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The jurisdictional return on investment from processing the backlog of untested sexual assault kits[☆]

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ABSTRACT

The economic problem for the forensic laboratory is a problem faced in all arenas; limited resources are available to address seemingly unlimited desires. This is as true for entities in the public sector as it is for any private concern. To assist decision-makers in the allocation of those scarce resources, we synthesize existing research on the benefits of additions to the DNA Database and the potential benefits from diverting resources to analysis of the backlog of sexual assault kits. We offer some guidance for the optimum use of limited resources, through the measurement of the return on investment (ROI) at the jurisdictional level (i.e., that is, the net benefits to society relative to the investment itself). These net benefits include those to survivors from a resolution to their assaults, the benefits to others from the prevention of repeated assaults from serial rapists, and the prevention of societal costs external to those directly victimized. Those external costs extend from the effects on friends and family to expenses for preventive measures to anyone aware of sexual assaults. Such metrics surrounding ROI will assist the public sector in the optimal allocation of scarce resources to the justice system by providing a measures of the marginal social welfare improvement from alternative allocations of these scarce resources in light of objectives of public sector entities. The analysis demonstrates that the societal return on investment from the testing of all sexual assault kits ranges from 9,874% to 64,529%, depending on the volume of activity for the laboratory conducting the analysis. There are extreme economies of scale in effect that are suggestive of some policy alternatives.

1. Introduction

DNA analysis has gained increased public attention through its highlighted use in criminal justice as well as attention from unlocking the mysteries of genealogy. The growth in the prominence of DNA analysis as some type of magic bullet has also led to increased outrage in many communities as revelations of untested sexual assault kits (SAKs) are uncovered. Many have speculated on the volume of untested SAKs and how many hundreds of thousands of SAKs remain to be tested [1,2]. But to date, no consensus has emerged on the number of kits awaiting analysis or gathering dust.

The heightened public awareness of the issues affiliated with the high quantity of untested SAKS has been the subject of popular television (e.g. Law and Order: Special Victims Unit) and notable films such as the Home Box Office documentary, *I Am Evidence* [3]. As that awareness has grown, so has the reaction by public officials via calls for increased testing. Sometimes these public reactions are voiced with mandates for testing, whether they be funded or unfunded mandates. More recently, the Department of Justice and individual states have formalized programs to discover the number of untested kits and for the testing itself through the Sexual Assault Kit Initiative (SAKI) program and various programs in the individual states [4,5].

The adoption of programs to analyze the backlog of SAKs has permitted researchers to observe data on the effectiveness of DNA analysis. The large number of processed kits in these programs can be tracked from laboratory analysis through the justice system to final resolution. With the large number of tested kits in a defined time period, large number statistical properties can be employed to assess various outcomes. The relative frequency of testing leading to a usable profile, identification of that profile, arrests, convictions, and exonerations can all be statistically evaluated and provide expectations for future testing. This includes the expected range of outcomes for jurisdictions that have a SAK backlog yet to be tested.

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The statistical analysis may be expanded to suggest expected outcomes from contemporaneous caseloads.

Beyond the moral and emotional benefits from addressing the backlog of SAKs, there are measurable societal and economic benefits from testing SAKs [6–8]. The direct and indirect benefits can be enormous. These include the benefits to survivors from a resolution to their assaults, the benefits from the prevention of repeated assaults from serial rapists, and the prevention of societal costs external to those directly victimized, such as increased preventative expenditures for security, productivity losses, and costs avoided by the justice system.

In a review of social science research on forensic science, Browning [9] concludes with the observation that "resources are decreasing. We must keep learning how to be more efficient in using ever-evolving forensics technologies and examining the actual justice outcomes resulting from forensic evidence so that limited resources can be used wisely." The economic problem for the forensic laboratory is a problem faced in all arenas; limited resources are available to address seemingly unlimited desires [10]. This is as true for entities in the public sector as it is for any private concern.

In the present study, evidence is presented to assist decision-makers in the allocation of those scarce resources. Existing research on the benefits of additions to the DNA Database Combined DNA Index System (CODIS) is synthesized and potential benefits from diverting resources to analysis of the backlog of untested sexual assault kits are illuminated. Through the measurement of the return on investment (ROI) at the jurisdictional level, we offer some guidance for the optimum use of limited resources. Such metrics will assist the public sector in the optimal allocation of scarce resources to the justice system by providing a measure of the social welfare improvement from alternative allocations of these scarce resources in light of strategic objectives of public sector entities.

