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FTCoE Contact

Jeri Roper-Miller, PhD, F-ABFT
Director, FTCoE
RTI International
jerimiller@rti.org

NIJ Contact

Jennifer Love, PhD, D-ABFA
Physical Scientist
Office of Investigative and
Forensic Sciences
Jennifer.love@usdoj.gov

Technical Contacts

Shannon Krauss, PhD
RTI International
skrauss@rti.org

Mikalaa Martin
RTI International
mmmartin@rti.org

FTCoE Help Desk
ForensicCOE@rti.org

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USER GUIDE

Cost-Benefit Analysis Tool for Labor Expenditure Associated With Sexual Assault Kit Processing Workflows

Impact Statement

Following a sexual assault, survivors may undergo a forensic examination during which a sexual assault kit (SAK) is collected and submitted to a crime laboratory for DNA testing and analysis. Ultimately, the DNA analysis results can play a role in the identification and prosecution of a perpetrator. Laboratories can use various SAK processing workflows, each of which has important impacts on laboratory

resources (e.g., the number of labor hours required to complete necessary tasks) or societal outcomes (e.g., entering probative DNA profiles into the Combined DNA Index System [CODIS] that may help identify perpetrators). A Direct-to-DNA workflow may increase laboratory efficiency and improve sensitivity while reducing labor expenditure, turnaround time, and overall financial burden. A study that assesses the costs and benefits associated with this approach can provide a critical resource for

For this document, the FTCoE has defined the following terms:

- **Direct-to-DNA Workflow:** A workflow that begins with DNA quantitation and is followed by DNA amplification. During DNA quantitation, the amount of male DNA among female DNA (known as Direct-to-DNA) is determined and informs which samples move forward to DNA amplification. For this workflow, serology testing is removed as the initial screening step of a SAK sample; instead, DNA quantitation is used to eliminate, or screen, samples for downstream processing.
- **Continuous Sampling:** A DNA testing process in which SAK sample testing continues sequentially until a CODIS-eligible profile is obtained or until all SAK samples are tested.



practitioners and decision-makers when evaluating differences between SAK processing workflows.

To date, limited research has empirically assessed the costs associated with different SAK processing workflows and the potential benefits or limitations of each. Thus, laboratories have little evidence-based data for guiding workflow decisions and evaluating the benefits of one workflow over another in regards to cost and efficiencies. Research efforts can inform laboratories on how to best use their resources and the advantages of changing to a different SAK processing workflow.

With funding from the National Institute of Justice (NIJ) under the Forensic Technology Center of Excellence (FTCoE), RTI International developed a free prototype SAK processing workflow cost-benefit analysis (CBA) tool to help laboratory personnel and decision-makers understand the cost of different SAK processing workflows as well as their impacts on laboratory resources and potential benefits to overall public safety.

Goals and Methodology

The goal of this tool was to evaluate the costs and benefits of a Direct-to-DNA SAK processing workflow coupled with continuous sampling compared with alternative workflows. Therefore, RTI developed a CBA tool that can be used to compare four typical SAK processing workflows:

- **Serology screening.** A workflow that begins with serology testing before DNA quantitation and DNA amplification. Here, both the initial serology and subsequent DNA quantitation can be used to eliminate samples from further processing (i.e., sample screening).
- **Serology screening with continuous sampling.** A workflow that mirrors serology screening coupled with a procedure to continue testing samples within a SAK request until a CODIS-eligible profile is obtained (i.e., continuous sampling).
- **Direct-to-DNA.** A workflow that begins with DNA extraction and DNA quantitation followed by DNA amplification. During DNA quantitation, the amount of

male DNA among female DNA (known as Direct-to-DNA)¹ is determined and informs which samples move forward to DNA amplification. For this workflow, serology testing is removed as the initial screening step of a SAK sample and DNA quantitation is instead used to eliminate, or screen, samples for downstream processing.

- **Direct-to-DNA with continuous sampling.** This workflow mirrors Direct-to-DNA but is coupled with a continuous sampling procedure.

This tool is the product of the following:

1. Cataloging all activities and resources for each of the four defined workflows and developing a prototype tool based on these considerations.
2. Developing questionnaires for collecting information about specific costs and CODIS outcomes associated with each of the four workflows.

