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**PAPER**

**GENERAL**

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# Child Abduction Murder: The Impact of Forensic Evidence on Solvability

**ABSTRACT:** This study examined 733 child abduction murders (CAMs) occurring from 1968 to 2002 to explore the influence of forensic evidence on case solvability in CAM investigations. It was hypothesized that the presence of forensic evidence connecting the offender to the crime would enhance case solvability in murder investigations of abducted children. This study examined the impact of CAM of different types of forensic evidence and the impact of the summed total of forensic evidence items on case solvability by controlling for victim age, victim race, victim gender, and victim–offender relationship. Time and distance theoretical predictors were also included. Binomial logistic regression models were used to determine whether forensic evidence was a critical solvability factor in murder investigations of abducted children. This research indicated that, while forensic evidence increased case solvability, the impact of forensic evidence on solvability was not as important as other solvability factors examined.

**KEYWORDS:** forensic science, forensic evidence, murder of missing and abducted children, murder, missing and abducted children, solvability, clearance, abduction, kidnapping, homicide

Previous research has shown that most criminal investigations do not rely on forensic evidence as a means to solve the case, but to bolster the detectives chance to use that evidence to obtain a confession from the suspect to clear a case (1). Other research does indicate that forensic evidence improves clearance and help obtain convictions in burglary and robbery cases (1). Another study examined the uses and effects of forensic science in the judicial processing of felony cases (2). More recent studies have examined the role of DNA in criminal investigations (3,4) and the judicial process (3). In addition, one of the studies was in Queensland, Australia, so those findings may not hold true in the United States (4). Other research has focused on distinctions between the use of forensic evidence by the police and the courts, and at which stages in the criminal justice process forensic evidence is underutilized (5). An overview of the effectiveness of the Forensic Science Service in England and Wales, United Kingdom, concluded that police referred a small portion of cases for forensic analysis, and those analyses were generally conducted to confirm existing evidence (6). The same study found that only 7% of suspects were actually eliminated from suspicion by forensic evidence. However, these results may not generalize to the United States. Each of these studies made valuable contributions to the literature regarding the role of forensic evidence in criminal investigation.

Very little is known about the role of multiple types of forensic evidence in murder investigation, in particular, there are few empirical studies on child abduction murder (CAM) (7–10). While limited descriptive statistics are available, no previous studies have explored the role of forensic evidence in solving murder investigations of abducted children. There is a general belief that the presence of forensic evidence will positively contribute to case solvability. However, comprehensive studies on the impact of forensic evidence on murder investigation solvability do not exist. Currently, no comprehensive homicide database has forensic variable information, which also indicates at what point in the investigation the investigators received the forensic analyses results. This study was undertaken to conduct an exploratory analysis to examine the role forensic evidence has on CAM investigation solvability. This analysis is important because it illustrates the dearth of data on the impact of forensic evidence on case solvability and highlights the need to collect comprehensive data that can properly address the role forensic evidence plays in murder investigation solution.

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### Forensic Evidence in Child Abduction Murder Investigations

A handful of studies present information about limited forensic evidence variables of interest in CAM, but that information has been largely descriptive (7–10). Those studies show that unlike murders in general, in which weapons are collected as evidence in almost 40% of cases; weapons are collected as evidence in only 17–20% of CAM investigations (7–10). The most common evidence collected in these types of investigations is hair (24.3%) followed by weapons (10.9%). Other types of physical evidence are also typically found, such as finger and shoe prints (16.8%), semen (16.1%), fibers (14.9%), and blood (13.4%).

In addition to evidence that was left behind by the offender at the crime scene, a previous study examined whether or not the offender deliberately discarded evidence after the murder. Discarded evidence was found by police in 24.2% of CAMs (7–10). Of that discarded evidence, 36.0% was found along the roadway on which the killer traveled in the course of the murder, body disposal, and escape (7–9). A prior study had found that almost half of discarded evidence was found along the roadway (10). Evidence was found along the roadway within one mile of where the body was recovered in 56.5% of cases (9). This finding was less than the 59% previously reported (10). This finding has important investigative implications for CAM investigations because an investigator is likely to find evidence discarded by the offender within a one-mile radius of where the body was recovered (7–10). These studies provide valuable information to police investigators on the probability of certain types of evidence recovered and where it is most likely to be found. However, to date, no researcher has addressed the impact of forensic evidence on case solvability in murder investigations of abducted children. This is surprising, especially considering the perception of increasing impact of forensic evidence on case solvability, clearance, and conviction of offenders.

## Data and Methods

The overall objective of this research project was to examine solvability factors in murder investigations of abducted children. The purpose of this analysis was to explore the impact of forensic evidence, specifically examining the influence of forensic evidence on case solvability in CAM investigations. The relative importance of forensic evidence in relation to the victim's age, race, and gender, victim–offender relationship, and time and distance separation between murder incident components was also explored. This article discusses the findings relating to the impact of forensic evidence on case solvability in CAM investigations.

The data used in this study were collected through a cooperative agreement between the Washington State Attorney General's Office and the United States Department of Justice Office of Juvenile Justice and Delinquency Prevention (OJJDP). This data set will be referred to as the CAM data set. Data were collected based on voluntary reporting of cases from each law enforcement jurisdiction contacted. Initially, data were collected by interviews with the detectives and the review of investigative case files. Responses were received from both large and small police departments. The departments were representative of all regions of the country and 44 states (7–10).

The CAM data set utilized for this research consists of 733 CAMs in which the victims were 17 years old or younger, with 515 of those victims being single-victim murder cases rather than part of a series. The data set contains CAMs committed between 1968 and 2002 (7–9). Of the 733 cases analyzed for this research project, 27.4% remained unsolved at the time of data collection. The cases of murder in the original CAM data collection were chosen for inclusion based on the following criteria:

- The victim was *younger than* 18 years old (except as described in #3 below), whose body had been recovered, or if the body had not been recovered, the killer was identified, tried, and convicted;
- The police agency receiving the initial contact about the case, whether as a missing, abducted, runaway, or dead body case, acted on the premise that abduction was a possibility; and
- The case was part of a series in which at least one victim in the series met the above-stated criteria (7–10).

Additionally, cases were included in this data set that were not considered closed in the traditional sense. If the reporting agency believed that abduction was a possibility and began investigating the case as a child abduction case, it was included in the data (7–9). The cases of CAM examined in this research project were selected from cases in the CAM data set in which the victim was 17 years old or *younger*, whose body had been recovered, or if the body had not been recovered, the killer was identified, tried, and convicted.