Return on investment is a ratio of the net benefit of an activity, the benefit minus the cost, relative to the investment in that activity. As a ratio metric it has comparability with other activities. For example, the economic benefit between investments in alternative public activities may be immediately compared. Similarly, the return on investment in the public sector may be compared to the return on investments in the private sector.

The resource demands for testing have been evaluated in the literature. While rough measures of average costs of testing have been used by both Doleac [6] and Wang & Wein [8] in their measurements of the benefits from additions to the DNA database, more detailed jurisdictional costs have been evaluated in Project FORESIGHT [11,12]. Analysis of the FORESIGHT data offers a more complete picture of the demands on the services of forensic laboratories and the fully-loaded costs of operation. Further, the FORESIGHT data highlights the differences in average total costs to laboratories because of economies of scale associated with forensic analysis. The unique caseload of each jurisdiction results in significant differences in the average total costs of analysis. Even though a laboratory may make efficient use of its resources for the caseload of its jurisdiction, that caseload may not be large enough to be as cost effective as other larger jurisdictions. With significant cost differentials come variations in the associated ROI from that activity.

Combining the studies on the societal benefits from testing with evaluations of the cost of testing offers an opportunity to provide an identification of the return on investment from testing at the jurisdictional level to address the statement of the economic problem by Browning [9]. Since competition for public funding pits these efforts regarding the testing of SAKs against other justice funding, as well as funding for the environment, the arts, and a whole host of public endeavors, translation of the evidence to a return on investment provides some objective measures for decision-makers to assist them in the allocation of scarce resources to the many competing desires.

The decisions regarding the testing of the backlog of SAKs has been and will be made on many grounds. It will be a humanitarian rationale, a moral argument, an emotional response, an economic interpretation, and/or a decision to reflect the societal sense of justice. The present study respects the validity of all these perspectives for the adoption of policies and provision of funding. The perspective here is an economic one, but that economic argument is provided in support of all perspectives. In their statistical analysis of the societal benefits from testing the backlog of SAKs, Wang & Wein [8] offer a conservative estimate of the benefits at a level of 81 times the cost to the justice system. When consideration is extended to the testing of contemporaneous cases, the present analysis demonstrates that the societal return on investment from the testing of all sexual assault kits ranges from 9,874% to 64,529%, depending on the volume of activity for the jurisdiction conducting the analysis. There are rewarding economies of scale in effect that are suggestive of some policy alternatives.

The paper is organized as follows. It begins with the literature on the testing of the backlog of SAKs and highlights the statistical results that explain the returns to the testing of backlogged kits and the statistical support for the testing of contemporaneous laboratory submissions. In the following section, some of the relevant literature on the quantity of untested SAKs is reviewed. These studies provide much of the foundational statistical support of relative frequencies that may be used as proxies for probabilities of outcomes. This is followed by a review of the associated debate regarding prioritization of which kits are tested, stranger versus acquaintance assaults. This debate is key in highlighting the possible deficiencies in the hit rates in the DNA database; that is, if profiles of a subset of the SAKs are not entered, then they cannot be matched to new queries and may suggest underrepresented underlying probabilities. The next two sections consider measures of the societal benefits and the associated costs from testing, respectively. The benefits section highlights the recent research methodologies from the large sample analyses of backlog testing in Detroit and New York city. The cost section highlights some key lessons from project FORESIGHT on the dramatic average cost differences across jurisdictions from diseconomies of scale. Next, the return on investment from testing backlogs is evaluated, followed by the return on investment to continual testing of SAKS with contemporaneous submissions. Concluding comments follow.

2. The volume of untested sexual assault kits

There is no general agreement regarding the volume of untested sexual assault kits. Estimates range into the hundreds of thousands and the bigger the estimate, the more dramatic is the moral outrage [2,3,13]. The volume of untested SAKs includes both the measured backlog at forensic crime laboratories and the unknown quantities of kits that have never been submitted to these laboratories for testing. The question of how many kits have never been submitted may be accompanied by the question of why so many have not been submitted.

The Bureau of Justice Assistance (BJA) at the Department of Justice has addressed this question regarding the size of the problem through the Sexual Assault Kit Initiative (SAKI). The program is designed to systematically count and track the status of SAKs whether the kits have made it to the laboratory or have yet to be submitted by hospitals or policing agencies. The program also provides financial support for the testing of kits. Critically, the program calls for the development of system repairs to alleviate the problem in the future. This includes support for tracking systems, training, research, and expansion of the CODIS uploads [4].

