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A Process Modeling Approach to Evaluating Worker Requirements for Sexual Assault Evidence Testing

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by

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Abstract

In recent years, over 100,000 untested sexual assault kits (SAKs) have been discovered in the custody of law enforcement and awaiting testing at publicly funded facilities. The backlog has been attributed to law enforcement discretion and a lack of resources at testing facilities. In response to the backlog, states have adopted various policies for testing SAKs. 11 states have adopted comprehensive policies, mandating testing of all backlogged and incoming kits, in addition to annual inventories, updated tracking systems, and increased funding for testing programs. 30 states have adopted "limited" policies and 4 states have proposed policy reforms. This research attempts to develop a process-modeling approach to SAK testing through a case study with Monroe County Crime Laboratory (MCCL). A model was created using Simio, a discrete-event simulation software, to assess the current state of the testing process within the facility, which was then modified to analyze various staffing levels and relative demand levels probabilistically determined by uniform distribution. This experiment resulted in 15 acceptable scenarios, given the New York State 90-day testing mandate for incoming SAKs, and a number of policy recommendations. Based on this research, jurisdictions with extremely low demand (relative demand < 3) are not recommended to assign full-time staff solely to SAK testing because all scenarios result in low worker utilization levels. There are also no scenarios which yields acceptable worker utilization for a staff of 10 or more full-time or full-time equivalent employees, assuming no change in resources or technology. Overall, process modeling is a useful tool for analyzing the allocation of resources and demand constraints for SAK testing facilities.

Introduction

In 2018, 734,630 rapes/sexual assaults were reported to law enforcement. It is estimated that 75% of rape/sexual assault goes unreported, making it the most underreported violent crime (Morgan 2018). Of the reported incidents, only 46 percent of cases result in arrest and 5 percent result in a felony conviction, according to Rape, Abuse, and Incest National Network (RAINN) statistics ("The Criminal Justice System: Statistics," 2019).

To document the evidence of reported sexual assault, Louis Vitullo, a Chicago-based police sergeant, created a method for collecting forensic evidence. The tool was called the "Vitullo Evidence Collection Kit". He developed the kit "'to standardize and protect evidence so that guilt can be established beyond a reasonable doubt…'" (Times 1978). The kit was standard practice in Illinois hospitals by the 1980's (CNN 2015).

Modern kits, now called sexual assault kits (SAKs) or rape kits, contain instructions, documentation, and various tools for collecting evidence. When a rape occurs, the victim can visit a Sexual Assault Nurse Examiner (SANE), or another trained medical professional, where a SAK is administered with the consent of the victim (Office on Violence Against Women 2013). The kit is then sent to law enforcement. Historically, kits are held in the possession of law enforcement until deemed useful for identifying, confirming, or prosecuting an alleged attacker. When sent to the testing facility, the kits then wait in a queue to be tested (The National Center for Victims of Crime, n.d.).

During testing, a forensic DNA specialist searches for the presence of non-victim DNA. If there is DNA present, the specialist will attempt to create a DNA profile. The profile is then uploaded into the Combined DNA Index System (CODIS), a national DNA database for arrested and convicted offenders. A match to an existing DNA profile yields a "hit" in the system. An "offender hit" occurs if the hit matches a convicted offender. The information from the tested kits is then used to develop an examination report (National Institute of Justice, n.d.). Figure 1 outlines the steps of the SAK testing process. The arrow representing movement from evidence storage to testing is dashed because until recently there has been inconsistent movement between the two locations.

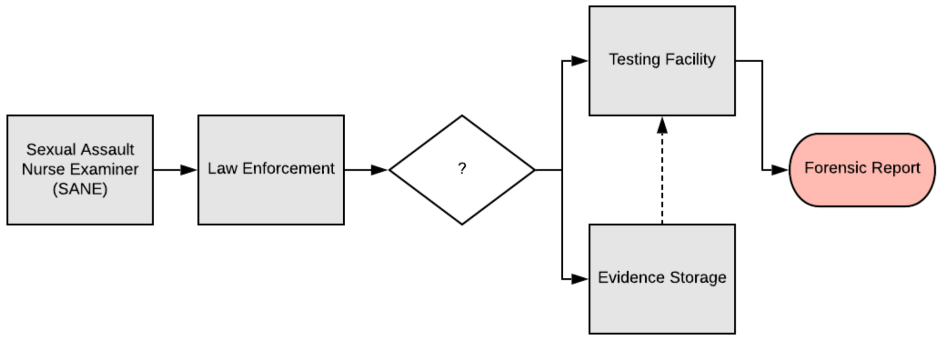

Figure 1. Path of Traditional Sexual Assault Evidence Collection and Testing

Background

The Backlog

In recent years, jurisdictions have been uncovering thousands of untested SAKs. Notably, New York City discovered 16,000 untested kits (Bashford 2013). Houston uncovered 16,000 kits (Wells, William, Campbell, Bradley, and Franklin, Cortney 2016). 11,000 were discovered in Detroit (Campbell et al. 2015), and nearly 11,000 in Los Angeles city and county (Peterson et al. 2012). Many more kits were uncovered across the country. In 2006, it was estimated that the number of kits backlogged in the testing process was 169,000 (Pratt et al. 2006). However, the exact number of backlogged kits is unknown because there is no nationwide mandatory reporting policy.

The SAK backlog has been highlighted in the media (Reilly 2015) and by activists like Mariska Hargitay, who founded the Joyful Heart Foundation (JHF), a non-profit victim advocacy group ("Our Story" n.d.). End the Backlog, a JHF initiative, estimates that there are over 100,000 untested kits across the United States ("Where the Backlog Exists and What's Happening to End It," 2019).

Legislation

In 1989 Debbie Smith was dragged from her home and repeatedly raped by a man in a ski mask for over an hour. After reporting the assault, she was administered a sexual assault kit, which went untested for over six years. When the kit was finally tested, the offender was identified to be a prisoner, serving 161 years for robbing and abducting two women the same year he attacked Debbie (Hewitt 2002). The Debbie Smith Act (also known as "Justice for All Act"), created in 2004 and reauthorized in 2008 and 2014, was enacted to provide funding for forensic testing facilities and support the growth of CODIS. The Debbie Smith Act was the first piece of legislation dedicated specifically to ending the SAK backlog and to prevent the tragic absence of justice seen in the case of Debbie Smith. In 2019, the Debbie Smith Act was proposed for reauthorization and is awaiting House approval (Cornyn 2019).

The Sexual Assault Forensic Evidence Reporting (SAFER) Act, born from the 2013 reauthorization of the 1994 Violence Against Women Act (VAWA), requires that at least 75% of the funding from Debbie Smith grants be used for SAK backlog reduction efforts. Recipients must report regular audit data to the Department of Justice (DOJ) (Sacco 2019). President Donald Trump approved of the SAFER Act's reauthorization in 2017, continuing efforts to eliminate the SAK backlog ("President Donald J. Trump Signs H.R. 560, H.R. 1242, H.R. 1306, H.R. 1927, S. 1393, S. 1532, S. 1766" 2018).

Literature Review

For many, the SAK backlog represents a failure of the criminal justice system. Federal policies like the Debbie Smith Act and SAFER Act were enacted to address the issue of the backlog, and reforming the policies surrounding SAK testing is underway at the state level. The purpose of the following literature review is to evaluate existing research regarding a) where and why the backlog exists and b) testing policies for addressing the SAK backlog.

Findings

19 papers are considered in this literature review. Of these papers, 16 included information about the cause of the backlog. 15 discussed the backlog in the possession of law enforcement and 8 discussed untested kits within the forensic laboratory. Table 1 outlines the causes that the literature identifies for the backlog at each location.

Table 1. Articles Including Location and Cause of SAK Backlog

Location (*Cause*)	**Sources**
Law Enforcement Custody	15
Discretion	*9*
Resources	*4*
Forensic Testing Facility	8
Resources	*7*

17 articles discussed policies for reducing the SAK backlog. The policies included are a test-all policy (or "forklift testing") and "conditional" testing. "Conditional" is used here to describe testing methods which do not support testing all kits or support prioritization of SAKs within the testing process, based on case characteristics. Table 2 shows the breakdown of these articles.

Table 2. Policies Supported by the Literature

Policy	**Sources**
Test-all	13
Conditional	9

Law Enforcement

Lovrich et al. (2003) and Strom & Hickman (2010) determined that the most common reason for law enforcement not submitting a SAK for testing is lack of suspect identification, which is interesting because testing a SAK could lead to identification of a suspect. Perceived kit utility is also considered when deciding whether to submit a SAK (Campbell and Fehler-Cabral 2018). Kit utility is based on the prediction of whether it is likely that SAK analysis results will change the outcome of the case or will aid in the identification or confirmation of a suspect. If at any point the victim decides not to pursue prosecution, or is unresponsive or uncooperative during the process, a SAK will likely not be tested (Fallik and Wells 2015). In other words, if law enforcement does not believe a SAK to be necessary for a case, the kit historically would not likely be submitted for testing.

Victim credibility is often cited as a reason for not submitting a SAK for testing. Embedded in the question of victim credibility is the problematic stereotype of a woman crying "rape" for her benefit, or a sex worker who was involved in a "deal gone bad" (Campbell and Fehler-Cabral 2018). The inherent disbelief of the victim from law enforcement has been called the "rape myth" (Parratt and Pina 2017) and victim-centered policies are being developed to combat this issue (Office on Violence Against Women 2010).

Resource limitations within law enforcement can pressure officers to decide which cases to prioritize, which has left many rape and sexual assault cases short of time and consideration. This resource issue has contributed to the backlog of SAKs prior to release for testing (Campbell, Fehler-Cabral, et al. 2017). Law enforcement is also aware of the resource limitations within testing facilities and have described this as a reason for not sending kits for testing (Campbell, Feeney, et al. 2017; Strom and Hickman 2010).

Forensic Laboratory

Many studies discovered that resources at forensic testing facilities inhibits the amount of SAKs tested (Campbell, Feeney, et al. 2017; Campbell, Fehler-Cabral, et al. 2017; Lovrich et al. 2003). Testing a kit costs up to $1,500 and typically takes 3 to 6 months to be tested (The National Center for Victims of Crime, n.d.). Considering the annual amount of reported rapes and sexual assaults, testing kits could require an incredible amount of resources from testing facilities.