Defining the terms used in this research project was critical. For instance, the word "abduction" can be interpreted from several different perspectives. For purposes of this research, as well as in the original data collection, abduction was defined as follows:

- the victim was kidnapped,
- the victim was detained and his or her freedom of movement was restricted,
- a victim of domestic violence was reported by the family (or someone else) as a missing child, and
- the police were initially of the opinion that the victim was taken or held against his or her will, whether or not that turned out to be the case in the end (7–9).

### *Dependent Variable*

*Solvability*—In the CAM data set, the dependent variable solvability was defined two ways: "Has the offender been arrested, or does probable cause exist for an arrest?" Cases that resulted in a "Yes" to the question of "Has the offender been arrested, or does probable cause exist for an arrest?" at the time of coding were considered solved, and cases that answered "No" to that question were considered unsolved. Cases coded with "Unknown" as an answer to the question were considered to have missing data and were not included in the analysis (7–9).

### *Control Variables*

Control variables were examined, which had previously been found to give an idea of the CAM sample characteristics and to determine whether these variables contributed to case solvability. These variables include, age, gender, race, victim–offender relationship, and time and distance. Because there was no general consensus in the literature on the precise age range that denotes childhood, the researcher created the following categories for the age range of the victims in this data set. Only victims 17 years old or *younger* were selected for analysis. Of those victims, the victim age variable was recoded into the following categories for descriptive statistic reporting purposes based on the age categories used in the National Incidence Studies of Missing, Abducted, Runaway, and Thrownaway Children (NISMART) study and a study on child homicide conducted by the OJJDP (11,12). The victim's age categories utilized were (i) young children (aged 1–5 years), (ii) middle childhood (aged 6–11 years), (iii) young teenagers (aged 12–14 years), and older teenagers (aged 15–17 years). However, the metric age of the child was used for the analyses.

The race of the victim is a categorical variable. Indicator coding was used to recode race into V_Black and V_Other dummy variables for statistical analysis. To examine all possible categories, the first dummy variable, V_Black, was coded as "0 = White, American Indian/Alaskan, Asian, Hispanic, and other (the reference group)" and "1 = Black (the indicator)." The second dummy variable, V_Other, was coded as "0 = White and Black (the reference group)" and "1 = American Indian/Alaskan, Asian, Hispanic, and other (the reference group)" (7).

The victim–offender relationship in this data was defined from the victim's perspective (7). Whether or not the offender was a Stranger, a Friend, or Intimate was examined. Table 1 indicates how the victim–offender relationship variable, Question 143 from the data collection instrument, was collapsed into four categories before inclusion in the CAM data set.

### *Time and Distance Theoretical Variables*

The relationships between each murder incident component were based on the theoretical model of murder investigation developed by Dr. Robert Keppel (13,14). The theoretical model for murder in

TABLE 1—*Victim–offender relationship types.*

| Original Data Collection Instrument | Child Abduction Murder Data Set |
|---|---|
| Total stranger | Stranger |
| Acquaintance (business, drugs, etc.) | Friend/Acquaintance |
| 1st Time acquaintance | |
| One-way acquaintance (victim did not know offender) | |
| Employee | |
| Friend/neighbor | |
| Hitchhiker | |
| Prostitute | |
| Student | |
| Other friend acquaintance | |
| Child | Intimate/family |
| Step-child | |
| Spouse | |
| Common law spouse | |
| Estranged spouse | |
| Ex-spouse | |
| Lover | |
| Ex-lover | |
| Sibling | |
| Family member (other) | |
| Mother's boyfriend | |
| Other intimate/family | |
| Unknown | Unknown |

general investigations states that the time and distance of each murder incident component location is under the control of the offender. The time and distance of each murder incident component is dependent on the motivation of the offender and other external conditions that were in place at the time of the murder. The murder incident components examined were the time and distance spans between the following: (i) where and when the victim was last seen, (ii) where and when the offender initially contacted the victim, (iii) where and when the murder took place, and (iv) where and when the body was recovered.

To explore the theoretical model, time and distance separation between murder incident components in CAM was examined. The components of the murder incident are as follows: the victim last seen (VLS) site, defined as the location where and time when the victim was last seen. The VLS was determined from eyewitness information and records indicating when and where the victim was last seen alive. The Initial Contact (IC) site, defined as the place where and time when the killer initially contacted the victim. The IC was established from evidence indicating that the killer first met the victim at a certain time and at a specific location during the course of the murder incident. The Murder Site (MS), defined as the place where and time when the victim sustained the death-producing injuries. The MS was established from evidence, confession of the offender, or other information provided by detectives. The Body Recovery (BR) site, defined as the location where and time when police, medics, or witnesses found the victim, dead or alive, prior to transportation to a medical facility or morgue (7–10).

There are six possible pairs of components for which a time and distance span was calculated:

- VLS to IC,
- VLS to MS,
- VLS to BR,
- IC to MS,
- IC to BR,
- MS to BR.

Time spans between the murder incident sites were examined in this study by calculating the duration of time from one murder component to each of the other components. The length of the separations was measured in hours and minutes. In the initial data collection, the distance between each pair of murder components was measured in feet or miles for each pair of components. Then the actual distance was placed into one of the following categories before inclusion in the CAM data set:

- 0 to 199 feet,
- 200 feet to <¼ mile,
- ¼ to <1½ mile,
- 1½ to <12 miles,
- >12 miles.

The first distance category of 0 feet to 199 feet was based on the collective experience of several homicide detectives originally consulted by Dr. Robert Keppel. The consensus of the detectives was that the maximum distance any killer was known to have carried a dead body to the Body Disposal site was no further than 150 feet. In their estimation, a body carried any less than 150 feet was considered to have been found in the same crime scene for investigative purposes; therefore, the distance would be considered the same as zero (7–10).

### *Forensic Evidence Independent Variables*

It is important to note that because these data cover investigations from 1968 to 2002, and the original data collection began in 1993, that the information included in the data set on forensic evidence is extremely limited. Of those items, the individual items of forensic evidence were coded as "0 = crime laboratory analysis did not link the offender to the victim," "1 = crime laboratory analysis did link the offender to the victim." Forensic evidence variables included those that were collected at the crime scene because of the investigators' supposition that the evidence would connect the offender to the crime and that connection was later verified by forensic analysis. The forensic variables also included those that were collected by the medical examiner's office or the crime laboratory which connected the offender to the crime by forensic analysis. The forensic variables collected at the crime scene because investigators believed they would connect the offender to the crime are shown in Table 2. Variables collected either by the medical

TABLE 2—*Types of forensic evidence recovered from the crime scene which were connected to the child abduction murder offender.*

| Variable Name | Percentage |
|---|---|
| Hair | 24.3 |
| Weapons | 10.9 |
| Prints (finger and foot?) | 16.8 |
| Semen | 16.1 |
| Fibers | 14.9 |
| Blood | 13.4 |
| Fluids | 7.6 |
| Firearms (spent bullet?) | 7.8 |
| Bitemarks | 1.4 |
| Tire tracks | 2.5 |
| Trace evidence | 3.0 |
| Vehicle | 2.5 |
| Clothing | 14.5 |
| Bedding | 2.0 |
| Bindings | 5.5 |
| Plants and dirt | 2.7 |
| Other evidence | 22.0 |

Totals will not equal 100% because more than one type of evidence may have been found, or no evidence may have been found by police. $N = 684$.

examiner's office or by the crime laboratory which connected the offender to the crime are shown in Table 3.