The inclusion of funding for training addresses one of the systemic issues regarding the volume of untested SAKs. Greater understanding of the physiology of assault is expected to lead to improved submissions to laboratories as representatives across the justice system have an increased awareness of the fight, flight, and freeze responses to the targets of assault. Campbell et al. [14] describe that a not uncommon explanation of why a SAK was not forwarded to the laboratory for analysis is a criticism of response from the victim of the assault for not fighting or fleeing an attacker or a seemingly calm retelling of the attack or having inconsistencies in the timeline of the event. All of these may be explained by the body's preservation mechanisms as the brain automatically provides the hormonal release for coping with an attack.

As training and education enlighten personnel involved in the aftermath of sexual assault, better sampling, storage, and faster throughput is expected. This will affect the relative frequency of hits. That, in turn, may well affect reporting of assaults. The analysis in the following sections does not include an upward adjustment for improved training and education and may understate the expected return on investment.

3. Prioritization

Tracking down the volume of untested SAKs is just the beginning. Once the untested SAKs are submitted to the forensic crime laboratory, the economic problem must be addressed. Many laboratories are unprepared to quickly process the high volumes uncovered from an organized search for all untested kits. While there may be a desire to test all kits, resources might not match that desire and some prioritization must be made. In fact, the volume of untested kits may partially be a result of a *de facto* prioritization, where many non-stranger sexual assault cases were withheld from laboratory analysis because the accused had admitted a sexual relationship. Unfortunately, if that sexual relationship was unwanted, the profile cannot be entered into CODIS if the DNA profile is never analyzed.

The question of prioritization between stranger and non-stranger SAKs has led to some interesting analysis by Campbell et al. [2]. In addressing the question as to whether stranger sexual assault cases should be examined before non-stranger assaults, there may be a fatal flaw in attempting to statistically analyze the success in finding a CODIS hit. That is, if non-stranger assaults remain unanalyzed or under-analyzed, then the corresponding underrepresentation of these profiles in CODIS prohibits matches. The historical bias against forwarding such cases to the laboratory leads to an impossibility of matches from someone repeating non-stranger or stranger assaults. As such, the debate on prioritization lacks a valid statistical analytical argument.

In a recent review of the literature Strom & Hickman [13] provide additional support for this interpretation of the historical bias and the inability to make an unbiased statistical determination towards prioritization. They acknowledge the argument that DNA analysis and entry into CODIS might represent the only way to identify a stranger attacker as argued by Johnson et al. [15]. However, they also note the strength of the argument by Campbell et al. [2] that the historical bias against analysis of non-stranger cases has an under-reported base in CODIS and that subsequent hits will necessarily represent a smaller chance of matches than would be the case without that bias. As a result, analysis of the likelihood of a match must wait for more consistent entries into CODIS from stranger and non-stranger assaults.

The prioritization question is critical to the analysis in the following section regarding the benefits from testing all SAKs. Wang & Wein [8] rely upon the reporting of data from several test cities, where entire backlogs were analyzed. The associated hit rates from these studies included the separation of stranger and non-stranger cases. As such, the corresponding relative frequencies of hits for each subgroup, are used in lieu of probabilities of outcomes. As noted above, training and education are expected to increase the submissions of non-stranger samples to CODIS, which may yield higher hit rates in the future.

4. Measuring the societal benefits from testing the backlog

The debate regarding stranger versus non-stranger SAK testing is nestled within a larger debate of public funding for all uses. The SAK testing debate on prioritization may presume a fixed budget or a fixed trained staff to perform the analysis. A larger debate involves SAK testing for either group versus funding for clean water, national defense, road upkeep, public parks, support of the arts, as well as other justice system support. Recent research has addressed the societal benefits from additions to the DNA database [6,7,16,17]. These benefits are measured by crimes avoided and the associated societal costs averted.