In a 2014 study of publicly funded forensic labs within the United States, 333,000 forensic biology cases were requested for examination, making up 9 percent of the total requests. 296,000 forensic biology cases were completed in public labs, 107,800 were backlogged, and 55 percent of the forensic biology case requests were outsourced to another public facility or a private testing lab. Although the number of backlogged kits within testing facilities has decreased over the years, the lack of resources still contributes to the amount of untested SAKs (Durose 2014).

Test-All Policy

According to End the Backlog, 11 states currently have "comprehensive" statewide reform, which includes testing of all backlogged and newly collected SAKs (see Table 3 for End the Backlog's categorization of statewide reform) ("Where the Backlog Exists and What's Happening to End It ," 2019). This language suggests that the most comprehensive policy is a test-all policy, and that states should be requiring testing of all backlogged kits and every kit collected in the future.

In 2016, New York became a "comprehensive" state by enacting Assembly Bill A8401C and Senate Bill S8977, developing a sexual assault victim's bill of rights (*NY State Assembly Bill A8401C* 2018; *NY State Senate Bill S8977* 2018). These pieces of legislation follow the 2016 bill which requires that all backlogged kits be submitted for testing and that all future kits be submitted for testing within 10 days of collection (*NY State Assembly Bill A10760* 2016).

Multiple studies of kits in Detroit's backlog recommend test-all policies on the basis that there are equivalent CODIS hits for stranger and non-stranger (Campbell et al. 2016) and statute of limitations-expired and -unexpired kits (Campbell et al. 2019). The studies suggest that there is utility in testing all kits, regardless of case circumstances.

Table 3. Types of Statewide Reform

Comprehensive *11 States*	**Limited** *30 States*	**Proposed** *4 States*	**None** *6 States*
Legislation includes all the following*: (1) Annual inventories collected and reported (2) Testing all backlogged kits related to a crime reported (3) Testing of all newly collected kits (4) Victims' right to notification and information about kits (5) Tracking system implemented (6) Funding with emphasis on testing	At least one of the six "Comprehensive" pillars	Reform under consideration	No reform

*Planned implementation of policies fulfills requirement.

Conditional Testing Policy

A study of previously untested kits in Houston's backlog revealed that only 3.1 percent of the 259 kits sampled could help to advance the case related to the SAK, despite nearly 75 percent of the kits containing forensic evidence. This is largely because the victim did not want to participate in the original investigation (73 percent), as characterized by: lack of victim cooperation (26.8 percent), victim's unwillingness to prosecute (25.8 percent), and/or victim's lack of communication with the detective (18.3 percent). 8.5

percent of the kits categorized as unhelpful for advancing a case were beyond the statute of limitations (Fallik and Wells 2015).

Recommendations following a 2012 study of the Los Angeles backlog do not suggest the testing of all backlogged kits, but rather prioritization favoring stranger kits connected to unsolved cases. This recommendation is based on the goal of increasing DNA profiles within CODIS and a lack of necessity for DNA testing in cases with identified offenders (Peterson et al. 2012). Interestingly, the results from the Los Angeles study conflict with a study in Detroit, which concluded with the concern of limiting CODIS uploads in the case of kit prioritization based on victim-offender relationship (Campbell et al. 2016).

Wang & Wein (2018) compared approaches to testing the backlog, including a method of prioritization, concluding in a recommendation to test all kits because the amount of time and resources necessary to review kit information (1.85 hours per kit) outweighs the benefits of prioritization for projects with a quick turnaround time. The authors do suggest, however, that in the case of a long, multi-year endeavor, prioritizing stranger kits could be advantageous, and that prioritizing kits near statute of limitations expiration could lead to more convictions (Wang and Wein 2018).

Discussion

When a victim reports a sexual assault, law enforcement has historically been the gatekeeper of justice because of their breadth of discretion. The immense backlog of untested kits is caused by both the hesitation to release kits by law enforcement and the resource constraints on forensic testing facilities. The introduction of test-all policies, being implemented in many states, eliminate police discretion and require all kits backlogged and collected in the future to be sent to a testing facility for examination.

There appears to be a discrepancy in what is believed to be the goal of SAK testing policies, as seen in the Peterson et al. (2012) and Campbell et al. (2016) studies, which emphasize goals of kit utility and amount of CODIS uploads, respectively. The lack of a clear goal for SAK testing could lead to conflicting metrics of success for a program or policy, making it difficult to evaluate their improvements. The disconnect may be due to the top-down approach of many of the policies surrounding backlog reduction. This issue could be addressed using the backward mapping technique, a method which closely considers the needs of the entities affected by policy changes (Elmore 1979).

Testing facilities currently receive funding through public grants and programs, such as the DNA Capacity Enhancement and Backlog Reduction (CEBR) program, to support the influx of kits caused by test-all policies. This program has dedicated over $1 billion to backlog reduction and prevention efforts, resulting in over 1 million kits processed ("U.S. Department of Justice, Office of Justice Programs, FY 2020 Program Summaries" 2019). This program, like others that support backlog reduction efforts, primarily reports results based on number of kits tested (throughput), yet this number may not necessarily reflect long-term process improvement for a jurisdiction. Success could be better indicated using average time in the system or time spent waiting for testing, in addition to throughput. This metric would provide a more meaningful description of process health as it relates to the goal of preventing future backlogs.

Conclusion

In recent years, there has been a heightened awareness of the backlog of sexual assault kits in law enforcement evidence and awaiting testing at forensic laboratories. The literature points to multiple reasons why kits have been backlogged. These reasons include police discretion, resource issues within law enforcement, and resource constraints at testing facilities. Within the walls of forensic laboratories, government grants support resources and improvements to the testing process, yet the influx of backlogged kits caused by the introduction of test-all policies will likely strain public facilities.

It is possible that the best policies for backlog reduction are not test-all policies, contrary to the trend of statewide mandatory testing of all backlogged and newly collected kits. Prioritization should be considered when developing policy, as it might better address a jurisdiction's goals for SAK testing. There should be more empirical research conducted to determine the best methods and intended goals for supporting backlog reduction. This includes the use of different process indicators of long-term improvement, such as time spent waiting for testing and time spent in the system, as these outputs should decrease over time with a successful program.

Research Questions

From the literature review, there is a clear gap in the goals of backlog reduction. Under the assumption that the goal of SAK backlog reduction is to test every kit quickly, there has been success in test-all policies with support from programs like CEBR. However, there is concern about whether a test-all policy is achieving the right goals. When considering process sustainability, or how facilities will fare after grants are dry, SAK backlog reduction success may not be so apparent. To consider the long-term success of test-all policies, the research questions for this thesis are as follows:

1. What does the process look like within publicly funded forensic testing facilities?
2. What is the time in system for SAKs in the testing process?
3. Is a test-all process sustainable?
    a. What resources are needed?

Methods

Process Modeling

The SAK testing process is made up of a series of tasks, each changing the state of the kit itself. For example, during the forensic examination of the kit, characteristics are revealed which can change the kit's path or outcome. If a kit does not contain DNA, it will not be uploaded to CODIS, as there is nothing to upload to the system. Because of the structure of the process, specifically from kit submission for testing through the development of a forensic report, the SAK testing process is a suitable candidate for discrete event simulation (DES), a process modeling tool used in the implementation of Lean.

At the heart of Lean is the concept of eliminating non-value-added work. Taiichi Ohno, one of the founding fathers of Lean manufacturing, identified seven modes of waste within manufacturing systems (Ohno 1988) and these wastes can also be modified to describe wastes in other industries (Table 4). Lean process improvements aim to minimize the wastes within a process, improving quality, reducing wait and service times, and optimizing process flow.

Table 4. Description of Ohno's Seven Wastes

Waste	*Description*
Overproduction	Producing more than what's necessary
Waiting	Employee or machine downtime
Unnecessary Transport	Excess movement of material
Over- or Incorrect Processing	Unnecessary or inefficient processing of materials
Excess Inventory	Excess material or product in the system
Unnecessary Movement	Unnecessary or inefficient employee motion
Defects	Defective parts or information which is wasted or reworked

Discrete Event Simulation (DES)

Discrete event simulation (DES) addresses each of the seven wastes, as described in Table 5 (inspired by Robinson, Radnor, Burgess, & Worthington (2012)). The use of DES spans many industries, production and service. Healthcare provision, transportation and logistics, and service systems are among the many non-traditional applications of the tool (Banks 1998).

Table 5. The Seven Wastes Modeled by Discrete Event Simulation

Waste	*Discrete Event Simulation Application*
Overproduction	Modeling variability in demand and production
Waiting	Modeling employee and machine utilization
Unnecessary Transport	Modeling transportation times and material movement
Over- or Incorrect Processing	Modeling expected vs. actual product flow
Excess Inventory	Modeling queues that develop within the process
Unnecessary Movement	Modeling connection between resources and process
Defects	Modeling defect or rework rate

A DES model was developed and analyzed to address the research questions stated above. The software Simio is used because of its availability for this research.

<u>Data Acquisition</u>

Information was gathered through meetings with a former technical manager at the Monroe County Crime Laboratory (MCCL). MCCL is located in Rochester, New York, and services 7 counties in New York State. The lab receives sexual assault evidence in the form of SAKs and "plus" material (underwear, bedsheets, etc.). Materials received are considered "cases" during the testing process.

MCCL does not perform direct to DNA testing, a method that is becoming more prevalent within sexual assault evidence testing facilities (National Institute of Justice, n.d.), but instead performs Y-screening prior to analyzing DNA. Y-screening allows an analyst to determine if there is any non-victim DNA present in the samples submitted before continuing with the DNA analysis portion of the testing process.

Multiple analysts are involved in the sexual assault evidence testing process at MCCL. Caseworkers perform the testing procedures and reviewers, technical and administrative, must check the caseworkers' results. At MCCL, there are fewer reviewers than caseworkers. Reviewers may not have handled a case prior to review, and caseworkers assigned may not have previously been a reviewer of that case. The caseworker-reviewer rule is an important rule that must be followed for all cases that undergo the sexual assault evidence testing process.

Model Assumptions

After examining arrival data at MCCL, arrival rates for the model were simplified so that it is equally likely that, on a weekday, 0 through the variable *DemandPerDay* cases will be submitted to the laboratory for testing. This variable can be changed to represent varying demand for different facilities.