Additionally, because it was hypothesized that even if individual items of forensic evidence did not impact case solvability, that the total sum of their effect may have an influence. The forensic variables from Table 2 were used to construct a summed scale of the different types of evidence collected at the scene which were connected to the offender. This scale was named Forens17. This summed scale indicates the total number of different types of evidence collected at the crime scene connecting the offender to the crime rather than whether or not one particular type of evidence connected the offender to the crime. The items included in Forens17 are defined in Table 4. The forensic variables in Table 3 were used to construct a summed scale of the forensic evidence analyzed by the crime laboratory or by the medical examiner's office which connected the offender to the crime, and this variable was named ForenslinkO. This summed scale indicates the total number of different types of evidence connecting the offender to the crime through forensic analysis rather than whether or not one particular type of evidence connected the offender to the crime. The variables used to construct ForenslinkO are defined in Table 5.

TABLE 3—*Types of physical evidence connected to the offender by forensic analysis or the medical examiner's office.*

| Variable Name | *n* | Percentage* |
|---|---|---|
| Autopsy evidence | 122 | 17.6 |
| Hair | 98 | 15.3 |
| Semen | 90 | 14.0 |
| Blood | 76 | 11.8 |
| Fingerprints | 69 | 10.7 |
| Fibers | 55 | 8.6 |
| Other | 38 | 5.9 |
| Trace | 31 | 4.8 |
| Footprints | 29 | 4.5 |
| Spent bullet/cartridge | 23 | 3.6 |
| Weapon(s) | 21 | 3.3 |
| Clothing | 17 | 2.6 |
| Vehicle | 16 | 2.5 |
| Tire track | 11 | 1.7 |

Totals will not equal 100% because more than one type of evidence may have been found linking the offender to the crime, or not all types of evidence may not have been recovered in each investigation, or if recovered, were not linked to the offender.

*The percentage (%) represents the valid percent of the number of cases to account for missing data.

TABLE 4—*Individual items collected at the crime connecting the offender to the crime, which were included in the summed scale of forensic evidence (Forens17).*

| Variable Name | Variable Description |
|---|---|
| Hair | Evidence related to the offender recovered was hair |
| Weapons | Evidence related to the offender recovered was a weapon |
| Prints | Evidence related to the offender recovered was a finger, foot, or shoe print |
| Semen | Evidence related to the offender recovered was semen |
| Fibers | Evidence related to the offender recovered was fibers |
| Blood | Evidence related to the offender recovered was blood |
| Fluids | Evidence related to the offender recovered was a type of unspecified body fluid |
| Firearms | Evidence related to the offender recovered was firearms |
| Bitemarks | Evidence related to the offender recovered was bitemarks |
| Tire tracks | Evidence related to the offender recovered was tire tracks |
| Trace evidence | Evidence related to the offender recovered was trace |
| Vehicle | Evidence related to the offender recovered was from a vehicle |
| Clothing | Evidence related to the offender recovered was clothing |
| Bedding | Evidence related to the offender recovered was bedding |
| Bindings | Evidence related to the offender recovered was bindings |
| Plants and dirt | Evidence related to the offender recovered was a type of plant material or dirt |
| Other evidence | Evidence related to the offender recovered was other |

### *Research Hypotheses*

Research Hypothesis I states that the presence of forensic evidence connecting the offender to the crime will enhance case solvability in murder investigations of abducted children. This hypothesis examined the impact of CAM forensic evidence variables on case solvability by controlling for victim age, victim race, victim gender, and victim–offender relationship. Time and distance theoretical predictors were also included. The dependent variable was Solved. The independent variables are listed in Tables 2 and 3.

Research Hypothesis II states that the presence of more types of forensic evidence connecting the offender to the crime will enhance case solvability in murder investigations of abducted children. This hypothesis examined the impact of CAM forensic evidence variables on case solvability by controlling for victim age, victim race, victim gender, and victim–offender relationship. Time and distance theoretical predictors were also included. The dependent variable was Solved. The independent variables are listed in Tables 3 and 4.

## Model Specification

The preliminary models below were based on the theoretical framework of the models of murder investigation and CAM investigations (7–10,13,14). To examine the impact of forensic evidence in CAM, a series of models was developed to describe how

TABLE 5—*Individual items collected by the crime laboratory or the medical examiner's office, which were included in the summed scale of forensic evidence (ForenslinkO).*

| Variable Name | Variable Description |
|---|---|
| Autopsy evidence | Evidence related to the offender recovered was obtained during autopsy |
| Hair | Evidence related to the offender recovered was hair |
| Semen | Evidence related to the offender recovered was semen |
| Blood | Evidence related to the offender recovered was blood |
| Fingerprints | Evidence related to the offender recovered was a finger print |
| Fibers | Evidence related to the offender recovered was fibers |
| Other | Evidence related to the offender recovered was other |
| Trace | Evidence related to the offender recovered was trace |
| Footprints | Evidence related to the offender recovered was footprints |
| Spent bullet/cartridge | Evidence related to the offender recovered was a bullet or cartridge |
| Weapon(s) | Evidence related to the offender recovered was a weapon |
| Clothing | Evidence related to the offender recovered was clothing |
| Vehicle | Evidence related to the offender recovered was from a vehicle |
| Tire track | Evidence related to the offender recovered was tire tracks |

forensic evidence was gathered and or analyzed in CAM. Because overfitting the model is a potential problem in all data analyses, these data were previously explored and those analyses were used to specify the relevant variables to include in the models (7–10). Initially, a baseline model was created by regressing all cases against the control and independent variables, whether or not forensic evidence was collected at the crime scene which linked the offender to the crime. Additional comparison models were run, which excluded the control and theoretical predictors and included only the statistically significant independent variables. However, the findings were substantially similar, so only the models below will be discussed.