By reviewing the effects in several states before and after a major statutory change with respect to submissions to CODIS, measures of the impact on crime may be analyzed [6]. Separate analysis is conducted of violent and non-violent crime and within categories of crime as to the impact of additions to the DNA database. Among other findings, Doleac [6] demonstrates that one addition to the DNA database may have a societal benefit approaching $20,000. Further, when the type of crime involved is isolated, the greatest impact of reducing recidivism comes with respect to violent crimes over property crimes. This analysis is expanded from the U.S. case to the impact on the social welfare from database additions in Europe with a consideration of other alienating social factors [17]. The authors show that the deterrence effects from additions to the DNA database are more pronounced with violent crimes, especially sexual assault, than property crimes.

A mathematical and statistical analysis of the benefits of testing SAKs permits an examination of the question of prioritization between stranger and non-stranger cases by Wang & Wein [8]. The statistical analysis suggests testing all kits and the authors calculate an estimate of the societal benefit from testing all SAKs, where an averted sexual assault provides lower bound savings of approximately $435,419, while the cost of testing a kit is only a fraction of that benefit [7]. To detail a societal benefit, Wang & Wein [8] piece together the results from various projects addressing the volume of untested SAKs. From Lussier et al. [18], we find the mean number of sexual assaults committed per rapist at 7.10. The distribution of assaults over the active period until conviction is estimated to be 26.22 sexual assaults that could be averted [8]. The data on Detroit's SAK backlog testing reveals a 0.316 hit rate in CODIS from a tested SAK [19].

Wang & Wein [8] use the CODIS hit rate from the Detroit testing of the backlog of SAKs and use the relative frequency of hits as the probability of a hit in their model. They turn to the Manhattan backlogged SAK testing, which is traced from the total tested kits through the process until resolution as presented by Bashford [20]. Combining the unconditional hit rate from Detroit with the New York City experience of convictions from CODIS hits, the probability of a hit multiplied by the probability that a hit leads to conviction yields the probability that an analyzed kit will result in a conviction. That probability multiplied by the number of sexual assaults averted and the cost savings from preventing one sexual assault results in the lower bound benefit of $133,484.

This lower bound social benefit is then combined with some existing research on the cost of testing from Roman et al. [21] to offer some initial cost-benefit analysis from addressing the volume of untested SAKs. Using data from five jurisdictions that piloted an examination of DNA costs, Wang & Wein [8] offer a conservative estimate of the cost per SAK DNA analysis and combine this average cost with the social benefit described above. The average costs include expenditures for preliminary testing, generation of a profile, CODIS entry, case verification, post-laboratory investigation, and post-arrest expenses. The estimated average cost of $1,641 is used in the resulting cost-benefit analysis in which the benefit of $133,484, compared to the $1,641 cost yields a cost/benefit ratio of more than 81:1, or a return on investment (ROI) of over 8,000%.[1]

As will be shown below, while 8,000% is a dramatic return, it understates the ROI to be expected in future SAK testing, once the existing backlogs have been eliminated.

5. Measuring the societal costs from testing the SAK backlog

The aforementioned conservative estimate of the average cost of SAK testing used by Wang & Wein [8] is adopted from a study by Roman et al. [21], where data was accumulated from DNA analysis in five jurisdictions (Denver, Los Angeles, Orange County, Phoenix, and Topeka). The expenditures isolated the costs for preliminary testing, generation of a profile, CODIS entry, case verification, post-laboratory investigation, and post-arrest expenses. Preliminary testing ranged from a low of $23 per kit in Orange County to a high of $980 in Los Angeles; generation of a DNA profile ranged from $126 in Topeka to $271 in Orange County (with Phoenix and Los Angeles reporting N/A for this category); CODIS entry ranged from $5 in Topeka to $167 in Los Angeles; case verification ranged from $69 in Phoenix to $195 in Orange County; investigation ranged from $300 in Los Angeles to $412 in Topeka; and post arrest from $108 in Topeka to $838 in Los Angeles.

However, as the authors of this study point out, these marginal costs are estimated with an assumption that fixed costs, such as laboratory equipment and a fully functioning policing agency are in place and do not add to the expense of evaluating additional DNA samples [21,22]. Additionally, investment in human capital development is ignored and skills are assumed to be in place.

A review of the six areas of marginal costs upon which the cost estimates are based opens up some questions. Within each of the six categories of measurement, the range of estimated costs are broad. For example, the estimated CODIS entry costs in Los Angeles are more than thirty times the estimated costs in Topeka. These estimated costs at the minimum and maximum of the five laboratories conflicts with evidence elsewhere [6,11,12].