First-in-first-out (FIFO) is assumed to be practiced at all steps of the testing process, as is practiced at MCCL.

Workers in the simulation are assumed to be full time equivalent (FTE). Employees are assigned to a case and pick up the case as soon as they become available. As cases require work, workers will complete this work as soon as they are available.

At the review stations (Y-screen and DNA), cases either experience "success" or "failure" for the review. In reality, some cases may need to be re-tested. These "rework" cases make up about 1-2 percent of cases reviewed and are not considered in the model.

"Plus" materials are considered to result in 1 sample, equivalent to 1 swab in a kit. Additionally, the number of samples used in DNA casework (following completion of successful Y-screen) is 1 for all cases, regardless of the original number of swabs in a kit.

Model Development

Facility

A model of the MCCL testing facility was created in Simio, based on the process diagram seen in Figure 2. The process steps were broken down into logical "stations" by reading MCCL standard operating procedures and discussing process flow with the MCCL technical manager. Figure 3 shows the facility view in Simio.

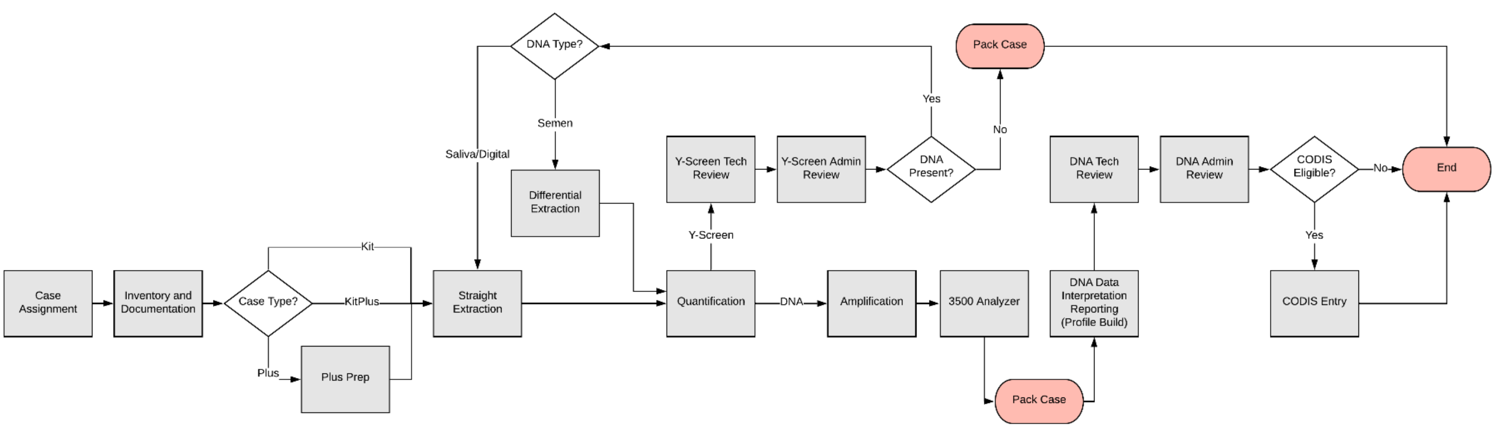

Figure 2. Sexual Assault Evidence Testing Process Map

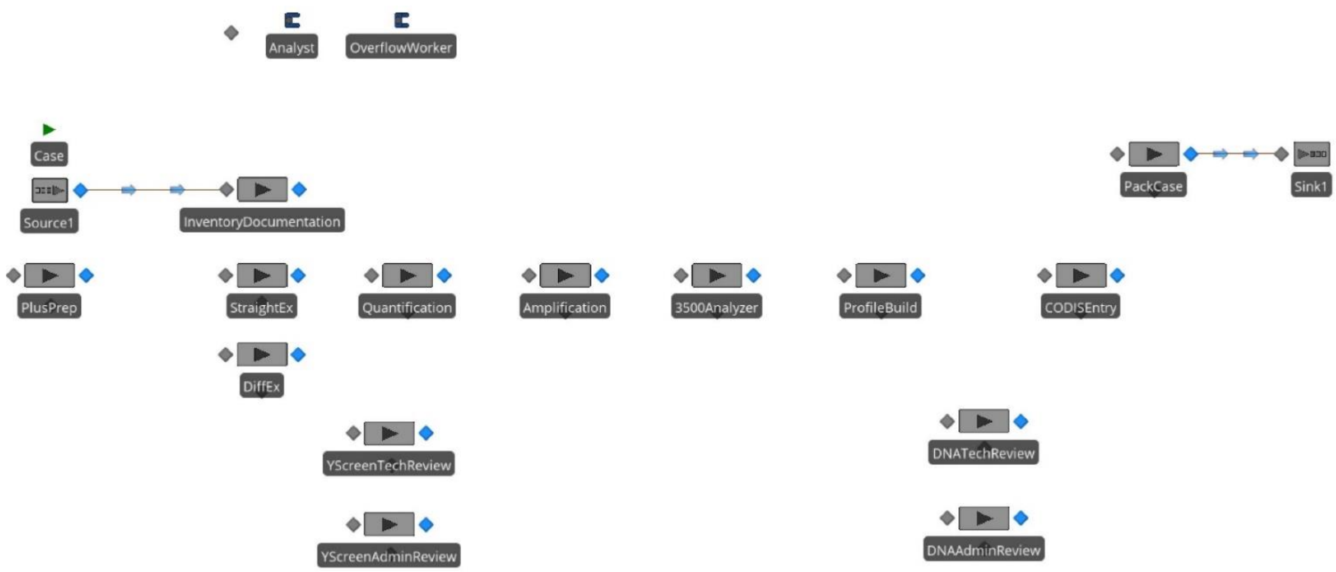

Figure 3. Simio Facility View

Stations

Stations with worker constraints are shown in Table 6. The stations not shown in Table 6 are constrained by the number of workers that can perform the task associated with the station.

Table 6. Workers at each station

Processing Step	**Workers**
Inventory and Documentation	2
Extraction Preparation for "Plus" Items	1
Straight Extraction (Y-Screen, DNA)	1
Differential Extraction	1
Quantification (Y-Screen, DNA)	1
3500 Analyzer	1

Some stations can batch samples to test simultaneously. Table 7 is the minimum and maximum number of samples for these stations. The batching amounts are primarily determined by the instruments used for the associated processing step.

Table 7. Batching Amounts at Stations

Processing Step	**Minimum Sample Count**	**Maximum Sample Count**
Straight Extraction (Y-Screen)	1	18
Straight Extraction (DNA)	2	13
Differential Extraction	1	6
Quantification	3	13
Amplification	3	13
3500 Analyzer	3	13

Processing Times

Processing times were estimated by the MCCL technical manager, with distinction between quantity-dependent and -independent times. This distinction is necessary because testing facilities can batch cases during certain process steps. Table 8 show processing times for quantity-dependent steps, including a "baseline" time for a single case and processing times for additional cases or samples batched during the step. The baseline time includes setup time and processing time.

Table 8. Processing Time for Quantity-Dependent Steps

Process Step	**Baseline Time, in minutes**	**Additional Processing Time, in minutes**
Inventory Documentation	25 + 5 per swab	N/A
Straight Extraction (DNA)	112	30-45 (per additional case)
Differential Extraction	90 (without worker) + 40	10 (per additional case)
Quantification	45	1 (per additional sample)
Amplification	45	20 (per additional case)
3500 Analyzer	45	5-10 (per additional case)
Time to Repack Complete Case	15	N/A

Table 9 is the approximated processing times for steps where there is no batching, or batching doesn't change the processing time. Coincidentally, these processing times are also more variable and were approximated using a min/mode/max method.

Table 9. Processing Time for Quantity-Independent Steps

Process Step	**Min Time, in minutes**	**Most Likely Time, in minutes**	**Max Time, in minutes**
Straight Extraction (Y-Screen)	20	30	45
Extraction preparation for "Plus" items	60	150	480
Y-Screen Tech Review	20	60	120
Y-Screen Admin Review	15	30	120
DNA Data Interpretation Reporting (Profile Creation)	60	120	480
DNA Tech Review	60	180	480
DNA Admin Review	10	30	180
CODIS Enter	10	15	30

Case Characteristics

As a case moves through the testing process, characteristics are revealed about the case that could determine the case outcome. When a case is created in the model, simulating case submission, the case is labeled as being a kit, a kit "plus", or only "plus" material. If a case includes a kit (assigned kit or kit "plus"), the case is assigned a quantity of swabs. The number of swabs is critical for determining processing times and batching of cases. In the case of kit "plus", "plus" materials are only handled if there is no DNA present in the kit.

If there is DNA present in a case, it is determined whether the DNA is semen, other (digital, etc.), or both. If there is both semen and "other" DNA present, the analyst will proceed with testing for the seminal DNA. Technical and administrative review must occur for all testing results; however, the case will not continue if there is no DNA present. A Y-screen review assignment of "failure" indicates that there is no DNA present in the samples provided, and the case will exit the system following case re-pack.

DNA review indicates whether a DNA profile could be successfully created for a case. If the result of DNA review is "success", the analyst will attempt to upload a DNA profile to CODIS (based on CODIS eligibility) and the case will exit the system. If DNA review results in "failure", there is no upload to CODIS, and the case exits the system. Table 10 includes these characteristics and the probability of conditions occurring.

Table 10. Case Characteristics and Probability of Occurrence

Characteristic	
Condition	**Probability**
Kit/KitPlus/Plus	
Kit	0.95
KitPlus	0.04
Plus	0.01
Number Swabs	
<2	0
2	0.01
3	0.01
4	0.03
5	0.317
6	0.317
7	0.317
>7	0
DNA Type	
Semen	0.85
Other	0.01
Both	0.14
Y-Screen Review Success/Failure	
Success	0.51
Failure	0.49
DNA Review Success/Failure	
Success	0.95
Failure	0.05

Characteristic	
Condition	**Probability**
CODIS Eligibility	
Yes	0.75
No	0.25

Analysts

The total number of analysts is varied by adjusting the associated input variable. The number of analysts trained with each skill (Y-screen casework, DNA casework, Y-screen technical review, Y-screen administrative review, DNA technical review, DNA administrative review) can also be defined by the model user. Analysts can have a variety of skills and it is possible that a worker is not utilized.