The workflow-specific questionnaires were designed to create a list of potential costs and performance metrics needed to assess each workflow based on data collected from a sample of publicly funded state crime laboratories and to ultimately improve the efficacy of the prototype tool. **For the purposes of producing this prototype CBA tool, costs that are relatively consistent across all SAK processing workflows, including those related to training, purchasing chemical reagents, and procuring SAKs, were excluded from the workflow-specific questionnaires and are not included within the accompanying initial tool.** Preliminary drafts of the workflow-specific questionnaires were sent to external subject matter experts for review and resulted in important insights that were used to refine the questions and response options.

The workflow-specific questionnaires included 43 questions organized into five core sections:

- **Part I: Respondent and Laboratory Background Information**, which included questions such as how many testing requests for SAKs the laboratory received and completed in the previous year.

¹ Determining the amount of male DNA among female DNA using DNA quantitation as a screening step in this workflow is not synonymous with a Y-screening approach, where DNA quantitation is used to screen for the

amount of male DNA among the total amount of DNA contained within a sample.



- **Part II: Completed SAK Testing Requests and Case Workflow**, which included questions such as the percentage of testing requests for SAKs that stopped at serology because of negative serology results (if applicable) versus the percentage that stopped after DNA quantitation because of low or no DNA quantity or poor DNA quality.
- **Part III: Laboratory Workflow Procedures**, which included questions such as the number of samples within a SAK typically moved forward for DNA extraction following serology (if applicable).
- **Part IV: Labor**, which included questions such as the number of hours of hands-on time spent by various laboratory staff for different procedures such as serology (if applicable) or DNA extraction.
- **Part V: Laboratory Staff Information**, which included questions such as the salary ranges most representative of different laboratory roles.

Before disseminating the workflow-specific questionnaires, RTI developed and administered an initial screening questionnaire to the forensic science community. Distribution of the survey was aided by the American Society of Crime Laboratory Directors (ASCLD) to identify laboratories using each of the four defined SAK processing workflows that would be interested in participating. Based on the laboratories that completed the screening questionnaire and the timeframe of this pilot study, nine laboratories were invited to complete the workflow-specific questionnaire. All nine laboratories followed either the serology screening, Direct-to-DNA, or Direct-to-DNA with continuous sampling SAK processing workflow. Eight laboratories completed the workflow-specific questionnaires (i.e., three representing the serology screening workflow, one representing the Direct-to-DNA workflow, and four representing the Direct-to-DNA with continuous sampling workflow). Workflow-specific questionnaire responses were valuable to inform additional adjustments to the default inputs of this tool. Although no data were collected from a laboratory representing the serology screening with continuous sampling workflow, information necessary to develop default inputs for this

workflow were derived from responses provided for the other three workflows.

Additional Definitions Used in the CBA Tool

Several terms used in this CBA tool are defined below. These terms and accompanying definitions were used to develop the default inputs in this tool. Although there may be more than one meaning or interpretation for some of these terms, the definitions provided below should be followed when using this tool.

- **Sexual Assault Kit (SAK)**. A kit used by medical professionals to collect and preserve forensic evidence from a victim following a sexual assault. For this tool, a SAK only includes evidence samples mentioned in the SAK instructions (i.e., evidence not explicitly stated on the SAK instructions such as victim's clothing or bedding would not be considered a part of a SAK) and does not include reference samples.
- **Batching**. Samples that are grouped together during one or more steps within a laboratory's workflow. Batching practices may vary between laboratories depending on which step in the workflow samples are grouped, or not grouped, together (e.g., DNA quantitation, DNA amplification). For this tool, consider batching of SAK evidence samples only, and do not consider reference samples.

The following terms, as defined in the 2020 Federal Bureau of Investigation's [Quality Assurance Standards for Forensic DNA Testing Laboratories](#), guide the interpretation of laboratory roles provided as options within this tool.

- **Technical Leader**. An employee who is accountable for the technical operations of the laboratory and who is authorized to initiate, suspend, and resume laboratory operations.
- **Casework CODIS Administrator**. An employee of the laboratory responsible for administration and security of the laboratory's CODIS at a laboratory performing DNA analysis on forensic and casework reference samples. An alternate casework CODIS administrator must be designated by the laboratory as required by the [National DNA Index System] (NDIS) operational procedures.



