden (2009, p. 104, 2018, p. 120) describes these occurrences, “Remember - even if there is accurate information about the subject’s footwear, it is quite possible that the subject may have lost his/her footwear…” This phenomenon is also mentioned in another tracking book (Moreira, 2016). If those cases stand out in someone’s memory more so than typical cases of shod subjects, shod versus unshod subject data may be skewed towards a higher-than-actual percentage of subjects found unshod (less common).

Researchers noted various reasons for 71 subjects found with one or both feet unshod: voluntary removal (20%); starting unshod (25%); paradoxical undressing (5.6%); involuntary removal (e.g., stripped by mud, vegetation, or water – 15%); medical circumstances, medication, or drugs involved (2.8%); and undetermined (31%) – though 25% of the ‘undetermined’ subjects likely started out unshod.

Paradoxical undressing (PU) is a terminal behavior associated with lethal hypothermia (Wedin et al, 1979). Anecdotes describe the actual oldest cases of PU encountered (Brown, 2009; James, 1965). Dr. Vejlens’ (1952) and subsequent papers reported over 200 cases of pre-terminal disrobing behavior (Albiin & Eriksson, 1984; Brändström et al., 2012; Gormsen, 1972; Hirvonen & Huttunen, 1982; Hlești et al., 2022; Kinzinger et al., 1991; Krispin et al., 2011; Lim & Duflou, 2008; Mizukami et al., 1999; Rothschild & Schneider, 1995; Shimizu et al., 1996; Sivaloganathan, 1985, 1986; Wedin et al., 1979). Though several theories about the cause of PU persist, none have been proven (Mizukami et al., 1999).

Researchers discovered 18 subjects for whom searchers found their footwear at different distances: less than six meters (56%), six to 100 meters (22%), and over 100 meters (22% - see Figure 11). These distances reflect more travel distance than mere victims of paradoxical undressing. Research encountered 55 cases of paradoxical undressing in literature. That research described distances of footwear from the subject at zero to six meters (74%), six to 100 meters (24%), and greater than 100 meters (2%) (Albiin &

Eriksson, 1984; Bertil Wedin et al., 1979; Gormsen, 1972; Sivaloganathan, 1986; Vejlens, 1952, as cited in Gormsen, 1972).

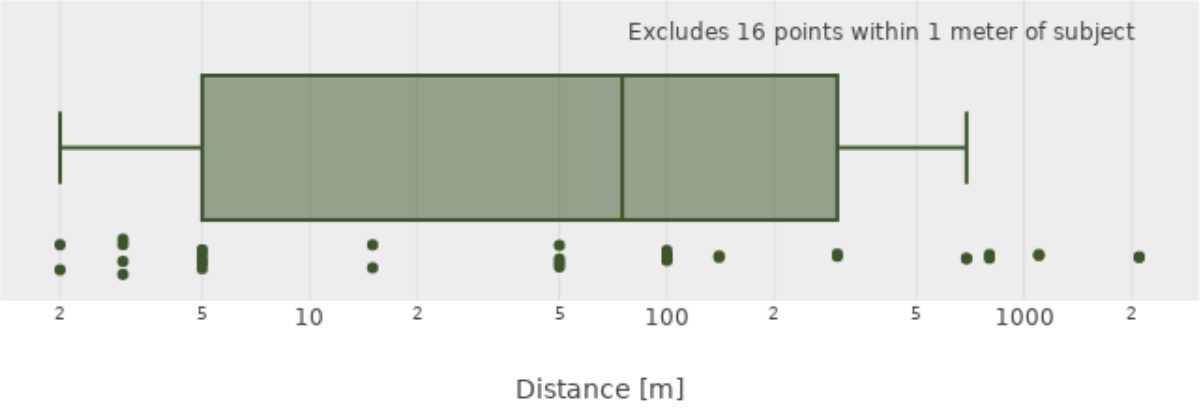


*Figure 11. Boxplot Showing Distances, on a Log Scale, of Footwear Found Separate of Missing Persons*

**Comparing Colors**

Knowing the subject's footwear color is of interest to searchers for a couple of reasons. First, footwear color, alongside other design characteristics, can assist trackers working to discover a tread pattern via research of a particular brand, model, and version of footwear. Second, color confirmation increases the confidence and ability of searchers to validate whether an item found during the search belongs to the subject. Other factors, such as the appearance of how a found item of footwear has been in its location and the size of the footwear, should be considered when assessing the relevance of any potential footwear clue.