### *Types of Forensic Evidence Models*

To test Research Hypothesis I, the following models were specified:

*Model 1*—This model included all CAM investigations, whether or not forensic evidence was collected at the crime scene connecting the offender to the crime and whether or not forensic evidence was connected to the offender by either the crime laboratory or the medical examiner's office.

*Model 2*—This model included all CAM investigations in which forensic evidence was collected at the crime scene connecting the offender to the crime based on the investigator's supposition that the evidence was connected to the offender. This hypothesized connection to the offender was later verified by forensic analysis.

*Model 3*—This model included all CAM investigations in which forensic evidence was collected at the crime scene connecting the offender to the crime (later verified by the crime laboratory), and any additional forensic evidence that was connected to the offender by either the crime laboratory or the medical examiner's office.

*Model 4*—This model included CAM investigations in which forensic evidence was connected to the offender by either the crime laboratory or the medical examiner's office. These forensic evidence items were not previously thought by investigators to be tied to the offender, and the relationship was uncovered by forensic analysis.

### *Summed Scale of Types of Forensic Evidence Models*

To test Research Hypothesis II to determine whether effects in the model were attributed to the individual types of forensic evidence collected and or analyzed in an investigation, models were rerun with the summed scale of individual items of forensic evidence. The summed scale added together the number of types of forensic evidence collected or analyzed in an investigation. The following revised models were run:

*Model 1a*—This model included all CAM investigations, whether or not forensic evidence was collected at the crime scene connecting the offender to the crime and whether or not forensic evidence connected to the offender by either the crime laboratory or the medical examiner's office.

*Model 2a*—This model included CAM investigations in which forensic evidence was collected at the crime scene connecting the offender to the crime based on the investigator's supposition that the evidence was connected to the offender. This hypothesized connection to the offender was later verified by forensic analysis.

*Model 3a*—This model included all CAM investigations in which forensic evidence was collected at the crime scene connecting the offender to the crime (later verified by the crime laboratory), and any additional forensic evidence that was connected to the offender by either the crime laboratory or the medical examiner's office.

*Model 4a*—This model included all CAM investigations in which forensic evidence was connected to the offender by either the crime laboratory or the medical examiner's office. These forensic evidence items were not previously thought by investigators to be tied to the offender, and the relationship was uncovered by forensic analysis.

## Data Analysis

Prior to the multivariate analysis, diagnostics were conducted on the data to check for biased coefficients, inefficient estimates, and invalid statistical inferences, and outliers (7). Detailed information about the preliminary data analysis is contained in the Appendix. Binary response models were chosen to explore the research hypotheses because the dependent variable (Solved) is a binary, or dichotomous, variable. Logistic regression was employed as the modeling mechanism to predict whether or not a case was solved on the basis of the impact of appropriate continuous and/or categorical control and independent variables. Detailed information about the modeling mechanisms and testing statistical significance of the models is also included in the Appendix. The results from the data analysis are presented below.

### *Descriptive Information*

Information about the forensic evidence linked to the offender was collected at the crime scene in 67.2% of the CAM cases. The most common evidence collected related to the killer was hair (Table 2). The detective's supposition that the hair was from the offender was verified through laboratory analysis. Strands of the killer's hair were collected in 24.3% of the cases of CAM. Hair evidence was present in only 18.0% of all murders in general (10,13). This includes killer, victim, animal, and unknown hair evidence (7). The most common evidence collected in 39.0% of all murder investigations was a weapon (7,9). In CAMs, weapons were collected in only 10.9% of the cases. This finding is consistent with cause of death data that show children are killed less often with a weapon and more often by human physical agency (7,9).

In some cases, the offender actually destroyed physical evidence. It was not noted in the data whether or not any remaining evidence from the destruction was useful to the investigation, or if the actual destruction method may have tied the offender to the crime. Table 6 indicated the types of evidence the offender destroyed at a crime scene location. Table 7 shows how the offenders destroyed physical evidence at a crimes scene location.

### *Laboratory Analysis of Forensic Evidence Linking Offender to the Crime*

The preliminary descriptive analysis conducted on each of the cases in the data set ($N = 733$) revealed that forensic evidence linking the offender to the victim was found in 35.6% of the cases ($n = 261$). Table 2 shows the individual types of evidence

TABLE 6—*Physical evidence destroyed by the offender at a crime scene location.*

| Variable Name | $n$ | Percentage |
|---|---|---|
| No evidence destroyed | 347 | 47.3 |
| Unknown | 139 | 21.1 |
| Clothing | 46 | 6.9 |
| Blood | 31 | 4.7 |
| Actual crime scene | 29 | 4.4 |
| Body/body parts | 28 | 4.3 |
| Other physical evidence | 28 | 4.2 |
| Other personal items | 12 | 1.8 |
| Murder weapon | 7 | 1.0 |
| Bindings | 3 | 0.5 |

Totals will not equal 100% because more than one type of evidence may have been found to be destroyed or no evidence may have been destroyed. The percentage (%) represents the valid percent of the number of cases in which the offender destroyed that particular type of evidence to account for missing data.

TABLE 7—*How the offender destroyed physical evidence at a crime scene location.*

| Variable Name | $n$ | Percentage |
|---|---|---|
| Cleaned or washed | 51 | 7.8 |
| Burned | 22 | 3.4 |
| Hidden or burried | 25 | 3.8 |
| Cut up | 6 | 0.9 |
| Threw away | 18 | 2.7 |
| Removed from scene | 18 | 2.5 |
| Other disposal | 14 | 2.1 |
| Unknown | 142 | 21.6 |

Totals will not equal 100% because the offender may have chosen more than one way to destroy evidence, or more than one type of evidence may have been found to be destroyed, or no evidence may have been destroyed. The percentage (%) represents the valid percent to account for missing data.

recovered in the investigation which were linked from the offender to the crime through forensic analysis. However, information on which individual items of evidence linked the offender to the victim could not be determined by the manner in which the data were collected. Of the known cases in which the crime laboratory analysis identified the offender before investigators only 4.0% of cases ($n$ = 28). Forensic or other special crime scene equipment was used in almost a quarter of cases (27.1%, $n$ = 182). When the equipment was used, it was determined that the use was productive about half of the time (55.5%, $n$ = 96).