- **[DNA] Analyst.** An employee or contract employee, that has successfully completed the laboratory’s training requirements for casework sample analysis, passed a competency test, and has entered into a proficiency testing program according to these standards. This individual can conduct and/or direct the analysis of forensic samples, interpret data, reach conclusions, and generate reports.
- **Technician.** An employee or contract employee who performs analytical procedures on forensic samples or casework reference samples under the direction of a qualified analyst. Technicians do not interpret data to reach conclusions or typing results or prepare final reports.

Introduction to the CBA Tool for SAK Processing Workflows

This is a Microsoft Excel–based CBA tool with two main worksheets. First, the **User Input worksheet** contains various input cells to collect data on the characteristics of the user’s laboratory. Each row in this worksheet contains a description of the input in the first column (column A), an input cell with a pre-filled default value² (blue-colored cells, columns B and C), and user input guidance cell (column E) to provide further details to assist the user while filling in data representing their laboratory. The user inputs are organized into the following sections:

- SAK requests and CODIS outcomes
- Current workflow type
- Percentage of requests passing each stage of your laboratory’s workflow
- Batch sizes for steps with batching
- Staff salary ranges for labor cost calculations
- Labor hours (by workflow step)

Next, the **Results worksheet** summarizes results organized into the following sections:

1. Cost and CODIS results by workflow
2. Workflow change analysis (incremental cost and CODIS uploads when changing workflows)
3. Average cost-effectiveness by workflow

For example, a laboratory that uses serology screening without continuous sampling can review a summary of costs and CODIS uploads for their current workflow and for the other workflows, thereby showing the hypothetical differences in costs or number of CODIS uploads for implementing a Direct-to-DNA workflow or continuous sampling procedure. Additionally, the **Results worksheet** presents workflow analyses, which include the cost per 100 CODIS uploads by workflow and the incremental cost per 100 CODIS uploads when adding continuous sampling. These calculations can help practitioners and decision-makers understand how much more or less an alternative workflow is likely to cost per CODIS upload.

Preparing Data for the CBA Tool’s User Input Worksheet

Users will open the CBA tool in Microsoft Excel to the **User Input worksheet**. Text boxes in this sheet direct the user to enter their data in blue-colored cells, columns B and C. These cells are pre-filled with default values, which are meant to demonstrate a plausible set of inputs; however, the user is encouraged to change all blue-colored cells to best reflect the parameters and workflow of their laboratory. For laboratories that do not conduct serology screening, it is suggested users leave in the pre-filled default values for inputs related to serology to allow for hypothetical serology workflow scenarios to be calculated, which enables the user to compare outputs among the four workflows. To expedite the data input process, users are encouraged to collect the following data values from internal documents before using this tool:

- SAK requests and CODIS outcomes:
 - Total SAK requests in a typical year
 - Completed SAK requests in a typical year
 - Completed SAK requests in a typical year that yielded a CODIS-eligible profile and were uploaded to CODIS

² Default values are based on data provided from the eight U.S. publicly funded crime laboratories that completed the workflow-specific questionnaires.



- Subgroup 1: CODIS forensic hit(s)
- Subgroup 2: Offender hit(s)
- Current SAK processing workflow type:
 - Does your laboratory use a Direct-to-DNA casework approach?
 - Does your laboratory use continuous sampling within the same SAK request when no DNA profile is obtained from the initial sample(s)?
 - If yes, approximately how many additional evidence samples per SAK are processed?
 - If yes, approximately what percentage of all CODIS-eligible profiles were obtained from continuous sampling within a SAK?
- Percentage of requests passing each stage of laboratory workflow (*the following four stages should sum to 100%*):
 - Stage 1: Percentage of SAK requests that were stopped at serology (*if serology is conducted as part of standard workflow*)
 - Stage 2: Percentage of SAK requests that passed serology (*if conducted*) and DNA extraction but stopped after DNA quantitation
 - Stage 3: Percentage of SAK requests that did not yield a CODIS-eligible profile after analysis
 - Stage 4: Percentage of SAK requests that yielded a CODIS-eligible profile that was uploaded to CODIS
- Batch sizes for workflow steps (*if batching is used*):
 - Batch size for DNA extraction
 - Batch size for DNA quantitation
 - Batch size when conducting PCR for STR amplification
- Staff member salary ranges for labor cost calculations (*by laboratory role*)

Users need to fill in salary ranges only for the staff who participate in the workflow steps listed in the labor hours section (see next section regarding labor hours by workflow step). The following staff member positions were provided as defaults (see laboratory roles defined in the **Additional Definitions Used in the CBA Tool** section). The roles and salary ranges can be customized for a user's laboratory and will automatically populate in the subsequent labor hours sections accordingly.