Table 2 shows percentages of interactions between reported and found colors. Any sample sizes (n) with a ".5" value reflects an individual for whom information was noted for only one item of footwear; whereas individuals with both items of footwear were counted as "1". Color information existed for 63% of subject reports and 56% of found subjects. Black and white comprised the most commonly found shoe colors (28% and 23%, respectively). Brown, the most common boot color, equaled or surpassed all other reported (50%) and found (62%) boot color quantities combined. While it would be interesting to compare percentages of colors of shoes worn by subjects to those of a country's population, the only reference to general footwear color choices differed from our findings and was discovered in Kuru's (2022) online reference to footwear colors. In general, "Americans' top two most popular footwear colors are black (44%) and white (17%)." The difference between the two samples is likely to be inherent in the discrepancy of vast quantities of people buying footwear versus only hundreds of cases in this research. When comparing footwear color reports with found information, shod subjects showed the vast majority (88%) as correct and only 12% as incorrect (Figure 9). All discrepancies between color reports and finds occurred with shoes.

| Color | Report | Found | Found Equals Report | Found Differs From Report | Report But No Found Info | Found But No Report |
|---|---|---|---|---|---|---|
| **n** | **217** | **152** | **86.5** | **11.5** | **120** | **66** |
| Black | 31.3% | 23.4% | 21.1% | 8.7% | 40.8% | 26.5% |
| Brown | 18.2% | 26% | 25.1% | 17.4% | 13.3% | 26.5% |
| White | 15.7% | 15.8% | 10.5% | 17.4% | 19.2% | 21.2% |
| Blue | 8.5% | 6.9% | 11.1% | 8.7% | 6.7% | – |
| Camo | 2.8% | 5.9% | 7% | – | – | 4.5% |
| Gray | 6.9% | 5.9% | 7% | 21.7% | 5.4% | 3% |
| Tan | 3.2% | 5.3% | 4.7% | 17.4% | 0.8% | 6.1% |
| Purple | 1.4% | 2.6% | 2.3% | – | 0.8% | 1.5% |
| Pink | 0.9% | – | – | – | 1.7% | – |
| Red | 2.8% | 1.3% | – | – | 3.3% | – |
| Green | 0.5% | 0.7% | – | – | 0.8% | 1.5% |
| Teal | 0.5% | – | – | – | 0.8% | – |
| Orange | – | 1.3% | – | – | – | 3% |
| Peach | – | 0.7% | – | – | – | 1.5% |
| Two + | 7.7% | 4.3% | 8.8% | 8.7% | 6.3% | 4.5% |
| **TOTAL** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

*Table 2. Frequency Table Showing Comparison of Footwear Color Reports with Found Information*

Overall, color reports are reasonably accurate when compared with found footwear. This is helpful to paint a previously-unavailable picture of reliability in reported characteristics. Less common shoe colors may increase confidence in relevance assessment due to the reduced frequency of those found with missing persons. Reported-to-found-color errors were mostly (7 of 12) color discrepancies (e.g., reported brown but found blue), and the remaining five were value discrepancies (reported brown but found tan).

**Comparing Brands**

Determining information about the brand of the subject's footwear provides a significant step towards determining their outsole pattern. After learning of the subject's reported footwear brand, and with knowledge of common brand tread patterns, some trackers have recognized the missing person's tracks. Awareness of other footwear information such as model, color, and size can help deduce a subject's tread pattern and dimensions. If someone at the search is wearing footwear similar to that which the subject is reported to be wearing (or the subject has an older pair of the same brand and model in their closet), that can be helpful for trackers. In the absence of a footwear report, requesting the subject's family provide a picture of subject wearing footwear, a related shoebox, or a receipt from an online retailer would be helpful. In addition to color and size, these characteristics help narrow possibilities of what tracks to seek.