The number of analysts assigned as having each skill is tracked by a model variable and is referenced before assigning a case. If the maximum number of workers has been reached, the workers already assigned to the model are reviewed to determine which worker has the fewest cases. If the maximum number of workers for a skill has not been reached, the worker with the fewest cases overall who also does not conflict with the caseworker-reviewer rule, is assigned to the case.

If a case cannot be assigned a worker without violating the caseworker-reviewer rule, the case is assigned to a dummy worker, called the overflow worker. The number of cases assigned to the overflow worker is stored in the model and can be used to determine the viability of a scenario. Scenarios with more than 1 case assigned to the overflow worker, on average, are not considered a viable recommendation.

Demand

The demand for testing is represented by the variable *DemandPerDay*. As mentioned in the model assumptions, the number of cases submitted for testing is equally likely to be any number of cases between 0 and the variable *DemandPerDay*. The resulting number of cases created are expressed as "relative demand" throughout the study, as the values of *DemandPerDay* were chosen to represent varying levels of demand, not to create a specific number of cases in the model.

Batching

When a case is approaching a station with instrumentation allowing for sample batching (Table 7), a model process is triggered which checks an output table for other cases waiting in the same queue with which the case can be batched. For a case to be batched with other cases, the caseworker-reviewer rule must not be violated, and the maximum number of samples must not be exceeded. Straight extraction and quantification batches must also include cases that are either all Y-screen or all DNA; mixed types are not allowed for batching at these stations.

If a viable batch is discovered, the case will be batched prior to entering the station and unbatched following completion of the process step. In the case where there is no batch available, the case information will be stored in the batch tracking output table. Cases will continue to be available for batching until the assigned worker arrives at the station.

Routing

Case movement throughout the testing process is dictated by background processes in the model and variables assigned to each case. After each casework processing step, model processes check where to send the case. For example, after quantification, a process is triggered which decides whether the case has already completed Y-screen review. If it has already completed Y-screen review, the case is sent to amplification. If it has not completed Y-screen review, it is sent to Y-screen technical review. After Y-screen and DNA administrative review, the case is assigned as "success" or "failure". If the case is a "failure", it is sent to the case packing station. Otherwise, the case is sent to the next step of the process.

Experiment Design

An experiment was designed to evaluate the capacity of sexual assault case testing in forensic testing facilities with a variety of demands and full-time equivalent (FTE) employees. Relative demand was varied from 1 to 10, and the number of analysts from 3 to 10. The minimum number of analysts employed for the testing process must be 3 because the caseworker, technical reviewer, and administrative reviewer must all be different employees.

Case time in system and worker utilization were the primary results for evaluating the experiment. The resulting values represent an average of the replications for each scenario. Quantity of replications were automatically set by the software so that the resulting information is presented with 95% confidence. Also evaluated is the time of case completion. Because of the New York State mandate to have cases completed within 90 days of submission to the testing facility (*NY State Assembly Bill A10760* 2016, 10760), the mix of case completion time is an important metric. If a scenario results in a significant amount of cases in the system for greater than 90 days, the scenario would be infeasible.

Results

The experiment results were measured by case time in system, worker utilization, and case completion mix. Figure 4 and Figure 5 show average case time in system and worker utilization for scenarios with 3 to 10 workers and a relative demand of 1 to 10. In this experiment, all skills could be assigned to each worker (i.e. the maximum number of workers trained in each skill is equal to the number of workers in the system).

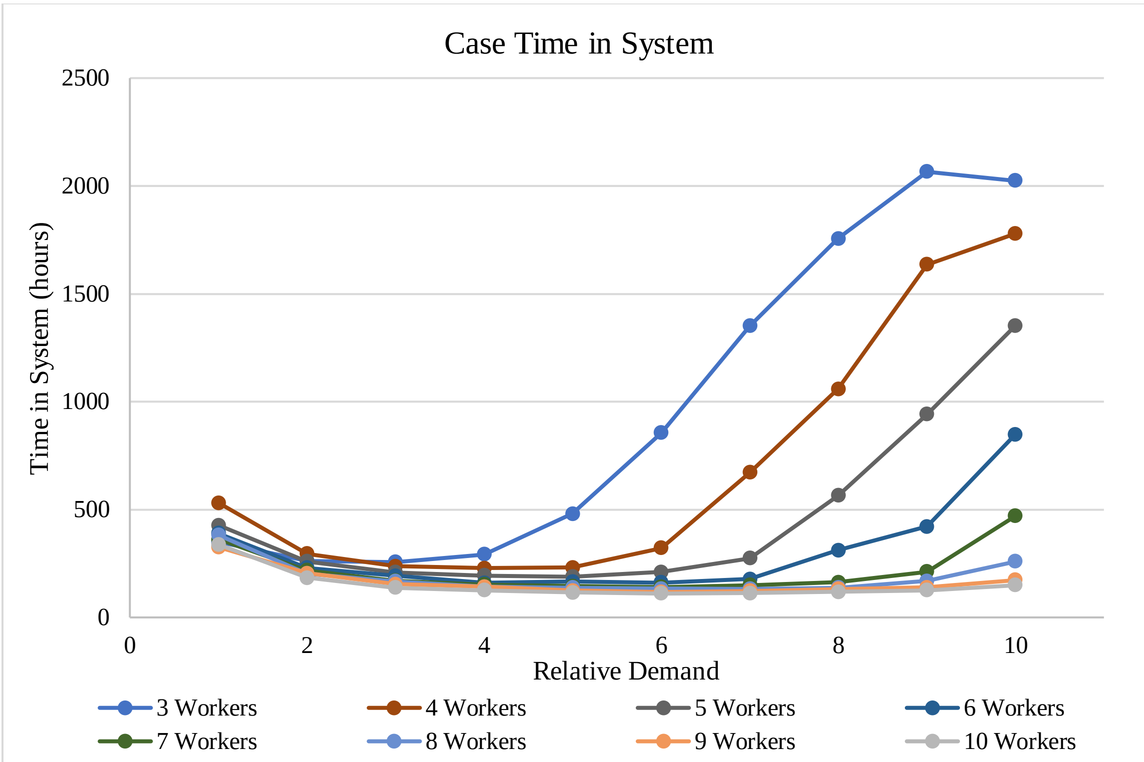

Figure 4. Case Average Time in System with Varying Demand and Staffing Levels

Average time in system for all scenarios with relatively low demand have similar average time in system, around 500 hours, or 21 days. Scenarios with a relative demand of 6 or higher have more variable results than the scenarios of lower demand.

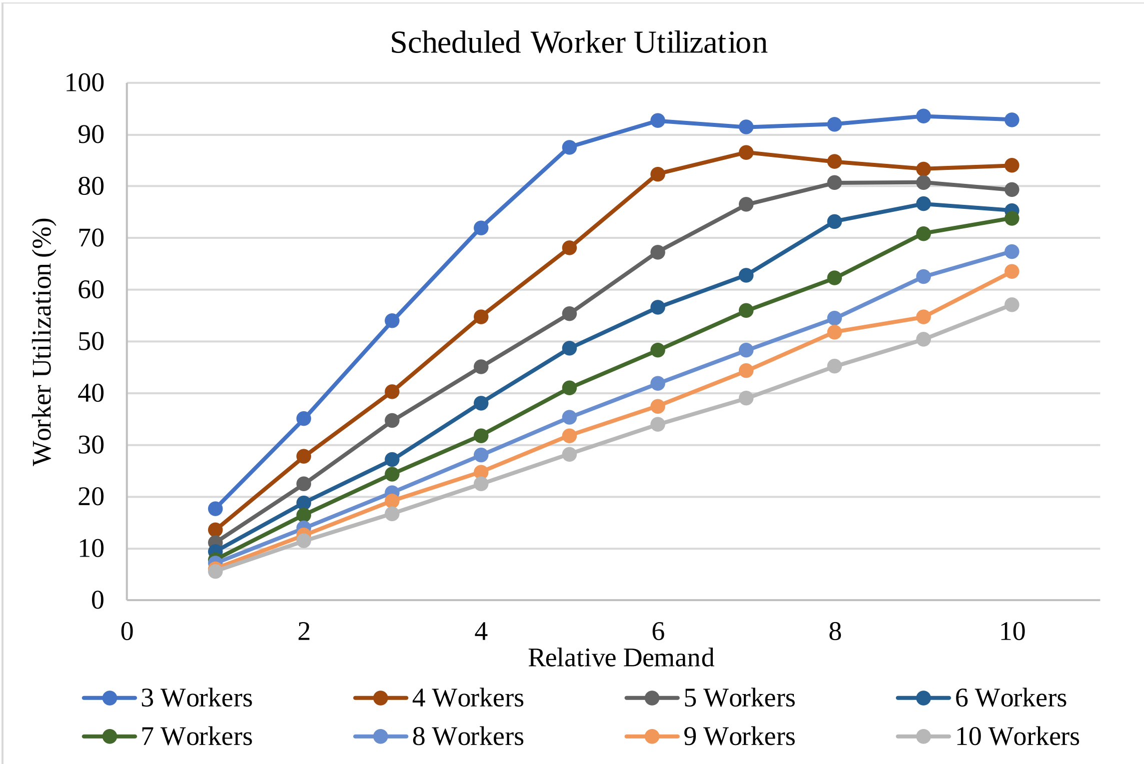

Figure 5. Worker Utilization with Varying Demand and Staffing Levels

Worker utilization appears to be linear for the lower-demand scenarios. For relative demand of 6 or higher, the worker utilization appears to level off in scenarios with 3 to 6 workers. Scenarios with 7 to 10 workers follow a linear trend for all demand levels.

Figure 6 shows mix of completion time results in scenarios with 3 to 6 workers. The results are depicted as the percent of the total cases completed, including the mix of cases completed within 30 days, between 30 and 60 days, between 60 and 90 days, and more than 90 days. Figure 7 shows the completion time for scenarios with 7 to 10 workers.