### *Forensic Evidence Recovered from Autopsy of Victim*

Autopsies were performed in 94.4% of cases ($n$ = 692). Physical evidence linking the offender to the victim was found in 34.1% of those cases ($n$ = 250). Cause of death was established by the autopsy in 45.3% of cases ($n$ = 316). Of the victims autopsied, toxicology tests were performed on the majority of the cases 94.3% ($n$ = 691). Drug analyses were performed on almost half of the cases (56.0%, $n$ = 371). Blood alcohol tests were also performed on over half of the cases (56.6%, $n$ = 375). Other toxicological analyses were performed only rarely (7.4%, $n$ = 49). Physical evidence of sexual assault was recovered from the bodies of 23.4% ($n$ = 163) of the victims. Other physical evidence was recovered from the autopsy in 20.9% ($n$ = 146) of cases. The victim was identified by evidence from the autopsy in only 2.4% of cases ($n$ = 17). It is unknown whether or not these individual results resulted in linking the offender to the victim, so these variables were not included in the models or used to construct the summed ForenslinkO scale.

## Results

It was determined when running the logistic regression models that once cases were selected which actually had forensic evidence collected at the scene and analyzed at the laboratory that due to the decrease in cases over all, only Models 1, 1a, 2a, and 3a converged. The data did not contain enough cases in which forensic evidence connected to the offender was collected to run each predicted model. It should be noted that each of the models lose some statistical power due to the decreased sample size because forensic evidence was not present in each case. This could explain the lack of statistical significance of some of the variables in each model.

Table 8 shows the results of regression Model 1, which evaluated Research Hypothesis I, compared to regression Model 1a, which evaluated Research Hypothesis II. Model 1 assessed the impact of forensic evidence on case solvability by including both control and theoretical variables. It was predicted that the presence of physical evidence left by the offender would enhance case solvability in murder investigations of abducted children. Individual items of forensic evidence linking the offender to the victim were only recovered in 482 cases of the original 733. As indicated in Table 8, the relationship between the dependent variable and the independent variables was statistically significant: $\chi^2$ (15, $n$ = 482) = 207.434, $p < 0.001$. The model explained approximately 60% of the variance in case solvability ($R^2 = 0.628$). Results indicated that while hair, firearms, trace, other types of evidence, and semen were retained in the model, only other types of evidence and semen showed a statistically significant impact on case solvability. If semen was linked to the offender through laboratory analysis, the case was 8.6 times more likely to be solved. The odds of solving a case were approximately 4.9 times higher when evidence defined as "other" was collected at the crime scene which linked the offender to the crime. A possible explanation for this would be that this type of evidence was a rare type that was collected so infrequently that it could not be included in one of the additional forensic evidence categories.

The strongest predictors of case solvability remained the victim–offender relationship. The odds ratio indicate that the odds of being solved were almost 306 times higher for cases in which the victim–offender relationship was that of strangers, approximately 286 times higher for friends or acquaintances, and about 36 times higher for intimate or family members as perpetrators compared to cases in which the victim–offender relationship was unknown. The time and distance theoretical variables indicated that the odds of solvability were higher if the time between the VLS and MS was greater. The odds of solvability were greater if the distance between the VLS to MS was shorter. However, a greater distance between the IC and MS increased the odds of solvability by 13.5. The victim's race being nonwhite was not statistically significant. There was no statistically significant relationship between victim age, victim gender, victim's race being black compared to white, the other time and distance variables, or the other forensic evidence variables.

Model 1a used the summed scales of the two types of forensic evidence to examine research Hypothesis II, which predicted that when control and theoretical predictors were included in the model the number of different types of physical evidence left by the offender would enhance case solvability in murder investigations of abducted children. When the total number of items of forensic

TABLE 8—*Logistic regression models predicting child abduction murder case solvability.*

| | Model 1 | | | Model 1a | | |
|---|---|---|---|---|---|---|
| | *B*† | *p* | Odds‡ | *B*† | *p* | Odds‡ |
| Control variables | | | | | | |
| Victim age | –§ | –§ | –§ | –§ | –§ | –§ |
| Victim gender | –§ | –§ | –§ | –§ | –§ | –§ |
| Victim race Black | 0.532 | 0.364 | 1.702 | –§ | –§ | –§ |
| Victim race Other | −0.886 | 0.116 | 0.412 | –§ | –§ | –§ |
| Stranger V–O relationship | 5.723 | 0.000*** | 305.874 | 5.308 | 0.000*** | 202.042 |
| Friend V–O relationship | 5.655 | 0.000*** | 285.660 | 5.404 | 0.000*** | 222.299 |
| Intimate V–O relationship | 3.593 | 0.000*** | 36.333 | 3.934 | 0.000*** | 51.089 |
| VLS_IC time | –§ | –§ | –§ | –§ | –§ | –§ |
| VLS_MS time | 0.082 | 0.001*** | 1.085 | 0.065 | 0.004** | 1.067 |
| VLS_BR time | –§ | –§ | –§ | –§ | –§ | –§ |
| IC_MS time | –§ | –§ | –§ | –§ | –§ | –§ |
| IC_BR time | –§ | –§ | –§ | –§ | –§ | –§ |
| MS_BR time | 0.054 | 0.173 | 1.085 | –§ | –§ | –§ |
| VLS_IC distance | –§ | –§ | –§ | –§ | –§ | –§ |
| VLS_MS distance | −2.716 | 0.001*** | 0.066 | −2.265 | 0.004** | 0.104 |
| VLS_BR distance | –§ | –§ | –§ | –§ | –§ | –§ |
| IC_MS distance | 2.602 | 0.001*** | 13.490 | 1.984 | 0.005** | 7.274 |
| IC_BR distance | –§ | –§ | –§ | –§ | –§ | –§ |
| MS_BR distance | –§ | –§ | –§ | –§ | –§ | –§ |
| Independent variables | | | | | | |
| Crime scene variables | | | | | Not included in Model 1a | |
| Hair | −0.902 | 0.066 | 0.406 | | | |
| Weapons | 0.906 | 0.208 | 2.474 | | | |
| Prints | –§ | –§ | –§ | | | |
| Semen | | | | | | |
| Fibers | –§ | –§ | –§ | | | |
| Blood | –§ | –§ | –§ | | | |
| Fluids | –§ | –§ | –§ | | | |
| Firearms | 2.300 | 0.141 | 9.978 | | | |
| Bitemark | –§ | –§ | –§ | | | |
| Tire track | –§ | –§ | –§ | | | |
| Trace | −1.341 | 0.088 | 0.262 | | | |
| Vehicle | –§ | –§ | –§ | | | |
| Clothing | –§ | –§ | –§ | | | |
| Bedding | –§ | –§ | –§ | | | |
| Bindings | –§ | –§ | –§ | | | |
| Plant | –§ | –§ | –§ | | | |
| Other evidence | 1.581 | 0.012* | 4.858 | | | |
| Forensic lab variables | | | | | | |
| Fingerprints | –§ | –§ | –§ | | | |
| Blood | –§ | –§ | –§ | | | |
| Semen | 2.147 | 0.019* | 8.556 | | | |
| Hair | –§ | –§ | –§ | | | |
| Fibers | –§ | –§ | –§ | | | |
| Clothing | –§ | –§ | –§ | | | |
| Weapons(s) | –§ | –§ | –§ | | | |
| Spent bullet/cartridge | –§ | –§ | –§ | | | |
| Footprints | –§ | –§ | –§ | | | |
| Tire tracks | –§ | –§ | –§ | | | |
| Vehicle | –§ | –§ | –§ | | | |
| Trace | –§ | –§ | –§ | | | |
| ME evidence | –§ | –§ | –§ | | | |
| Other lab evidence | –§ | –§ | –§ | | | |
| Summed evidence scales | | Not included in Model 1 | | | | |
| Forens17 | | | | 0.323 | 0.016* | 1.382 |
| ForenlinkO | | | | –§ | –§ | –§ |
| Constant | −3.318 | 0.001 | 0.036 | −2.578 | 0.002 | 0.076 |
| −2 Log likelihood | 184.834 | | | 200.677 | | |
| Model $\chi^2$ (df) | 207.434 (15)*** | | | 168.276 (7)*** | | |
| % Correctly predicted | 92.9 | | | 92.7 | | |
| Nagelkerke $R^2$ | 0.628 | | | 0.554 | | |
| *N* | 482 | | | 465 | | |