Footwear brand reports existed for 37% of all subjects reported shod and for 68% of subjects found shod. Interestingly, Figure 4 shows that the brand category is the only characteristic for which the quantity of found records exceeded that of reported records. The figure also shows that both reported and found brand information existed for 61 (14% of all) subjects. Comparing reported brands with found brands resulted in an 87% success rate – the second highest correct rate of compared variables (Figure 9). This finding suggests that if a reporting party is able to recall a footwear brand, those reports are quite accurate.

Brand-specific inferences from the IMPFD are described here. Nike, which claims over 50% of the U.S. shoe market (Goddiess, 2022) and 38% of the worldwide footwear market (Andersen, 2023), dominated the found shoe brands. They were worn by 38% of the 61 subjects for which research determined shoe brand. Boot brands, however, proved more diverse. No brand was found on more than three subjects. Three subjects wore steel/composite-toed boots; this footwear may be worth researching to determine if there is any difference in track dimensions compared to regular boots.

**Figure 12**. *Images of a Crocs™ Shoe and Similar Shoes Showing Similar and Dissimilar Tread Patterns*

As a last learning point from the brand data, there is a significant discrepancy between the number of subjects reported to be wearing Crocs, and those actually found wearing Crocs. Crocs is the only brand with more than 4 counts in the reported and found brand quantities that also had a value of reported subjects which exceeded the number of subjects found actually wearing Crocs. Crocs was one of three brands that had two occurrences of shoes being found separate of the subject. Nike had more with five of 23. Of the 17 subjects reported to be wearing Crocs, eight were found wearing Crocs; no footwear type or brand was determined for eight; and one was wearing Rugged Shark shoes, a brand similar to Crocs. Exemplified by the last case, likelihood for the higher reports of Crocs is that there are shoes that look similar to Crocs but are made by other manufacturers. Figure 12 shows the outsole of a common Crocs pattern. To the right of that shoe are other shoes with similarly-structured uppers, and similar (tan shoe) as well as dissimilar tread patterns (blue and green shoes). A Sperry-Margaritaville pairing of loafers is another combination of shoes that may have similar uppers but they have a distinctly different tread pattern.

**Comparing Sizes**

Footwear "size" can be interpreted two ways that are loosely related. Firstly, the nominal size of footwear is a description given by the manufacturer. Secondly, size can be interpreted as length, width, or other dimensions of certain features. Knowledge of a subject's footwear size can provide trackers with an approximate idea of resulting track dimensions. While there is good information for SAR trackers regarding footwear sizes, nominal size systems are varied and can be complex.

The U.S. sizes in the IMPFD do not characterize dimensions of tracks because they are catalogued in three classes (youth's, men's, and women's), which have different dimensions for a given size in each of those three classes. Bodziak (2017, p. 189) describes the lack of consistency across the footwear industry: "there are standards in shoe sizing, but there is not standardization between manufacturers." Some individual manufacturers do, however, provide size charts with measurement data (Andersen, 2023; Crocs.com, 2024; Rockyboots.com, 2024; RunRepeat, 2024). The nominal size, therefore, can give a good indication of the length of the outsole, as can the track length made by the subjects' bare or shod feet, even if a searcher compares the reported size to be smaller, similar, or bigger than their own footwear. With the variety of shoe sizing systems in the world, it will likely be necessary, or at least convenient, to convert sizes in the IMPFD to a more standard system such as the European or Mondopoint system for ease of comparison and dimension relationships.

Size information proved to be the rarest characteristic noted when found, and thereby provided the fewest cases (35) for comparison (Figure 4). Size information filtered for both reported and found yielded eight cases for boots, 26 for shoes, and one un-typed. Shoe sizes seem more accessible than boot sizes because size is typically printed on shoe tongues. Most boots need to be removed from the person to observe the nominal size, presenting an obstacle to data collection. Some footwear have the size stamped in the outsole design (see Figure 12).