Consider instead the cost of these activities as highlighted in project FORESIGHT data [23]. Five of the six cost categories are attributed to the forensic crime laboratory and the remaining category is a policing expense [21,22]. Project FORESIGHT collects data on casework, personnel allocation, and detailed expenditures across areas of investigation in the laboratory. FORESIGHT casework detail includes measurement of requests to the laboratory in each area of investigation, items submitted, examined internally and outsourced, and the samples examined, tests conducted, and reports generated. When combined with the detail on expenditures, a jurisdictional profile emerges for each submitting laboratory. The financial data in FORESIGHT includes detailed expenditures for capital equipment, personnel, consumables, and overhead. The data also includes details on the allocation of personnel, analytical and support staff, across scientific areas of investigation and administration. Taken across jurisdictions, a picture of the potential economies of scale across forensic laboratories emerges [11]. When all costs are considered, it is expected that the costs in Los Angeles would be considerably lower than the costs in Topeka simply due to economies of scale. Even considering the higher average compensation in Los Angeles and Orange County, the volume of casework should lead to lower average costs than experienced in a smaller jurisdiction such as Topeka [24,25]. Some of the estimated costs in Ref. [21] for the five jurisdictions are in sharp contrast with the decades of data across hundreds of laboratories represented in the FORESIGHT data.

Fig. 1 illustrates the average cost curve for the costs for preliminary testing, generation of a profile, CODIS entry, case verification, and post-arrest expenses as estimated in Speaker [25]. The curve is derived from individual laboratory submissions of their caseload and total expenditures, where the average cost is mapped against caseload and the efficient frontier, showing the expected average cost emerges. The FORESIGHT data for FY2016 is used for the estimated efficient frontier depicted in Fig. 1. Of the 119 laboratories used in the estimation of the frontier, the twenty smallest laboratories conducted DNA analysis for fewer than 500 cases in each laboratory, while the twenty largest laboratories dealt with volumes exceeding 5,000 cases.

The corresponding average costs to process a case showed that the smallest laboratory cost per case was nearly four times that of the most cost-effective laboratory. The minimum combined costs of the five expenditures is $1,842, which far exceeds the suggested testing expenditures used in the studies referenced above [8,21]. However, even with updates on the costs using FORESIGHT data, the testing of the backlog of SAKs will still yield a ROI above 5,000% for the five jurisdictions in the sample.

Movement along the downward sloped portion of Fig. 1 as caseload is increased represents the achievement of economies of scale. Perfect economies of scale would be reached at the minimum average total cost, around a 6,250 caseload. Since the average total cost across jurisdictions will vary widely, depending upon the associated caseload, the ROI will also vary widely. To evaluate the ROI for each jurisdiction, requires an examination of their specific cost structure.

6. Jurisdictional return on investment for the contemporaneous inflow of SAKs

Given that the average testing cost varies widely across jurisdictions because of the significant economies of scale, then how can each jurisdiction address their unique economic problem, once SAK backlogs have been addressed? The use of the ROI metric permits a simple comparison of the uses of public funds towards desired public services. Public expenditures in the forensic laboratory compete for funds with roads, clean water, and the arts. Even within the laboratory, once a budget allocation has been made, areas of investigation compete for those limited funds. An ROI metric for each alternative use offers an economic argument for prioritization of fund allocation. While the ROI from DNA analysis as it is tied to the testing of SAKs is demonstrated below, a similar analysis may be conducted for all laboratory activities from fingerprint identification to analysis of trace evidence. Likewise, arguments for public investment in roads, border protection, the arts, etc. can be put under the same comparative scrutiny and compared with respect to their ROI for the highest valued uses of limited public funds.

The backlog of untested SAKs has been addressed in many jurisdictions, but remains to be addressed in others. The cost-benefit analysis of the SAK backlog addressed by Wang & Wein [8] provides a foundation for the expected returns moving forward. Consider the ROI on testing SAKs moving forward, once the backlog has been cleared. The data from Manhattan's testing of their backlog, as

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[1] ROI = (Benefit - Cost)/Cost.