BR, body recovery; IC, initial contact; ME, medical examiner; MS, murder site; VLS, victim last seen; V–O, victim–offender.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

†Unstandardized coefficients.

‡Odds ratios reported for statistically significant and substantively meaningful variables.

§Endash (–) indicates variables that were included in the initial step of the logistic regression model, but eliminated because of the backward stepwise logistic regression.

Backward elimination was used because that method has the capacity to uncover relationships that may be missed by the use of forward inclusion alone. However, in cases where only one of the race or victim–offender relationship variables was included and the other associated variables were excluded, the forward inclusion method was used to force the additional dummy variable(s) completing the overall concept into the reduced model.

evidence was summed, the information was available for 465 cases. As indicated in Table 8, the relationship between the dependent variable and the independent variables was statistically significant: $\chi^2$ (7, $n$ = 465) = 168.276, $p < 0.001$. The model explained approximately 55% of the variance in case solvability ($R^2 = 0.554$).

Evidence that was collected at the crime scene linking the offender to the crime as statistically significant, but the impact was slight. Recovering any number of evidentiary items of this type only increased the odds of case solvability by 1.4. There was no statistically significant relationship between victim age, victim gender, and victim race. The odds ratio indicate that the odds of being solved were approximately 202 times higher for cases in which the victim–offender relationship was that of strangers, approximately 222 times higher for friends or acquaintances, and about 51 times higher for intimate or family members as perpetrators compared to cases in which the victim–offender relationship was unknown. The odds of solvability were higher (1.1) if the time between the VLS and MS was greater. The odds of solvability were greater if the distance between the VLS and MS was shorter. However, a greater distance between the IC and MS slightly increased the odds of solvability (7.3).

Table 9 shows the results of Model 2a compared to Model 3a. Both evaluated Research Hypothesis II, which predicted that the presence of physical evidence left by the offender would enhance case solvability in murder investigations of abducted children. Model 2a examined CAM investigations in which forensic evidence was collected at the crime scene connecting the offender to the crime. Model 3a examined CAM investigations in which forensic evidence was collected at the crime scene connecting the offender to the crime, and forensic evidence was connected to the offender by either the crime laboratory or the medical examiner's office. The two models showed similar results when compared side by side. This suggests that forensic variables collected at the crime scene which connect the victim to the offender are not as important to solvability as variables which are connected to the offender through laboratory analysis. Model 2a will be discussed. The results of Model 3 can be similarly evaluated by comparing statistical significance and odds ratios, so only a detailed discussion of Model 2a will follow.

Individual items of forensic evidence linking the offender to the victim were only recovered in 483 cases of the original 733. As indicated in Table 9, the relationship between the dependent variable and the independent variables was statistically significant: $\chi^2$ (11, $n$ = 483) = 177.941, $p < 0.001$. The model explained approximately 69% of the variance in case solvability ($R^2 = 0.690$). Results indicated that the summed scale of forensic evidence linked by the forensic laboratory to the offender has a significant impact

TABLE 9—*Logistic regression models predicting child abduction murder case solvability.*

| | Model 2a | | | Model 3a | | |
|---|---|---|---|---|---|---|
| | $B^{\dagger}$ | $p$ | Odds$^{\ddagger}$ | $B^{\dagger}$ | $p$ | Odds$^{\ddagger}$ |
| Control variables | | | | | | |
| Victim age | –§ | –§ | –§ | –§ | –§ | –§ |
| Victim gender | −2.224 | 0.012* | 0.108 | −2.034 | 0.017* | 0.131 |
| Victim race Black | 1.734 | 0.102 | 5.663 | 1.444 | 0.130 | 4.239 |
| Victim race Other | −1.378 | 0.083 | 0.252 | −1.390 | 0.078 | 0.249 |
| Stranger V–O Relationship | 7.074 | 0.000*** | 1180.556 | 7.063 | 0.000*** | 1167.740 |
| Friend V–O relationship | 7.654 | 0.000*** | 2108.629 | 7.531 | 0.000*** | 1864.690 |
| Intimate V–O Relationship | 4.347 | 0.000*** | 77.262 | 4.323 | 0.000*** | 75.388 |
| VLS_IC Time | –§ | –§ | –§ | –§ | –§ | –§ |
| VLS_MS Time | –§ | –§ | –§ | –§ | –§ | –§ |
| VLS_BR Time | –§ | –§ | –§ | –§ | –§ | –§ |
| IC_MS Time | –§ | –§ | –§ | –§ | –§ | –§ |
| IC_BR Time | –§ | –§ | –§ | 0.076 | 0.071 | 1.079 |
| MS_BR Time | 0.054 | 0.259 | 1.056 | –§ | –§ | –§ |
| VLS_IC Distance | –§ | –§ | –§ | –§ | –§ | –§ |
| VLS_MS Distance | −1.092 | 0.103 | 0.336 | −1.175 | 0.088 | 0.309 |
| VLS_BR Distance | –§ | –§ | –§ | –§ | –§ | –§ |
| IC_MS Distance | –§ | –§ | –§ | –§ | –§ | –§ |
| IC_BR Distance | –§ | –§ | –§ | –§ | –§ | –§ |
| MS_BR Distance | 2.295 | 0.006** | 9.927 | 2.051 | 0.012* | 7.774 |
| Independent variables | | | | | | |
| Crime Scene Scale | | | | | | |
| Forens17 | −0.086 | 0.635 | 0.918 | –§ | –§ | –§ |
| Forensic Lab Scale | | | | | | |
| ForenlinkO | 0.458 | 0.022* | 1.581 | 0.434 | 0.028* | 1.543 |
| Constant | −1.136 | 0.525 | 0.321 | −1.529 | 0.371 | 0.217 |
| −2 Log likelihood | 117.180 | | | 115.365 | | |
| Model $\chi^2$ (df) | 177.941 (11)*** | | | 171.375 (10)*** | | |
| % Correctly predicted | 95.4 | | | 95.4 | | |
| Nagelkerke $R^2$ | 0.690 | | | 0.683 | | |
| $N$ | 483 | | | 483 | | |

BR, body recovery; IC, initial contact; MS, murder site; VLS, victim last seen; V–O, victim–offender.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

†Unstandardized coefficients.