A half-size margin of error was used as consideration for correct/incorrect assessments. If the report stated size 8, and the subject wore size 7½, 8, or 8½, the comparison was counted as correct. If the same subject wore footwear sized size 7 or smaller, or size 9 or larger, the comparison was tabulated as incorrect. Figure 13 shows found sizes compared to reported sizes. Find information showed 91% of the size reports (88% of boots and 92% of shoes) as correct. Size provided the lowest quantity for comparison and the highest success rate among the four characteristics (Figure 9).

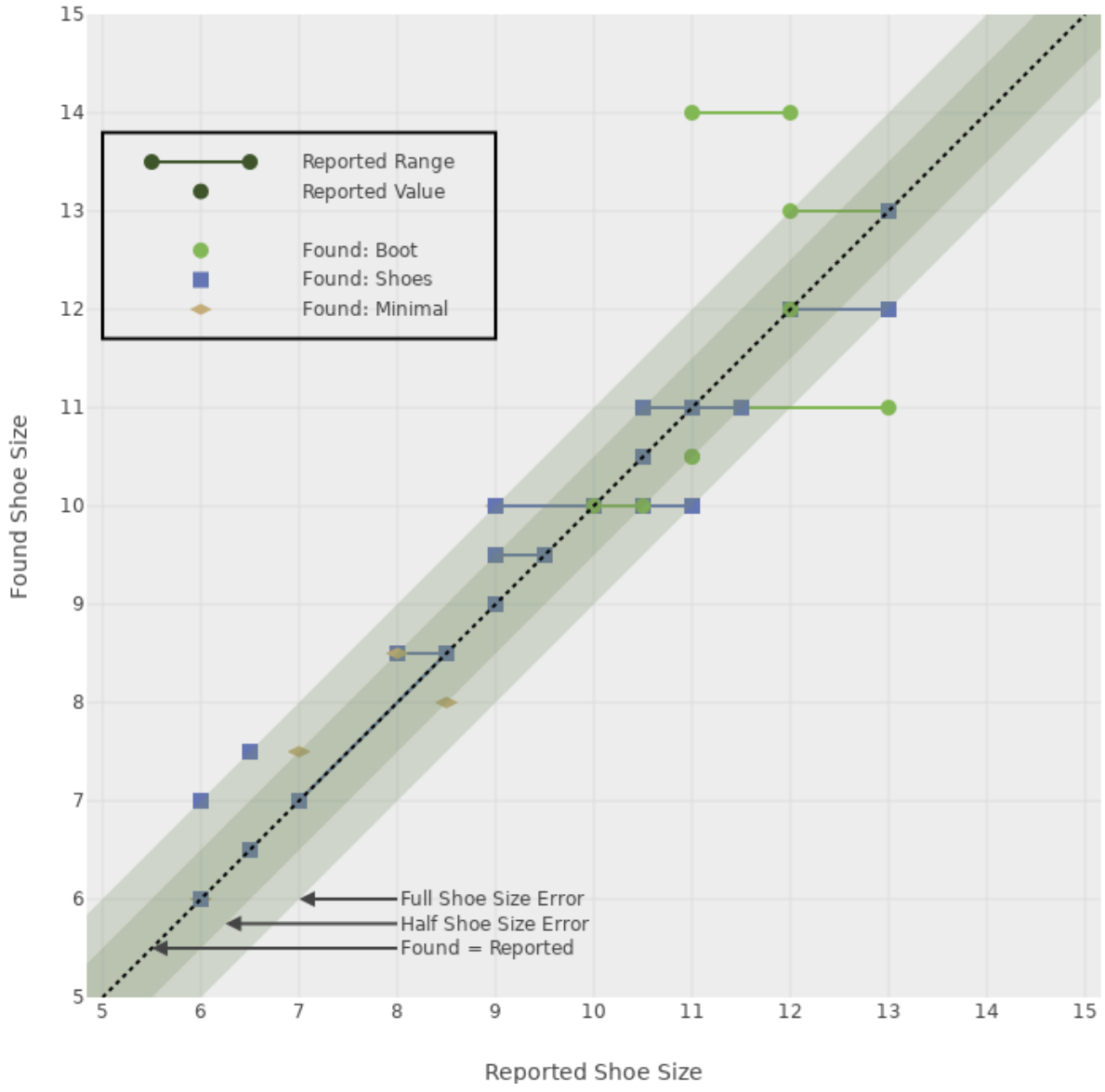


*Figure 13. Regression Plot Comparing Found with Reported Footwear U.S. Sizes*

**Recommended Footwear Form**

The research was unable to locate questionnaires or other documentation designed to record information about subjects' footwear when found. With the interest in contributing to the data already collected, this paper presents Figure 14, two sides of a card designed to assist with footwear information documentation before and after the subject is found. While non-trackers can complete the footwear information queried in most lost person questionnaires, a trained visual tracker should collect the information on this card for these reasons: (1) a tracker should be familiar with the terminology, (2) a tracker should be practiced in footwear measurement techniques, and (3) a tracker will be better trained to utilize this information.