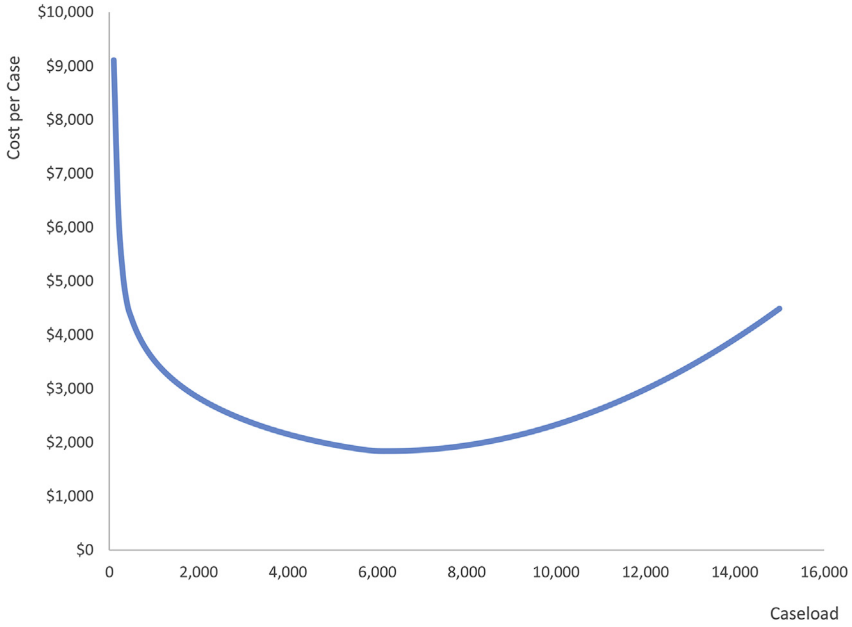

Fig. 1. Average total cost for DNA analysis by caseload.

outlined by Bashford [20], will be used as a foundation here, as it was used by Wang & Wein [8]. The New York project tested 3,777 SAKs of which 1,329 generated CODIS hits. Of those CODIS hits, 1,071 were cases where the identified person was already under arrest or the statute of limitations had run out. Thus, the probability of conviction, given a CODIS hit, used by Wang & Wein [8] only applies to the situation of a severe backlog. The resulting probability that a CODIS hit would lead to a conviction of less than 4% needs to be reconsidered with respect to SAKs that are immediately submitted to the laboratory for analysis. If the SAK is submitted immediately to the laboratory, then the statute of limitations would not have come into play, nor is it likely that the perpetrator of the sexual assault has already been arrested.

The cost-benefit analysis of the untested SAKs suggested a roughly 81:1 return [8]. Consider the same methodology for estimating the societal benefits, but updating the probabilities once the backlog has been addressed. That is, the benefits equal the probability of a CODIS hit times the probability that a CODIS hit leads to a conviction times the number of sexual assaults averted times the expected savings from avoiding a sexual assault. Reconsider the probability of a conviction after a CODIS hit with the Manhattan data to form the new probability. Taking the 47 convictions divided by the CODIS hits minus the arrestees, the cases where the statute of limitations had been reached, and the open cases, yields a probability that a hit leads to a conviction of nearly 22% (compared to 3.7% of the backlog) [20].

An additional adjustment towards calculation of the ROI comes from adjusting the benefits described by Lussier et al. [18] for inflation and consistency with the cost data from FORESIGHT for fiscal year 2016 [25]. When the probability of a hit (1,329/3,777) is multiplied by the probability of a conviction (47/214) and multiplied by the sexual assaults averted (26.22), which is then multiplied by the expected savings in 2016 dollars ($499,997), a benefit of $908,739 emerges.

This interpretation of the ROI follows the conservative approach used by Wang & Wein [8]. However, rather than dropping the open cases from consideration, the probability that an open case leads to a conviction may be estimated. An alternative interpretation of the New York data addresses the 44 open cases [20]. Instead of removing these unresolved cases from consideration, suppose that the open cases are subject to the same possible outcomes, namely either a conviction or that the DNA was not conclusive. In this case the probability of a conviction from a CODIS hit rises to 28.76% and a benefit of $1,190,148 emerges.

The two interpretations of the probability of a conviction from a CODIS hit yields a range for the return on investment for various case levels of DNA casework analysis. Using the 2016 FORESIGHT data [25] with the inflation-adjusted benefits estimation yields the results in Table 1.

Table 1 data represent the total DNA casework from all sources, SAKs and other. Even a very small caseload leads to a high ROI. For example, the smallest DNA caseload illustrated, 100 cases, leads to an estimated return on investment of 9,874% - 12,962%, where ROI_1 follows the description above when the open cases in Bashford [20] are excluded, while ROI_2 includes an estimate of the number of convictions from those open cases. Notice that the highest ROI is associated with perfect economies of scale around 6,250 DNA cases per year, yielding an expected ROI in the range of 49,247% - 64,529%. Beyond the level of perfect economies of scale, average costs begin to rise and the ROI falls.