‡Odds ratios reported for statistically significant and substantively meaningful variables.

§Endash (–) indicates variables that were included in the initial step of the logistic regression model, but eliminated because of the backward stepwise logistic regression.

Backward elimination was used because that method has the capacity to uncover relationships that may be missed by the use of forward inclusion alone. However, in cases where only one of the race or victim–offender relationship variables were included and the other associated variables were excluded, the forward inclusion method was used to force the additional dummy variable(s) completing the overall concept into the reduced model.

on case solvability. If any type of forensic laboratory evidence was linked to the offender through laboratory analysis, the case was 1.6 times more likely to be solved.

However, clearly the strongest predictors of CAM case solvability remained the victim–offender relationship. The odds ratio indicate that the odds of being solved were approximately 2108.6 times higher for friends or acquaintances, almost 1180.6 times higher for cases in which the victim–offender relationship was that of strangers, and about 77.3 times higher for intimate or family members as perpetrators compared to cases in which the victim–offender relationship was unknown. It stands to reason that cases in which the victim and offender are related to each other, or connected by friendship or acquainted in some way, are easier to solve than when the victim–offender relationship is that of a stranger. However, cases in which the perpetrator was suspected to be a stranger typically received a larger amount of resources directed to solvability because of public fear and pressure.

The time and distance theoretical variables indicated that the odds of solvability were higher (1.6) if the time between the VLS and MS was greater. No other time or distance pairing was statistically significant. The victim's gender decreased solvability. If the victim was male, the case was less likely to be solved (0.108). An explanation for this finding is that male victims are overrepresented in stranger cases which may be more difficult to solve. There was no statistically significant relationship between victim age, victim race, victim gender, victim's race, or the other time and distance variables.

## Discussion

Each of the models indicated that the most important predictor of solvability was the victim–offender relationship followed by the distance between the MS and BR site. The odds ratios for the victim–offender relationship were greater in each model than for any of the other variables. Each model did show that forensic evidence did have a statistically significant impact on case solvability. In Model 1, which examined all cases, the individual types of forensic evidence linked to the offender, only "other" type evidence collected at the crime scene and semen analyzed by the crime laboratory had a statistically significant impact on solvability. However, the odds ratios of the statistically significant individual items of forensic evidence were much lower than the victim–offender relationship variables and the distance between the IC site, indicating only a slight impact on solvability.

Model 1a, which included only cases in which any type of forensic evidence was collected and analyzed, showed that only forensic evidence collected at the scene which linked the offender to the victim had an impact on solvability. However, when the odds ratio for the summed scale of forensic evidence collected at the crime scene are compared to the victim–offender relationship, it is clear that the victim–offender relationship has a much greater impact on solvability. Model 2a that included only cases in which evidence was collected at the scene indicated that the summed total of forensic evidence collected at the scene had no impact on solvability. However, the summed total of evidence items analyzed by the crime laboratory did have a significant impact on case solvability. Model 3a, which included cases in which evidence was both collected at the crime and analyzed by the crime laboratory, also showed that only the summed total of items analyzed by the laboratory had a significant impact on case solvability. Overall, the findings support that a greater amount of forensic evidence tied to the offender in the investigation increase case solvability, but not as much as the victim–offender relationship.

### *Limitations*

The CAM data are neither a random sample of CAM cases nor a sample of all CAMs occurring in the United States. Data were collected based on voluntary reporting of cases from each law enforcement jurisdiction contacted. In addition, the variables contained in the data do not designate at which point in the investigation, each variable captured was used, if at all, by investigators to link the offender to the crime. This makes it difficult to know whether the fact that forensic evidence connected the offender to the crime resulted in the case solution, or whether another type of evidence may have allowed investigators to link the offender to the crime. However, it was determined that while limited, the analysis of the forensic variables of interest would provide an adequate exploratory analysis.

### *Investigative Implications*

In CAM investigations, police detectives should follow the important elements of the solvability factors discovered by this research. First investigators should examine the victim–offender relationship. To gather information about the victim–offender relationship, some time and distance pairings had a greater impact on case solvability than others. In Model 1, information about the distance between the IC site and the MS increased the odds of solvability 13.5 times. Models 2a and 3a also indicated that the distance between the MS and the BR increased solvability. With such an influence on the increased solution of the case, investigators must focus and prioritize the investigative work that identifies the time and location of the IC site between the offender and the victim and the actual MS for the extant murder. By quickly identifying the IC and MS, detectives will find clues that help them apprehend the killer before he or she strikes again.

Investigators can use this information proactively to prioritize resources. Area canvasses are of great value in CAM investigations because the knowledge gained from people interviewed in the canvass has proven valuable in identifying the probable relationship between the offender and the victim. Previously, the area canvass has aided in finding an unknowing witness who saw the child being abducted, but did not realize that an abduction was in progress. Other witnesses may have seen the child with the offender or be able to provide other useful information such as a vehicle description and/or a direction of travel. Information about the IC site could generate information about any abduction conspirators. If a child is not recovered alive, the MS will likely provide many useful leads. In addition, evidence may be found at the MS, which can be used in an interrogation to facilitate a confession from a suspect. The finding that forensic evidence is not the driving force in solving an investigation will allow investigators to prioritize their information gathering and collection of evidence. These findings suggest that circumstantial information uncovered in an investigation may be equally important.

### *Ideas for Further Research*

Existing murder data sets do not typically include comprehensive information about forensic evidence. Data should be collected to further address the impact of the types of physical evidence left by the victim or offender during an abduction murder on case solvability. Because additional or different factors may affect how useful forensic evidence is in prosecutorial decision making and whether or not an identified offender is convicted, a closer examination of factors relating to offender conviction should also be undertaken.

Finally, a comparison between abduction cases in which a child was recovered alive and those in which a child was murdered would provide valuable—perhaps even lifesaving—information.