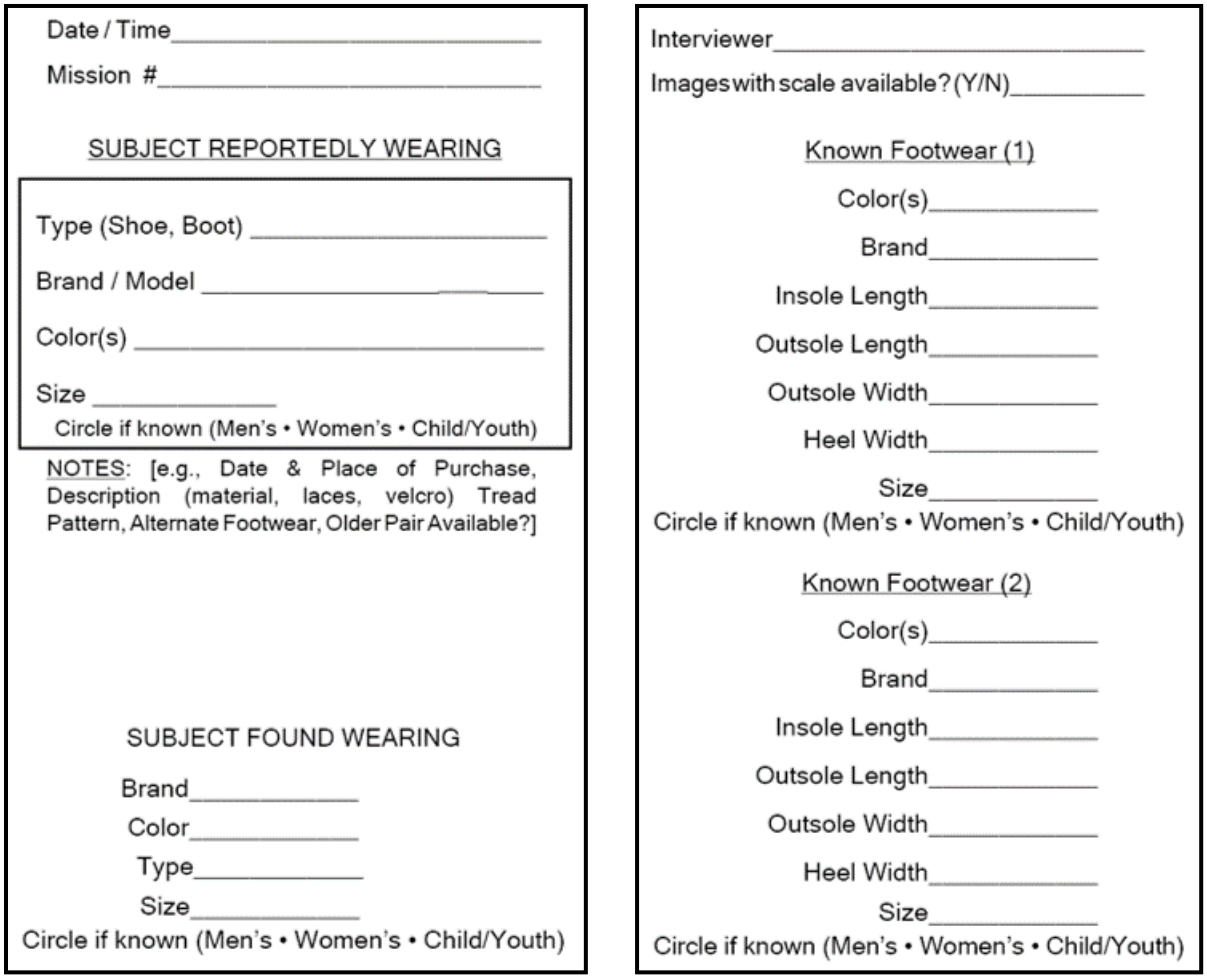


*Figure 14. Footwear Information Card Recommended for Tracking Resources and Inclusion in Missing Person Questionnaires*

**CASE STUDY**

A hunter, missing in Mecklenburg County, Virginia in December 2021 was initially reported to be wearing camouflage boots. A tracker interviewed the misper's family, and they located a box that described the boots likely worn by the misper (Figure 15A). With brand and size information, internet research produced the suspected footwear's tread pattern and measurements (Figure 15B). The tracker initially found a set of tracks that, while similar to the suspected tread pattern, was actually different in both characteristics and dimensions (Figure 15C). The tracker later found a track consistent with the suspected misper's footwear (Figure 15D). Shortly thereafter, the misper was found nearby the track, over a kilometer away from the point last seen, wearing the suspected boots (Figure 15E).