7. Concluding remarks

Data driven decision-making benefits from convenient metrics from which to compare alternative uses of funds. Ratio metrics are useful business tools that permit simple comparisons while correcting for scale of operations. The ROI metric of this study for the returns from DNA analysis of SAKs permits laboratories from all jurisdictions to take their expected caseload and relate the net benefits as public funds are allocated to this effort.

While this detail will directly benefit jurisdictions of varying sizes, it is important to note that the funding problem is a dynamic one. As backlogs are addressed with increased funding, it is expected that turnaround times will improve, but with that improvement will be a signal for more sexual assault survivors to come forward as suggested by Wang & Wein [8]. The key for each jurisdiction is to target the expected caseload as it grows in response to investment into more DNA testing.

Table 1
Return on investment range by caseload.

Caseload	ROI$_1$	ROI$_2$	Caseload	ROI$_1$	ROI$_2$
100	9,874%	12,962%	5,500	47,951%	62,831%
200	14,215%	18,648%	5,750	48,727%	63,848%
300	17,470%	22,910%	6,000	49,189%	64,452%
400	19,740%	25,884%	6,250	49,247%	64,529%
500	21,015%	27,554%	6,500	49,188%	64,450%
600	22,120%	29,000%	6,750	49,011%	64,219%
700	23,105%	30,291%	7,000	48,720%	63,838%
800	24,003%	31,467%	7,250	48,320%	63,314%
900	24,836%	32,558%	7,500	47,816%	62,654%
1,000	25,617%	33,581%	7,750	47,214%	61,866%
1,100	26,357%	34,550%	8,000	46,524%	60,962%
1,200	27,063%	35,475%	8,250	45,753%	59,952%
1,300	27,742%	36,363%	8,500	44,910%	58,848%
1,400	28,397%	37,222%	8,750	44,005%	57,663%
1,500	29,033%	38,054%	9,000	43,047%	56,409%
1,600	29,652%	38,865%	9,250	42,046%	55,097%
1,700	30,256%	39,656%	9,500	41,010%	53,740%
1,800	30,848%	40,431%	9,750	39,947%	52,348%
1,900	31,428%	41,191%	10,000	38,866%	50,933%
2,000	31,999%	41,939%	10,250	37,774%	49,502%
2,100	32,560%	42,674%	10,500	36,678%	48,067%
2,200	33,114%	43,399%	10,750	35,583%	46,633%
2,300	33,660%	44,114%	11,000	34,495%	45,208%
2,400	34,199%	44,820%	11,250	33,418%	43,797%
2,500	34,732%	45,518%	11,500	32,357%	42,407%
2,600	35,259%	46,208%	11,750	31,314%	41,042%
2,700	35,780%	46,891%	12,000	30,292%	39,704%
2,800	36,296%	47,566%	12,250	29,295%	38,397%
2,900	36,806%	48,235%	12,500	28,322%	37,124%
3,000	37,311%	48,897%	12,750	27,377%	35,886%
3,250	38,552%	50,522%	13,000	26,459%	34,684%
3,500	39,761%	52,105%	13,250	25,570%	33,519%
3,750	40,936%	53,644%	13,500	24,709%	32,391%
4,000	42,076%	55,136%	13,750	23,877%	31,302%
4,250	43,176%	56,578%	14,000	23,074%	30,250%
4,500	44,234%	57,963%	14,250	22,299%	29,236%
4,750	45,245%	59,287%	14,500	21,553%	28,258%
5,000	46,205%	60,544%	14,750	20,834%	27,316%
5,250	47,108%	61,727%	15,000	20,142%	26,410%

Moving forward, more work needs to be done to predict the response of survivors and the volume of SAKs making their way to the laboratory. Broad-based measures of this response via a queuing elasticity of demand has been presented by Speaker [25], but better predictions for sexual assault need to be determined.

The varying ROI from economies of scale also invite systemic questions to be addressed. Are there better ways to conduct DNA analysis than what we presently have? Should cross-jurisdictional alternatives be considered? How will new technologies affect the cost structures for analysis? There is much more work to be done.

Declaration of interest

None.

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