- Technician or equivalent
- Serology analyst or equivalent
- DNA analyst or equivalent
- Casework CODIS administrator or equivalent
- Technical leader or equivalent
- Section supervisor or equivalent
- Laboratory manager or equivalent
- Other
- Labor Hours

Input labor hours by workflow step and staff position for each of the following (users can enter partial hours for staff or 0.0 for staff not involved in a workflow step):

1. Hours for serology per SAK request
2. Hours for serology report per SAK request
3. Hours for DNA extraction per SAK request or batch
4. Hours for DNA quantitation per SAK request or batch
5. Hours for PCR per SAK request or batch
6. Hours for STR preparation and run per SAK request
7. Hours for STR data analysis per SAK request
8. Hours for DNA report per SAK request
9. Hours for administrative or technical review
10. Hours for CODIS data entry
11. Hours to verify/review CODIS hit reports

Interpreting the CBA Tool Outputs

The **Results worksheet** is automatically updated based on the user's input data from the **User Input worksheet**. The cells in the **Results worksheet** are conditionally formatted to display green for lower costs or more effective outcomes and yellow for higher costs or less effective outcomes. The conditional formatting for costs and CODIS outcomes depends on the relative costs or CODIS outcomes within a set of workflow results (i.e., within each table column).

See **Exhibit 1** for a screenshot from Section 1 in the **Results worksheet** (Cost and CODIS results by workflow) of the CBA tool, which contains the workflow-related costs and CODIS outcomes by workflow type. Section 1 presents results per 100 completed SAK requests (**Exhibit 1**, left) and per year (**Exhibit 1**, right), based on the user input value for the number of SAK requests completed in a typical year. Currently, cost results only include workflow-related labor costs, and the hourly labor rates include fringe benefits (assuming an additional 30% labor cost for fringe benefits).



and calculating an hourly wage based on 2,080 working hours per year). Materials costs and general overhead costs were not included in this prototype tool because of relative similarities across workflows.

CODIS results presented in the **Results worksheet**, including “CODIS upload results” and “CODIS forensic and offender hit results,” are influenced by the user’s data inputs such as the percentage of SAKs passing each stage of the laboratory workflow (i.e., stopped at serology, stopped after DNA quantitation, did not yield a CODIS-eligible profile, yielded a CODIS-eligible profile that was uploaded to CODIS), information related to continuous sampling, and the number of CODIS forensic and offender hits relative to requests completed. These are key inputs, and if the user is unsure or has a range of possible values, they should adjust them in the **User Input worksheet** to understand the impact on their results.

See **Exhibits 2–4** for screenshots from Section 2 (Workflow change analysis) in the **Results worksheet** of this tool, which presents six potential workflow changes and the associated differences in costs and CODIS uploads. This section is designed for laboratory personnel and decision-makers to evaluate differences between SAK processing workflows. Workflow changes such as switching from Direct-to-DNA approaches to serology screening procedures are not included because of the benefits of Direct-to-DNA approaches, including increased laboratory efficiency and reduced labor consumption.³ Each workflow change is described in column A; the six changes are as follows:

1. Serology screening to serology screening with continuous sampling
2. Serology screening to Direct-to-DNA
3. Serology screening to Direct-to-DNA with continuous sampling
4. Serology screening with continuous sampling to Direct-to-DNA

Exhibit 1. Results worksheet screenshot: Section 1, Cost and CODIS results by workflow.

1) Cost and CODIS results by workflow		
	Results per 100 SAKs	Results per year
Cost results	Expected cost per 100 SAKs	Expected SAK costs per year
Workflow	Median	Median
Serology screening	\$59,550	\$9,349,350
Serology screening with continuous sampling	\$68,226	\$10,711,485
Direct-to-DNA	\$29,188	\$4,582,438
Direct-to-DNA with continuous sampling	\$30,669	\$4,815,088
CODIS upload results	Expected CODIS uploads per 100 SAKs	Expected CODIS uploads per year
Workflow	Median	Median
Serology screening	42.9	67.4
Serology screening with continuous sampling	44.4	69.6
Direct-to-DNA	47.7	74.9
Direct-to-DNA with continuous sampling	49.0	76.9
CODIS forensic and offender hit results	Expected CODIS forensic and offender hits per 100 SAKs	Expected CODIS forensic and offender hits per year
Workflow	Median	Median
Serology screening	15.4	24.1
Serology screening with continuous sampling	15.9	24.9
Direct-to-DNA	17.1	26.8
Direct-to-DNA with continuous sampling	17.6	27.6