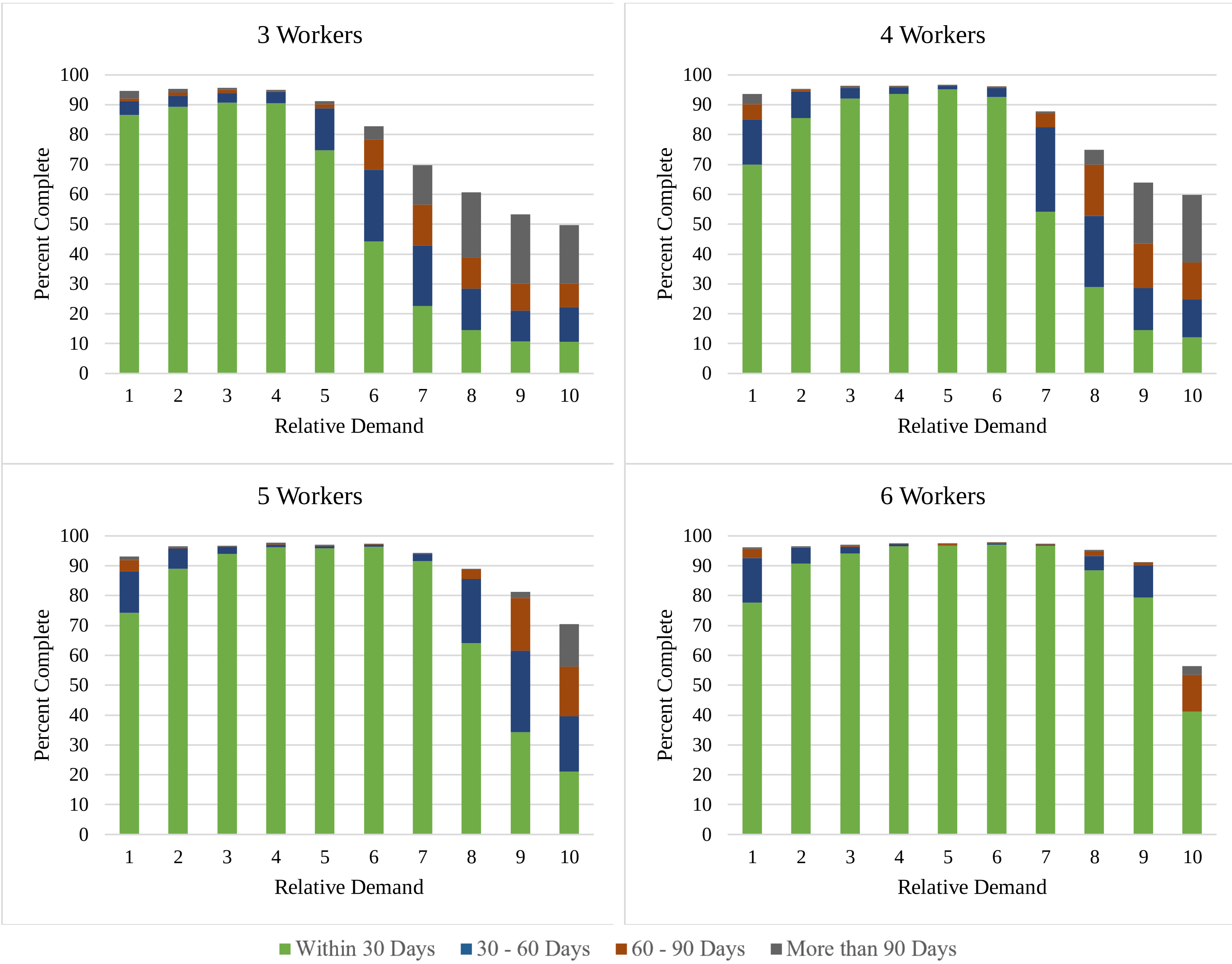

Figure 6. Completion Time Mix for 3- to 6-Worker Staffing Levels

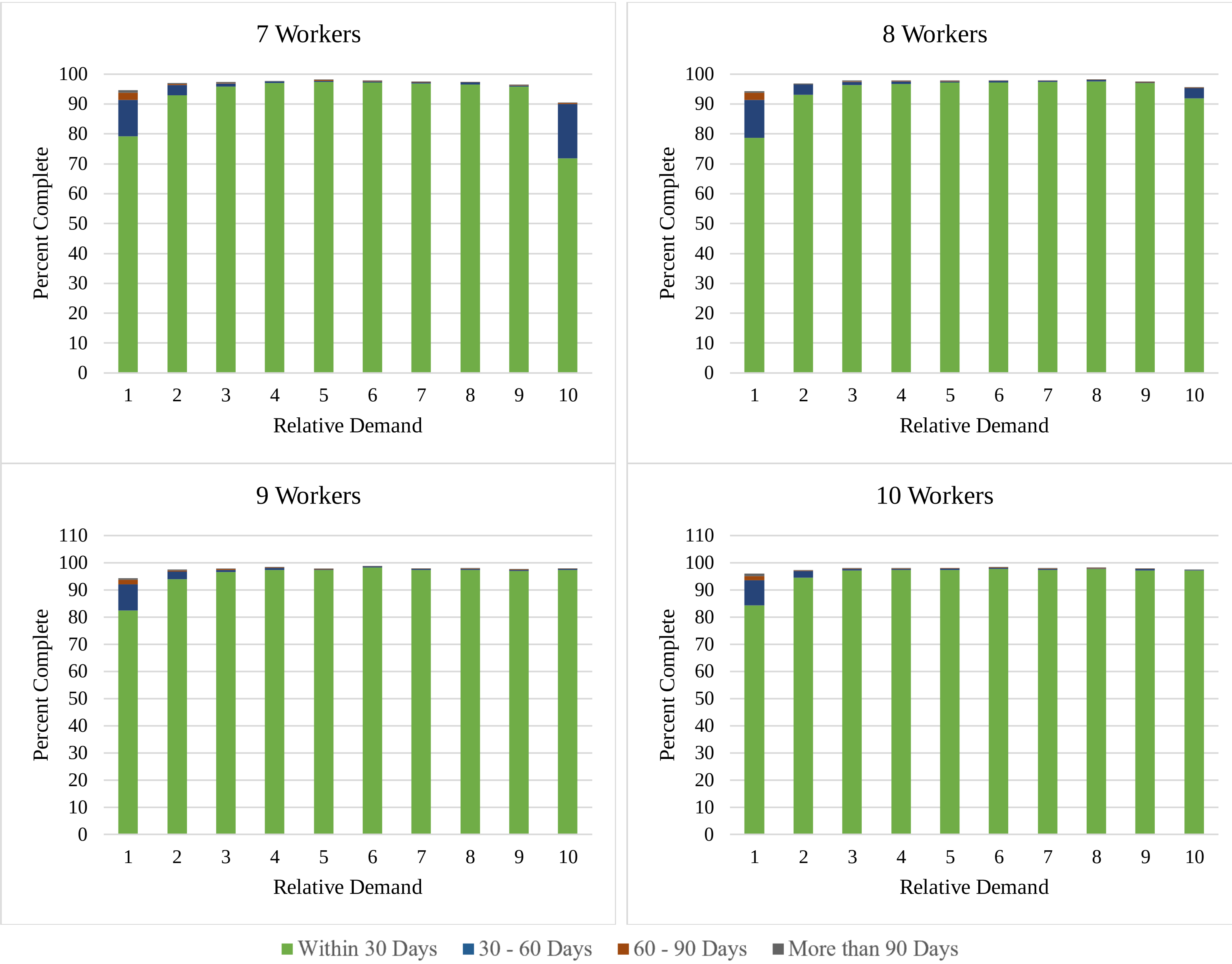

Figure 7. Completion Time Mix for 7- to 10-Worker Staffing Levels

All scenarios, for all staffing levels, complete more than 80 percent of the cases created in the model for relative demands 1 through 6. Scenarios with 7, 8, 9, and 10 workers staffed can complete more than 80 percent of cases submitted for all demands shown. Cases completed in scenarios with 3 workers decrease significantly with a relative demand of higher than 5. The mix of cases which take more than 30 days to complete is diversified in the higher-demand scenarios as well. Cases which take more than 90 days to complete make up about 20 percent of the cases completed in the scenarios with a relative demand of 7, 8, 9, and 10 in a 3-worker system.

The scenarios with 10 workers resulted in more than 95% completion of all cases and the lowest worker utilization among all scenarios, regardless of the relative demand. Figures 8, 9, and 10 depict the results of an iteration of the experiment where the upper bound of the relative demand on a high-staffed laboratory (10 workers) is extended from 10 to 20.