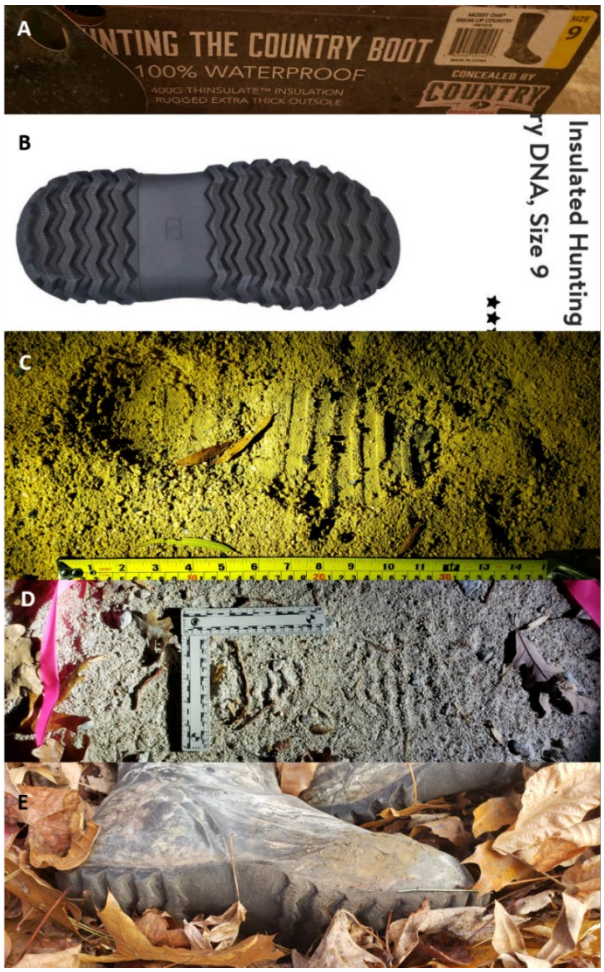


*Figure 15. Images of (A) Box of Likely Footwear, (B) Boot Outsole from Walmart App, (C) Dismissed Track, (D) Suspected Track, and (E) Misper's Boot Outsole*

## LIMITATIONS

Many comparisons discussed in this paper represented statistically small sample sizes. No form or document was found that collects found footwear information. Hopefully that absence will be alleviated by the form presented in this paper. More data may prove out or modify noted trends in footwear characteristics involved in searches. An author (RS) participated in the search efforts for 64% of the subjects included in this study, increasing potential for some bias in the information. With the expansion of the IMPFD, gathering more search data may reduce that percentage and potential biases. Access to relatives, friends, caretakers, or acquaintances who are aware of subject footwear information is crucial; a lack thereof results in data omissions.