³ SAFER Working Group. “Improving Laboratory Efficiency: A Direct-to-DNA Approach for Testing Sexual Assault Kits.” Sexual Assault Kit Initiative, RTI International. <https://www.sakitta.org/toolkit/docs/Improving->

[Laboratory-Efficiency-A-Direct-to-DNA-Approach-for-Testing-Sexual-Assault-Kits.pdf](#)



5. Serology screening with continuous sampling to Direct-to-DNA with continuous sampling
6. Direct-to-DNA to Direct-to-DNA with continuous sampling

Exhibit 2 displays the incremental cost per 100 SAKs for each workflow change as the cost of the newly adapted workflow minus the cost of the current workflow per 100 SAKs (costs by workflow are shown in Section 1 tables in **Exhibit 1**). Based on the data provided from eight U.S. publicly funded crime laboratories, these results demonstrated cost savings associated with changing from a serology workflow to a Direct-to-DNA workflow. However, this result can change based on the user’s input values. Users are encouraged to conduct their own sensitivity analyses by returning to the **User Input worksheet** to change one or two inputs and then view the newly populated results displayed on the **Results worksheet**. For example, if a user wanted to hypothesize the impact of increasing the number of hours allocated for a step in their SAK processing workflow (e.g., DNA report writing), that user can observe the magnitude of the cost changes associated with the number of hours needed for a DNA analyst or equivalent to expend on DNA report writing per SAK request from 0.5 hour to 2 hours by changing the input in the **User Input worksheet** and noting the corresponding change in cost within the **Results worksheet**.

Exhibit 2. Results worksheet screenshot: Section 2, Incremental cost.

Incremental cost per 100 SAKs: changing to Direct-to-DNA or adding continuous sampling	
Workflow	Median
Serology screening > Serology screening with continuous sampling	\$8,676
Serology screening > Direct-to-DNA	-\$30,363
Serology screening > Direct-to-DNA with continuous sampling	-\$28,881
Serology screening with continuous sampling > Direct-to-DNA	-\$39,039
Serology screening with continuous sampling > Direct-to-DNA with continuous sampling	-\$37,557
Direct-to-DNA > Direct-to-DNA with continuous sampling	\$1,482

Exhibit 3 displays the incremental CODIS uploads per 100 SAKs for each workflow change as the CODIS uploads of the newly adapted workflow minus the CODIS uploads of the current workflow per 100 SAKs (CODIS uploads by workflow

are shown in Section 1 tables; **Exhibit 1**). Based on the data provided from eight U.S. publicly funded crime laboratories, these results demonstrated that the largest increase in CODIS uploads occurred when changing from a serology workflow to a Direct-to-DNA workflow. Adding continuous sampling resulted in additional CODIS uploads, but the incremental difference was not large given the low input values for the percentage of CODIS-eligible profiles obtained from continuous sampling.

Exhibit 3. Results worksheet screenshot: Section 2, Incremental CODIS uploads.

Incremental CODIS uploads per 100 SAKs: changing to Direct-to-DNA or adding continuous sampling	
Workflow	Median
Serology screening > Serology screening with continuous sampling	1.4
Serology screening > Direct-to-DNA	4.8
Serology screening > Direct-to-DNA with continuous sampling	6.1
Serology screening with continuous sampling > Direct-to-DNA	3.3
Serology screening with continuous sampling > Direct-to-DNA with continuous sampling	4.7
Direct-to-DNA > Direct-to-DNA with continuous sampling	1.3

Exhibit 4 displays the incremental cost per additional CODIS upload for each workflow change as the cost of the newly adapted workflow minus the cost of the current workflow, divided by the number of CODIS uploads of the newly adapted workflow minus the number of CODIS uploads of the current workflow (CODIS uploads by workflow are shown in Section 1 tables in the **Results worksheet** shown in **Exhibit 1**). Based on the data provided from eight U.S. publicly funded crime laboratories, adding continuous sampling to corresponding workflows (e.g., Direct-to-DNA to Direct-to-DNA with continuous sampling, serology screening to serology screening with continuous sampling) increased workflow costs and CODIS uploads resulting in an additional cost to gain additional CODIS upload(s) (as shown in **Exhibit 3**). In some cases (e.g., changing to Direct-to-DNA from serology), costs decreased while CODIS uploads increased. In these cases, the tool calculates the average cost savings per additional CODIS upload (see **Exhibit 4**). The largest cost savings per additional CODIS upload was observed for a serology workflow changing to a Direct-to-DNA workflow.