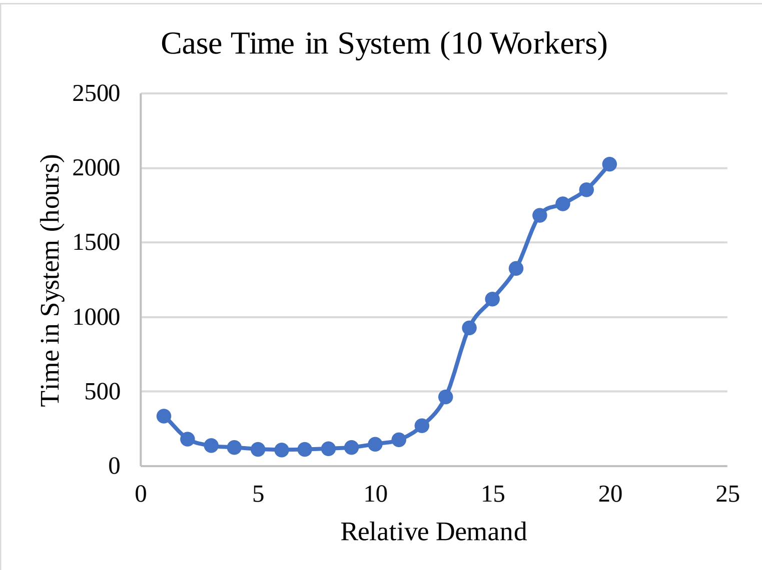

Figure 8. Time in System for 10-Worker Staff

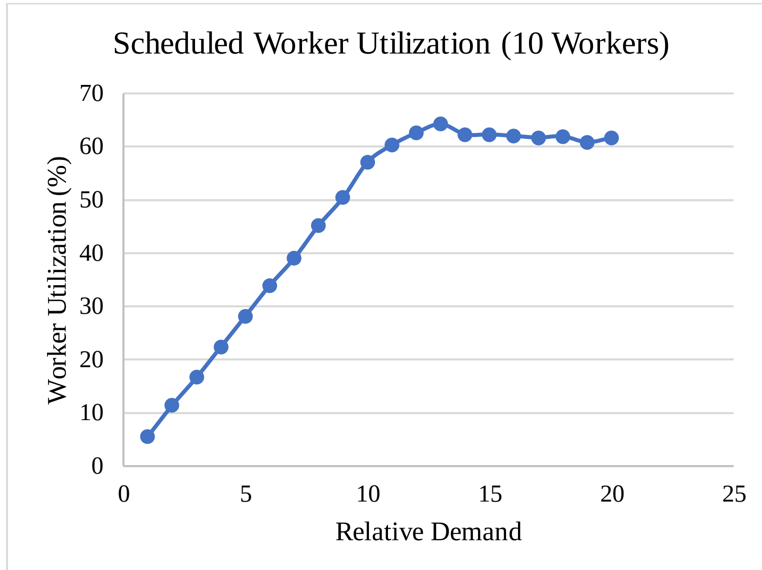

Figure 9. Worker Utilization for 10-Worker Staff

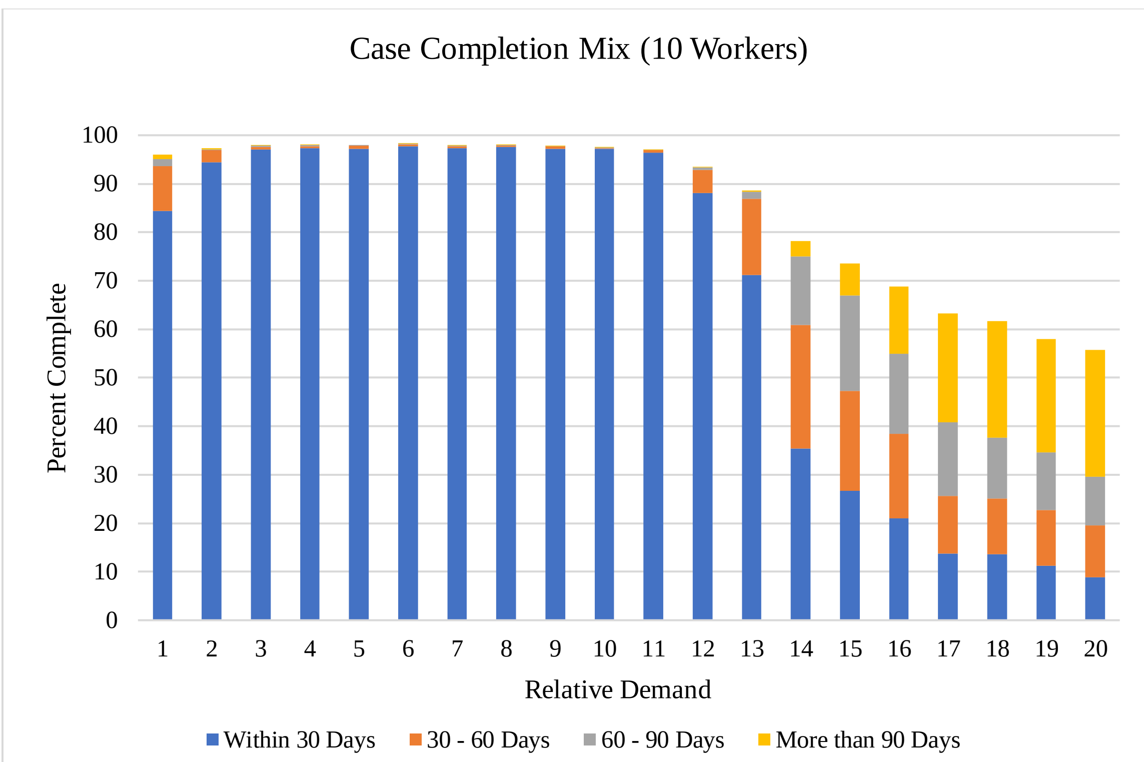

Figure 10. Completion Time Mix for 10-Worker Staff

In another iteration, the experiment was run with 3 workers and varying competencies. The number of caseworkers was set so that all 3 workers could perform Y-screen and DNA casework. Scenarios were created to test the variations of Y-screen and DNA technical and administrative reviewers. The scenarios were limited to demand from 1 to 6. The experiment resulted in 486 scenarios in total, however only 36 scenarios resulted in less than 1 case assigned to an overflow worker, on average.

After removing scenarios with less than 80 percent completion of cases created and more than 5 percent of cases completed in more than 90 days, 32 scenarios remain, none of which have a relative demand of 6. Figures 11 and 12 are box and whisker plots which display the range of case time in system and worker utilization for all skill assignment variations.

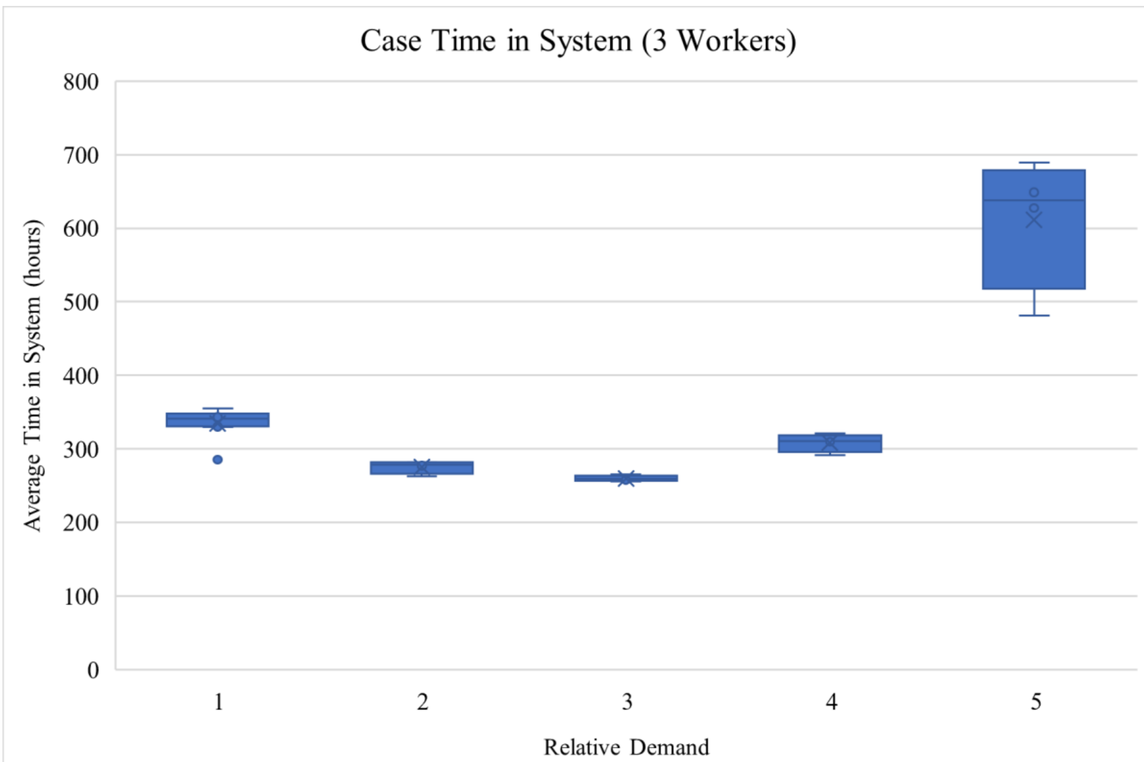

Figure 11. Case Average Time in System for 3-Worker Staff with Skill Variations

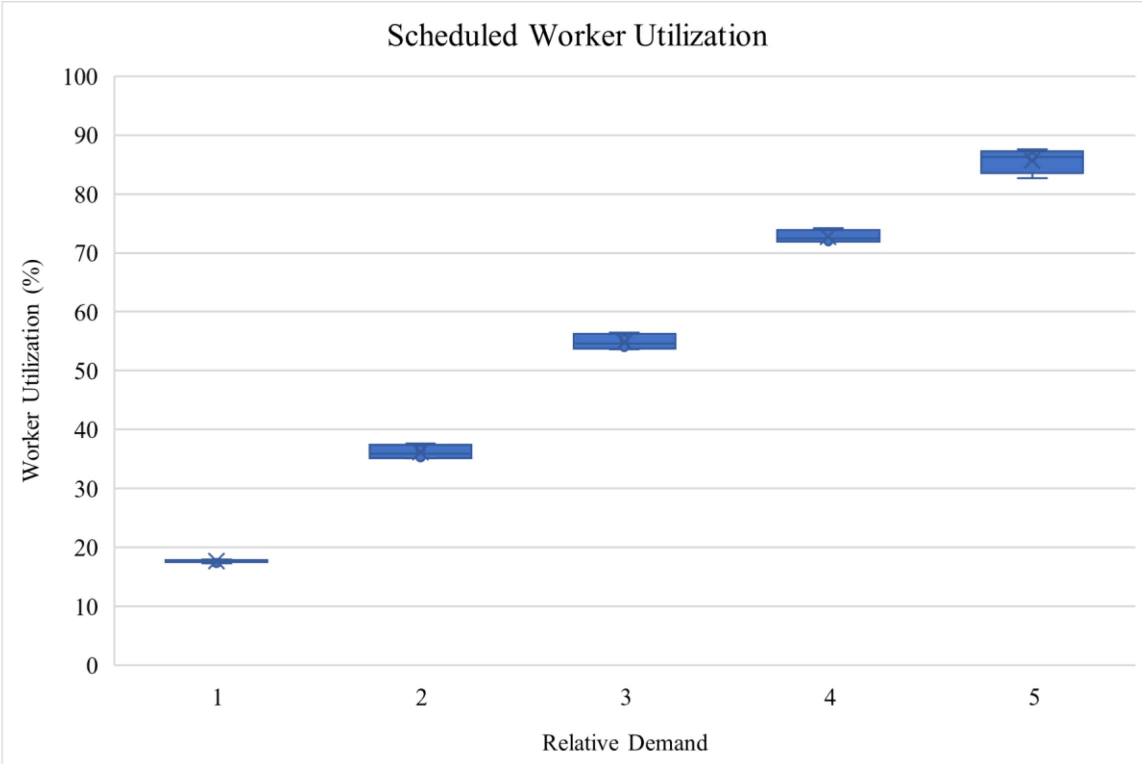

Figure 12. Worker Utilization for 3-Worker Staff with Skill Variations

Case time in system and scheduled worker utilization have very little variation in all scenarios for a 3-worker system, apart from the scenario where relative demand is 5. Scenarios with relative demand of 3 and 4 fall within the FTE worker utilization for all variations of skill assignment, and all scenarios' average time in system fall well below 90 days.