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## ADDITIONAL RESEARCH

One intention of creating the IMPFD was to provide foundational data for numerous subsequent studies. Further studies recommendations include gathering more data similar to this study to increase the database. Gathering enough data to compare the effect of climate (or latitude) on misper footwear findings, or an urban-rural comparison of the same, could be helpful.

Due to the lack of data on basic interpretations (e.g., made by subject or not) of tracks found at searches, research could be conducted to gather and report that information. Moreover, the authors recommend a study of additional clues found during searches for missing persons, particularly those that were confirmed to have been made by or belonging to the missing person. The potential exists for future studies to utilize some of this paper's findings to generate heuristics for predicting clue and track search image information. The catalogued brands and sizes of footwear will provide guidance for additional research into footwear and track dimension relationships. For example, a study can be conducted to determine if composite-toed boots have measurably different outsole dimensions when compared to those of similarly-sized regular boots.

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## CONCLUSIONS

People in the United States purchased over two billion pairs of shoes each year from 2010 through 2019 (Statista, 2024). Even though an extremely small portion (approximately 0.2%) of the entire U.S. population is reported missing each year, narrowing down the possibilities of footwear worn by a particular subject to useable characteristics, including the tread pattern and dimensions, remains a daunting task for even the best visual trackers.

Trackers want to find and follow tracks left by subjects. In the absence of any information about the subject's footwear, difficulties exist while sorting out the subject's tracks from those of anyone else walking around, including searchers. Having some information about the footwear helps narrow down possible tracks by a process of elimination. Even if searchers have a thorough report of the subject's footwear, the subject can, at any time, lose or remove their footwear and continue moving unshod. In those cases, knowing the nominal size of the subject's footwear - or better yet, having access to footwear for measurements – can provide useful information to distinguish subject's tracks from tracks of others.

This study focused on developing a database of information that could help interpret tracks potentially left by a mispers. While the color and brand name of the shoe have little to do with track dimensions, those characteristics can assist in determining track patterns, and they also give information about what clues search teams seek. Together, these data may assist in finding the subject.

All data in this research was collected from resolved missing person cases. A significant majority (80% - 91%) of the footwear reports collected in this study turned out to be correct, as confirmed when the subject and/or their footwear was located. Searchers found twice as many subjects wearing shoes (50%) than boots (25%), and they found a significant portion of subjects partially or completely unshod (25%). Searchers found the majority (56%) of unshod subjects' footwear within sight (less than six meters) of the subject, and they found 22% of subjects' footwear within 100 meters of the subject.

Subjects typically wore black (29%) or white (30%) shoes, and subjects wore brown boots most (62%) of the time. While variety exists in the types and characteristics of footwear missing persons wear, the research to date shows exclusion of some types of footwear. Importantly, this analysis narrows the types of footwear generally worn by missing persons for tailored research on relevant footwear information, thereby excluding extraneous or irrelevant footwear types.

. Practical applications of this research include guiding the focus of additional studies regarding missing persons' footwear. Applications include narrowing the possibilities of size, design, and other characteristics, including tread pattern of tracks made by footwear (or the lack thereof) that missing persons are wearing. Even when missing persons lose their footwear, the footwear information can also indicate probable measurements of unshod (barefoot or sock-clad) footprints (Speiden & Serrano, 2024).

Supplemental materials for this study can be found at https://tinyurl.com/MPF-materials. The authors would like to end this paper with a request for readers to submit data to the IMPFD. The questionnaire for submitting footwear data can be found through the QR code (Figure 16).

*Figure 16. QR Code for the IMPFD Survey at https://tinyurl.com/mpf-survey*

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**Joel Serrano** earned his Ph.D. degree in Chemistry from Virginia Tech. He is an EMT and Search Team Leader with the Blacksburg Volunteer Rescue Squad. Joel is an Operational Tracker with the Search and Rescue Tracking Institute, and he is certified as a Level I Tracker in the Cybertracker conservation program. Through the scientific lens, Joel seeks to alleviate human suffering, if only for a moment.

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