Exhibit 4. Results worksheet screenshot: Section 2, Incremental cost per additional CODIS upload.

Incremental cost per additional CODIS upload: changing to Direct-to-DNA or adding continuous sampling	
Workflow	Median
Serology screening > Serology screening with continuous sampling	\$6,081
Serology screening > Direct-to-DNA	-\$6,365
Serology screening > Direct-to-DNA with continuous sampling	-\$4,752
Serology screening with continuous sampling > Direct-to-DNA	-\$11,677
Serology screening with continuous sampling > Direct-to-DNA with continuous sampling	-\$8,075
Direct-to-DNA > Direct-to-DNA with continuous sampling	\$1,133

Exhibit 5 displays the average cost per 100 CODIS uploads by workflow (not by workflow change as in Section 2, shown in **Exhibits 2–4**). The average cost per 100 CODIS uploads is equal to the expected cost divided by the expected CODIS uploads, multiplied by 100 (to express these results per 100 CODIS uploads). Based on the data provided from eight U.S. publicly funded crime laboratories, these results demonstrated a lower cost per CODIS upload associated with Direct-to-DNA workflows and a higher cost per CODIS upload associated with serology screening and continuous sampling. For example, in a hypothetical laboratory where serology screening excludes the same samples that would be stopped after DNA quantitation, this average cost comparison would favor a change to Direct-to-DNA by \$10,000 to \$30,000 less per 100 CODIS uploads (depending on the workflow).

Exhibit 5. Results worksheet screenshot: Section 3, average cost-effectiveness.

3) Average cost-effectiveness by workflow	
Cost per 100 CODIS upload results	
Workflow	Median
Serology screening	\$138,714
Serology screening with continuous sampling	\$153,812
Direct-to-DNA	\$61,190
Direct-to-DNA with continuous sampling	\$62,581

Future Directions

This is the first version of the CBA tool developed from this study. Data from additional crime laboratories could be collected (including voluntary feedback on the usability of the tool) to adapt this tool, and corresponding trends in user input values and result outputs could be monitored to refine the tool. If deemed useful by crime laboratory personnel and key decision-makers, this tool could also be expanded to include nominal costs (e.g., training costs) or modified so that laboratories can assess the costs and benefits of hybrid approaches to SAK processing (e.g., a mixed approach when certain evidence types, case types, case circumstances, or investigator-driven requests result in the inclusion of a serology screening workflow in an otherwise Direct-to-DNA SAK processing laboratory).

Currently, the outputs in this tool are strictly related to laboratory workflows and depend on the labor hours associated with each step within the defined workflows. Calculated benefits are limited to the number of CODIS uploads and resulting CODIS hits. In the future, this tool could be expanded to include additional costs and benefits. For instance, CODIS hits are associated with a potential reduction in crime, which can be quantified in terms of economic and quality-of-life impacts for community members (e.g., sexual assault survivor compensation, cost per individual incarcerated for sexual assault, financial and quality-of-life costs averted by preventing sexual assaults through incarcerating potential repeat offenders). Incorporating additional research on related costs and benefits will offer laboratory management and decision-makers a more robust view of the potential long-term impacts that can stem from changes to their workflow procedures.



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The NIJ FTCoE is led by RTI, a global research institute dedicated to improving the human condition by turning knowledge into practice. With a staff of nearly 6,000 providing research and technical services to governments and businesses in more than 75 countries, RTI brings a global perspective. The FTCoE builds on RTI’s expertise in forensic science, innovation, technology application, economics, data analytics, statistics, program evaluation, public health and information science.

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The NIJ Office of Investigative and Forensic Sciences (OIFS) is the federal government’s lead agency for forensic science research and development. OIFS' mission is to improve the quality and practice of forensic science through innovative solutions that support research and development, testing and evaluation, technology, information exchange, and the development of training resources for the criminal justice community.

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