Discussion

Results from the experiments show that there is a clear trend between number of full-time equivalent (FTE) workers and case time in system and worker utilization. The average time in system for facilities with a relatively low demand, from 1 to 5, falls at or below 500 hours for all staffing levels. There is more variety in the average time in system by number of workers as the relative demand increases above 5. Using average time in system as a metric for comparison may not be the most comprehensive because it only accounts for cases which are completed. Time in system does not include cases that remain in the system at the end of the experiment's run. The metric, however, does show that the average time in system for cases in a facility with a relative demand of 1 to 5, at all staffing levels, falls well below 90 days, the New York State mandated time for case completion (*NY State Assembly Bill A10760* 2016).

Worker utilization results show that in all scenarios where there is a relative demand of 1, the scheduled worker utilization is less than 20 percent. Worker utilization in a testing facility may be higher than what the results of the model show. The model is limited to what is known about the testing process and administrative work associated with the process but does not include time spent performing tasks loosely related to the process (e.g. walking to retrieve cases) or worker breaks. The workers' ability to immediately work on a case as the worker becomes available does not necessarily reflect the response time of an analyst in reality. Worker utilization output should inform the model user of the system boundaries and relative utilization but should not be considered to be exact. For recommendations made from this model, utilization within the range of 60-80 percent will be considered FTE.

New York State's mandated 90-day testing of all sexual assault kits is used as a guide for evaluating the completion of cases in the model. Scenarios with more than 1 percent of completed cases with a testing time of more than 90 days will not be considered a viable option for recommendation.

Given the considerations for full time equivalence (60-80% worker utilization) and the 90-day testing period, potential recommendations for various staffing levels are shown in Table 11. Table 12 is the case completion time mix for the recommended scenarios.

Table 11. Worker Utilization for Recommended Scenarios

Number Workers	**Relative Demand**							
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**
3	53.96	71.99	-	-	-	-	-	-
4	-	-	68.11	83.38	-	-	-	-
5	-	-	-	67.28	76.51	80.70	-	-
6	-	-	-	-	62.85	73.25	76.61	-
7	-	-	-	-	-	62.31	70.85	73.87
8	-	-	-	-	-	-	62.53	67.42
9	-	-	-	-	-	-	-	63.49

Table 12. Completion Time Mix for Recommended Scenarios

Number Workers		Relative Demand							
		3	4	5	6	7	8	9	10
3	Total Cases Complete (%)	95.66	95.01	-	-	-	-	-	-
	Within 90 Days (%)	*94.97*	*94.67*						
	>90 Days (%)	*0.69*	*0.34*						
4	Total Cases Complete (%)	-	-	96.63	96.16	-	-	-	-
	Within 90 Days (%)			*96.42*	*95.97*				
	>90 Days (%)			*0.21*	*0.19*				
5	Total Cases Complete (%)	-	-	-	97.41	94.38	-	-	-
	Within 90 Days (%)				*97.24*	*94.18*			
	>90 Days (%)				*0.17*	*0.20*			
6	Total Cases Complete (%)	-	-	-	-	97.37	95.33	91.24	-
	Within 90 Days (%)					*97.31*	*94.95*	*91.12*	
	>90 Days (%)					*0.06*	*0.37*	*0.12*	
7	Total Cases Complete (%)	-	-	-	-	-	97.26	96.42	90.53
	Within 90 Days (%)						*97.17*	*96.32*	*90.43*
	>90 Days (%)						*0.09*	*0.10*	*0.10*
8	Total Cases Complete (%)	-	-	-	-	-	-	97.40	95.67
	Within 90 Days (%)							*97.35*	*95.58*
	>90 Days (%)							*0.05*	*0.08*
9	Total Cases Complete (%)	-	-	-	-	-	-	-	97.79
	Within 90 Days (%)								*97.75*
	>90 Days (%)								*0.04*

Scenarios with 10 workers and a relative demand of 1 to 10 did not result in any reasonable recommendations because of the low worker utilization. When extending the demand to 20, case time in system spikes and worker utilization levels at around 60 percent at a relative demand of 13. Mix of case completion time agrees with a relative demand of 13 as the maximum capacity for a system with 10 workers.

The scenarios with a relative demand of less than 3 did not result in any reasonable recommendation for FTE employees. Areas with demand this low could combine their cases with another jurisdiction or designate sexual assault forensic testing to analysts who have responsibilities outside of sexual assault case testing.

In the experiment run with 3 workers where the number of workers trained in each skill is varied, the variation in case time in system and worker utilization is minimal. Scenarios with a relative demand of 3 and 4, the recommended scenarios mentioned above, resulted in worker utilization varying less than 5 percent. An interesting result of the lower-demand scenarios (relative demand of 1 and 2) in this experiment is that the actual number of workers assigned to each task is less than the maximum number allowed. These results suggest that the optimal number of workers with a skill may be less than the allowed number of workers for that skill. Specific worker competencies could be analyzed for each recommended scenario in the main experiment.

Table 13 is the average number of cases created during the model run and a comparable location for each relative demand. Data used for reported rapes by location is from the FBI's Universal Crime Reporting (UCR) statistics (FBI 2018).

Table 13. Average Cases Created by Model Relative Demand and Comparable Location

Relative Demand	Cases Created (average)	Comparable Location	Reported Rapes (2018)
1	134.75	South Carolina, cities outside metropolitan areas	133
2	270.42	California, nonmetropolitan counties	264
3	404.38	Virginia, nonmetropolitan counties	400
4	535.075	Texas, nonmetropolitan counties	544
5	677.96	New York, nonmetropolitan counties	676
6	811.11	Connecticut, metropolitan statistical area	728
7	946.05	Kentucky, metropolitan statistical area	944
8	1,087.35	Michigan, nonmetropolitan counties	1,065
9	1,219.36	Nebraska, state total	1,233
10	1,355.62	Arkansas, metropolitan statistical area	1,420

Research conducted in this study, and the subsequent results, have shown that it is possible to test more than 90 percent of sexual assault cases within a 90-day testing period. These findings show that there are viable options for facilities to complete testing quickly. In previous research regarding sexual assault evidence testing, there is mention of a lack of resources allocated to sexual assault forensic testing facilities. Although this study cannot confirm a relationship between the increased funding to facilities which perform sexual assault forensic testing and timely completion of testing, this research shows that there are multiple potential recommendations for staffing these facilities.

Research questions posed prior to the study were the following:

1. What does the process look like within publicly funded forensic testing facilities?
2. What is the time in system for SAKs in the testing process?
3. Is a test-all process sustainable?
    a. What resources are needed?

The first question was addressed in the development of the model, considering resources and processes within Monroe County Crime Laboratory (MCCL), a publicly funded facility. Decision processes were developed in the model to reflect the processes which occur in the testing facility. These decisions can be modified to reflect parameters specific to any facility.

Case time in system, the second research question, is an output metric for the study. Time in system is shown to vary with respect to the demand and the number of workers staffed at the facility. Metrics such as worker utilization and case completion mix were found to be more meaningful metrics for success in this study.

The third research question, regarding sustainability of a test-all process and the resources needed, is dependent on demand and the resources present at the facility. Allowing for flexibility of demand, by redirecting cases, and/or flexibility of FTE staff at a facility, sustainable testing of all sexual assault cases is possible. Interestingly, these points were not addressed in the research discovered in the literature review conducted prior to this research.

Policy Recommendations

For policymakers, a model can offer quantitative guidelines for the resources necessary for testing sexual assault cases in their jurisdiction. Below are some reasonable policy recommendations derived from this study:

- **In a jurisdiction where the demand is comparable the relative demand of less than 3 in this study, it is not recommended to have a staff of FTE employees assigned to sexual assault case analysis.**
  The results for a relative demand of less than 3 showed a low worker utilization. Workers were assumed to be full time equivalent throughout the study. However, the low utilization in these scenarios are too low to recommend any configuration of FTE workers. Areas with a comparable demand could combine cases with other jurisdictions to increase worker utilization to full-time equivalence. Alternatively, analysts could be assigned tasks other than sexual assault evidence testing.

- **It is not recommended to have a staff of 10 or more FTE employees with the equipment at MCCL.**
  Scenarios with 10 or more FTE employees resulted in worker utilization of less than 60 percent for relative demands 1 to 10. In higher demand scenarios (relative demand 11-13), worker utilization hovers around 60 percent.

- **A model is a useful tool for informing decisions about test-all policies, equipment upgrades, and staffing levels within testing facilities.**

  Facilities or government agencies can utilize an informed model, based on local demand and resources available, for making decisions about employee/resource allocation. Decisions about factors not included in this model (e.g. equipment upgrades, test all vs. conditional policies) can also be evaluated using a model. Results from these models can be displayed using graphs and figures, suitable for presenting to any audience.

Conclusion

A model, such as the one created for this research, can offer insight to an appropriate number of full time equivalent (FTE) employees for sexual assault forensic evidence testing at a laboratory, based on local demand. The model does not necessarily offer exact outcomes for every facility but can offer guidelines for the number of analysts necessary for supporting a location's demand. As discussed in the literature review, there are conflicting beliefs about the appropriate method for testing sexual assault evidence. A model could be used to weigh the benefits of conditional testing versus test-all policies. The information can also be used when determining where cases should be sent for testing. From a policymaker's perspective, the results from a model can inform policy regarding resource allocation for public facilities and important decisions about testing sexual assault evidence.

Limitations

There are several limitations to this research which could affect the results and reach of application. The most significant limitation is that the model was developed to reflect the resources at MCCL. The experiments only vary the number of workers staffed in the laboratory, and not the variation of the other resources. Considering resources with more testing capacity or faster cycle times would change the results of the experiments. In other words, the model has high internal validity and low external validity.