## Conclusion

Because of the possible "CSI Effect" (15,16), there may be a public misconception that forensic evidence solves murder investigations, however, in reality, there are other more important solvability factors. Another commonly held belief is that a greater amount of forensic evidence tying an offender to a particular murder will increase solvability. The summed total of forensic evidence recovered did have a positive effect on case solvability, but was not as important to case solvability as identifying the victim–offender relationship. To explore these findings further, data should be collected that include at what time in the investigation forensic evidence was collected, analyzed, and a report was available to investigators. Also, further consideration should be given to the impact of forensic evidence on case solvability and appropriate analyses conducted.

Time and distance separation between murder incident components should not be ignored as a solvability factor. Knowledge about any aspect of the case should increase the probability of case solvability, particularly in the absence of knowledge about the other predictors examined. This data set was designed to examine case solvability as measures by arrest rather than conviction of an offender. While forensic evidence may not have a large impact on case solvability, it is relevant to investigations because it is needed for prosecution assistance in court. Further study of the role of forensic evidence in murder investigation solvability and conviction should be explored. Empirically supported research in this area will enable agencies to focus their limited resources on those items of evidence most likely to influence case solvability.

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## References

1. Horvath F, Meesig R. The criminal investigation process and the role of forensic evidence: a review of empirical findings. J Forensic Sci 1996;41(6):963–9.
2. Peterson JL, Ryan JP, Houldon PJ, Mihajlovic S. The uses and effects of forensic science in the adjudication of felony cases. J Forensic Sci 1987;32(6):1730–53.
3. Broidy M. The effects of DNA evidence on the criminal trial process [dissertation]. Queensland (AU): Griffith Univ., 2004.
4. Roman JK, Reid J, Chalfin A, Adams W, Knight C. The DNA field experiment: cost-effectiveness analysis of the use of DNA in the investigation of high-volume crimes. Washington, DC: National Criminal Justice Research Service, 2009;NCJ 222318.
5. Peterson JL. Use of forensic evidence by the police and courts. Research in Brief No. 106. Washington, DC: National Criminal Justice Research Service, 1981; NCJ 107206.
6. Ramsay M. The effectiveness of the Forensic Science Service. Home Office Research Study 92. London, UK: Home Office Research Service [Her Majesty's Statuary Office], 1987.
7. Brown KM. Child abduction murder: an analysis of the effect of victim age, victim race, victim gender, victim-offender relationship, forensic evidence, and time and distance separation on case solvability [dissertation]. Huntsville, TX: Sam Houston State Univ., 2008.
8. Brown KM, Keppel RD. Child abduction murder: an analysis of the effect of time and distance separation between murder incident sites on solvability. J Forensic Sci 2007;52(1):137–45.
9. Brown KM, Keppel RD, Weis JG, Skeen M. Investigative case management for missing children homicides: Report II. Seattle, WA: Attorney General (WA) and U.S. Department of Justice Office of Juvenile Justice and Delinquency Prevention (US), 2006;Cooperative Agreement No.: 98-MC-CX-0001.
10. Hanfland KM, Keppel RD, Weis JG. Investigative case management for missing children homicides. Seattle, WA: Attorney General (WA) and U.S. Department of Justice Office of Juvenile Justice and Delinquency Prevention (US), 1997;Cooperative Agreement No.: 93-MC-CX-K006.
11. Sedlak A, Finklehor D, Hammer H, Schultz D. National estimates of missing children: an overview. National Incidence Studies of Missing, Abducted, Runaway, and Thrownaway Children (NISMART). Washington, DC: U.S. Department of Justice Office of Justice Programs, 2002;Grant number 95–MC–CX–K004.
12. Finklehor D, Ormrod R. Homicides of children and youth. Washington, DC: Office of Justice Programs, 2001;NCJ Publication No.: 187239.
13. Keppel RD. An analysis of the effect of time and distance relationships in murder investigations [dissertation]. Seattle, WA: Univ. of Washington, 1992.
14. Keppel RD, Weis JG. Time and distance as solvability factors in murder cases. J Forensic Sci 1993;39(2):286–401.
15. Robbers MLP. Blinded by science. Crim Justice Policy Rev 2008;19(1):84–102.
16. Mopas M. Examining the 'CSI effect' through an ANT lens. Crime, Media, Culture 2007;3(1):110–7.

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## Appendix

### *Preliminary Data Analysis*

Prior to the multivariate analysis, diagnostics were conducted on the data to check for biased coefficients, inefficient estimates, and invalid statistical inferences (7). There was no evidence of nonadditivity or nonlinearity in the models. Particular attention was paid to collinearity issues because of the wide dispersion of values in the time and distance variables. Preliminary collinearity diagnostics suggested that a natural log transformation was appropriate for the time and distance variables and a natural log transformation was performed. Post-data analysis collinearity diagnostics indicated that the natural log transformation of the time and distance variables was an adequate measure to reduce collinearity.

In logistic regression, residuals are not assumed to have a normal distribution, but rather follow a binomial distribution that approximates a normal distribution only in large samples. Residual analyses were conducted to determine whether the residuals were normally distributed which increased the confidence that inferential statistics were appropriate. The diagnostic plots and casewise analysis indicated that outliers did not exert an undue influence on the models when retained or removed, so all cases were retained in the analyses (7).

### *Multivariate Data Analysis*

Binary response models were chosen to explore the research hypotheses because the dependent variable (Solved) is a binary, or dichotomous, variable. Binary logistic regression analysis can be used with independent variables of any type; therefore, it was appropriate for this analysis. Logistic regression was employed as the modeling mechanism to predict whether or not a case was solved on the basis of the impact of appropriate continuous and/or categorical control and independent variables.

Models were run using the backward stepwise elimination method to obtain reduced models that included only statistically significant predictors. Backward elimination was used because that method has the capacity to uncover relationships that may be missed by the use of forward inclusion alone. However, in cases where only one of the race or victim–offender relationship variables were included and the other associated variables were excluded, the forward inclusion method was used to force the additional dummy variable(s) for the overall concept into the reduced model (7).

The statistical significance of the overall model was tested using the model chi-square statistic. If the model chi-square ($\chi^2$) is statistically significant, then it can be concluded that the independent variables allow the model to better predict solvability than the model without the independent variables. Statistical significance of individual coefficients in each model was tested using the likelihood ratio chi-square test. Tests of significance are used in this research to draw inferences about the population parameters and to select independent variables for retention in the final models. Substantive significance for the models is indicated by the overall percentage of cases correctly predicted. Substantive significance for the variables is indicated by the magnitude of the statistically significant odds ratios.