Another limitation to the study is that the model will make logical decisions based on the user's inputs and does not consider subjective decisions that might be made by analysts. For example, when assigning workers to a case, the model will consider the limitations for review to ensure that a reviewer has not been in contact with the case prior to review. In reality, analysts may not frequently use every skill in which they are trained. Subjectivity and experience surely play a role in day-to-day assignment of tasks at a testing facility.

Case submission is modeled as being uniformly likely to be 0 through the variable *DemandPerDay*, as defined by the user. This assumption simplifies the model but may not be the most accurate method for representing actual levels of demand. A more accurate model, in general, could be made with specific resource and demand information for a given location and facility. Alternatively, exact case submission data from a facility could be used as input data for the model.

Recommendations for Future Research

Future research should look at other resource changes, such as upgraded or additional testing equipment. A model could also be used to streamline and improve the testing process with the goal of decreasing testing time. Decreased testing time could also lead to consolidation or merging of testing sites. Additionally, future research could evaluate optimal specific worker competencies and costs associated with each skill. A supplementary optimization model could be developed alongside the DES model with this information.

Of Ohno's 7 forms of waste, unnecessary transport, unnecessary movement, and defects are not considered in this study, but could be considered in future research. The primary form of waste that is evaluated in this sexual assault evidence testing model is resource utilization, specifically the scheduled utilization of workers in the system. All other forms of waste not evaluated in this model could be examined in future research.

Works Cited

Banks, Jerry. 1998. *Handbook of Simulation: Principles, Methodology, Advances, Applications, and Practice*. John Wiley & Sons.

Bashford, Martha. 2013. "How New York City Tackled Its Backlog." February 13. https://victimsofcrime.org/docs/DNA%20Trainings/brashford-slides.pdf?sfvrsn=0.

Campbell, Rebecca, Hannah Feeney, Giannina Fehler-Cabral, Jessica Shaw, and Sheena Horsford. 2017. "The National Problem of Untested Sexual Assault Kits (SAKs): Scope, Causes, and Future Directions for Research, Policy, and Practice." *Trauma, Violence, & Abuse* 18 (4): 363–76. https://doi.org/10.1177/1524838015622436.

Campbell, Rebecca, and Giannina Fehler-Cabral. 2018. "Why Police 'Couldn't or Wouldn't' Submit Sexual Assault Kits for Forensic DNA Testing: A Focal Concerns Theory Analysis of Untested Rape Kits." *Law & Society Review; Amherst* 52 (1): 73–105. http://search.proquest.com/docview/2007415077/abstract/C7DE919109114D9BPQ/1.

Campbell, Rebecca, Giannina Fehler-Cabral, Deborah Bybee, and Jessica Shaw. 2017. "Forgotten Evidence: A Mixed Methods Study of Why Sexual Assault Kits (SAKs) Are Not Submitted for DNA Forensic Testing." *Law and Human Behavior* 41 (5): 454–67. http://dx.doi.org.ezproxy.rit.edu/10.1037/lhb0000252.

Campbell, Rebecca, Fehler-Cabral, Giannina, Pierce, Steven, Sharma, Dhruv B., Bybii, Deborah, Shaw, Jessica, Horsford, Sheena, and Feeney, Hannah. 2015. "The Detroit Sexual Assault Kit (SAK) Action Research Project (ARP), Final Report," November, 556.

Campbell, Rebecca, Steven J. Pierce, Dhruv B. Sharma, Hannah Feeney, and Giannina Fehler-Cabral. 2016. "Should Rape Kit Testing Be Prioritized by Victim–Offender Relationship?" *Criminology & Public Policy* 15 (2): 555–83. https://doi.org/10.1111/1745-9133.12205.

Campbell, Rebecca, Steven J. Pierce, Dhruv B. Sharma, Hannah Feeney, and Giannina Fehler-Cabral. 2019. "Developing Empirically Informed Policies for Sexual Assault Kit DNA Testing: Is It Too Late to Test Kits Beyond the Statute of Limitations?" *Criminal Justice Policy Review* 30 (1): 3–27. https://doi.org/10.1177/0887403416638507.

CNN, Jessica Ravitz. 2015. "The Story behind the First Rape Kit." CNN. November 21, 2015. https://www.cnn.com/2015/11/20/health/rape-kit-history/index.html.

Cornyn, John. 2019. *S.820 - 116th Congress (2019-2020): Debbie Smith Act of 2019*. https://www.congress.gov/bill/116th-congress/senate-bill/820/text.

Durose, Matthew. 2014. "Publicly Funded Forensic Crime Laboratories: Resources and Services, 2014," 12.

Elmore, Richard. 1979. "Backward Mapping: Implementation, Research and Policy Decisions."

Fallik, Seth, and William Wells. 2015. "Testing Previously Unsubmitted Sexual Assault Kits: What Are the Investigative Results?" *Criminal Justice Policy Review* 26 (6): 598–619. https://doi.org/10.1177/0887403414528001.

FBI. 2018. "Crime in the United States by State, 2018." 2018. https://ucr.fbi.gov/crime-in-the-u.s/2018/crime-in-the-u.s.-2018/topic-pages/tables/table-5.

Hewitt, Bill. 2002. "No Time to Wait." PEOPLE.Com. June 3, 2002. https://people.com/archive/no-time-to-wait-vol-57-no-21/.

Lovrich, Nicholas, Travis Pratt, Michael Gaffney, Charles Johnson, Christopher Asplen, Lisa Hurst, and Timothy Schellberg. 2003. "National Forensic DNA Study Report," December, 473.

Morgan, Rachel E. 2018. "Criminal Victimization, 2018," 37.

National Institute of Justice. n.d. "National Best Practices for Sexual Assault Kits: A Multidisciplinary Approach," 140.

NY State Assembly Bill A8401C. 2018. https://www.nysenate.gov/legislation/bills/2017/a8401/amendment/c.

NY State Assembly Bill A10760. 2016.

NY State Senate Bill S8977. 2018. https://www.nysenate.gov/legislation/bills/2017/s8977.

Office on Violence Against Women. 2010. "Summary of the Proceedings: Eliminating the Rape Kit Backlog: A Roundtable to Explore a Victim-Centered Approach." https://victimsofcrime.org/docs/dna-resource-center-documents/eliminating-the-rape-kit-backlog--a-roundtable-to-explore-a-victim-centered-approach-(2010).pdf?sfvrsn=6.

———. 2013. "A National Protocol for Sexual Assault Medical Forensic Examinations - Adults/Adolescents Second Edition," April, 144.

Ohno, Taiichi. 1988. *The Toyota Production System: Beyond Large-Scale Production*. Portland: Productivity Press.

"Our Story." n.d. Joyful Heart Foundation. Accessed December 11, 2019. http://www.joyfulheartfoundation.org/about-us/our-story.

Parratt, Kayleigh A., and Afroditi Pina. 2017. "From 'Real Rape' to Real Justice: A Systematic Review of Police Officers' Rape Myth Beliefs." *Aggression and Violent Behavior* 34 (May): 68–83. https://doi.org/10.1016/j.avb.2017.03.005.

Peterson, Joseph, Donald Johnson, Denise Herz, Lisa Graziano, and Taly Oehler. 2012. "Sexual Assault Kit Backlog Study," June, 133.

Pratt, Travis C., Michael J. Gaffney, Nicholas P. Lovrich, and Charles L. Johnson. 2006. "This Isn't CSI: Estimating the National Backlog of Forensic DNA Cases and the Barriers Associated With Case

Processing." *Criminal Justice Policy Review* 17 (1): 32–47. https://doi.org/10.1177/0887403405278815.

"President Donald J. Trump Signs H.R. 560, H.R. 1242, H.R. 1306, H.R. 1927, S. 1393, S. 1532, S. 1766." 2018. The White House. January 8, 2018. https://www.whitehouse.gov/briefings-statements/president-donald-j-trump-signs-h-r-560-h-r-1242-h-r-1306-h-r-1927-s-1393-s-1532-s-1766/.

Reilly, Steve. 2015. "Tens of Thousands of Rape Kits Go Untested across USA." *USA TODAY*, July 16, 2015. https://www.usatoday.com/story/news/2015/07/16/untested-rape-kits-evidence-across-usa/29902199/.

Robinson, Stewart, Zoe J. Radnor, Nicola Burgess, and Claire Worthington. 2012. "SimLean: Utilising Simulation in the Implementation of Lean in Healthcare." *European Journal of Operational Research* 219 (1): 188–97. https://doi.org/10.1016/j.ejor.2011.12.029.

Sacco, Lisa N. 2019. "The Violence Against Women Act (VAWA): Historical Overview, Funding, and Reauthorization," April, 42.

Strom, Kevin, and Matthew Hickman. 2010. "Unanalyzed Evidence in Law-Enforcement Agencies: A National Examination of Forensic Processing in Police Departments." *Criminology & Public Policy* 9 (April). https://doi.org/10.1111/j.1745-9133.2010.00635.x.

"The Criminal Justice System: Statistics | RAINN." 2019. September 26, 2019. https://www.rainn.org/statistics/criminal-justice-system.

The National Center for Victims of Crime. n.d. "Sexual Assault Kit Testing: What Victims Need to Know." https://victimsofcrime.org/docs/default-source/dna-resource-center-documents/dna-sak-victim-brofinal.pdf?sfvrsn=2.

Times, Betty Freudenheim Special to The New York. 1978. "Chicago Hospitals Are Using New Kit to Help Rape Victims Collect Evidence." *The New York Times*, December 2, 1978, sec. Archives. https://www.nytimes.com/1978/12/02/archives/chicago-hospitals-are-using-new-kit-to-help-rape-victims-collect.html.

"U.S. Department of Justice, Office of Justice Programs, FY 2020 Program Summaries." 2019.

Wang, Can, and Lawrence M. Wein. 2018. "Analyzing Approaches to the Backlog of Untested Sexual Assault Kits in the U.S.A." *Journal of Forensic Sciences* 63 (4): 1110–21. https://doi.org/10.1111/1556-4029.13739.

Wells, William, Campbell, Bradley, and Franklin, Cortney. 2016. "Unsubmitted Sexual Assault Kits in Houston, TX: Case Characteristics, Forensic Testing Results, and the Investigation of CODIS Hits, Final Report," March, 66.

"Where the Backlog Exists and What's Happening to End It | ENDTHEBACKLOG." 2019. October 21, 2019. http://www.endthebacklog.org/backlog/where-backlog-exists-and-whats-happening-end-it.